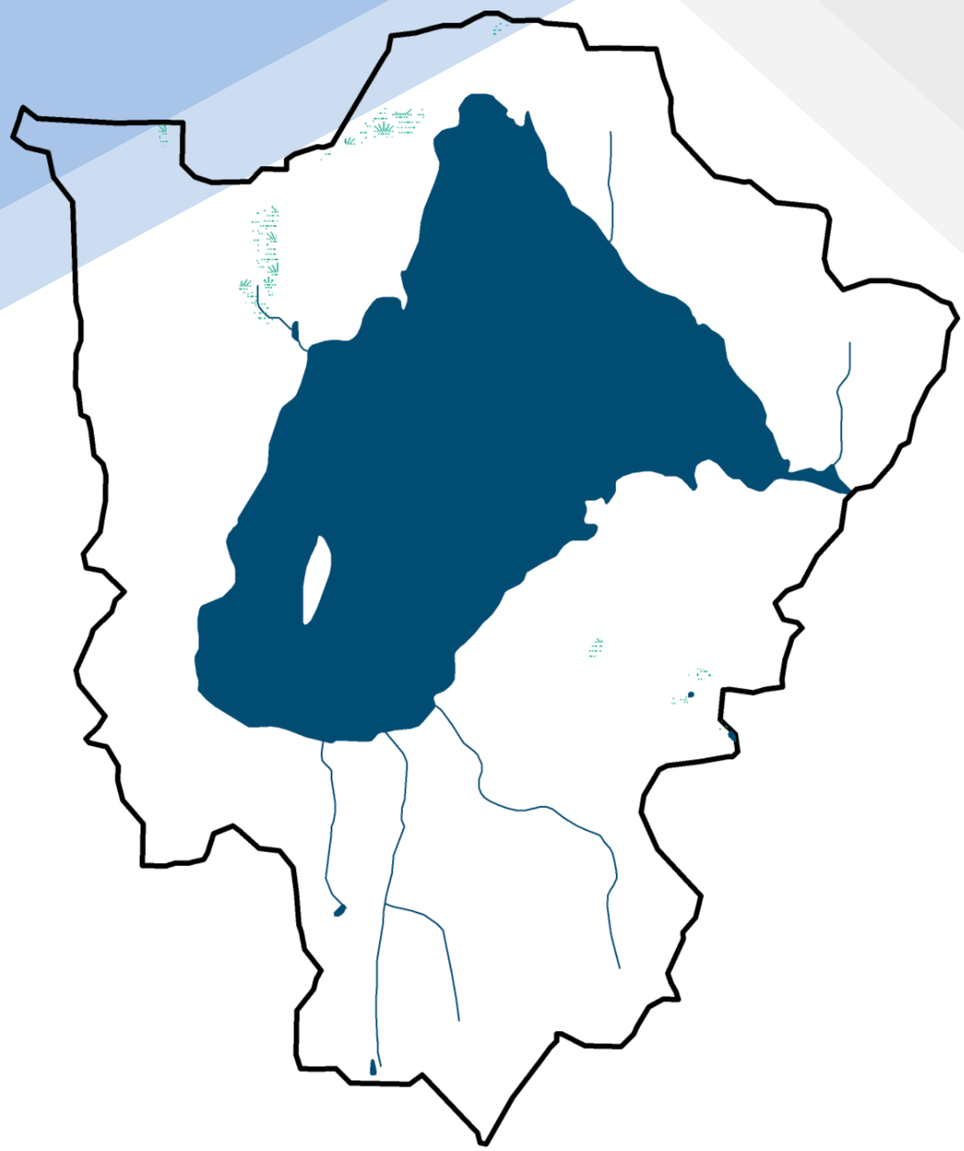
SPOFFORD LAKE

WATERSHED MANAGEMENT PLAN



FINAL November 2018

Southwest Region Planning Commission

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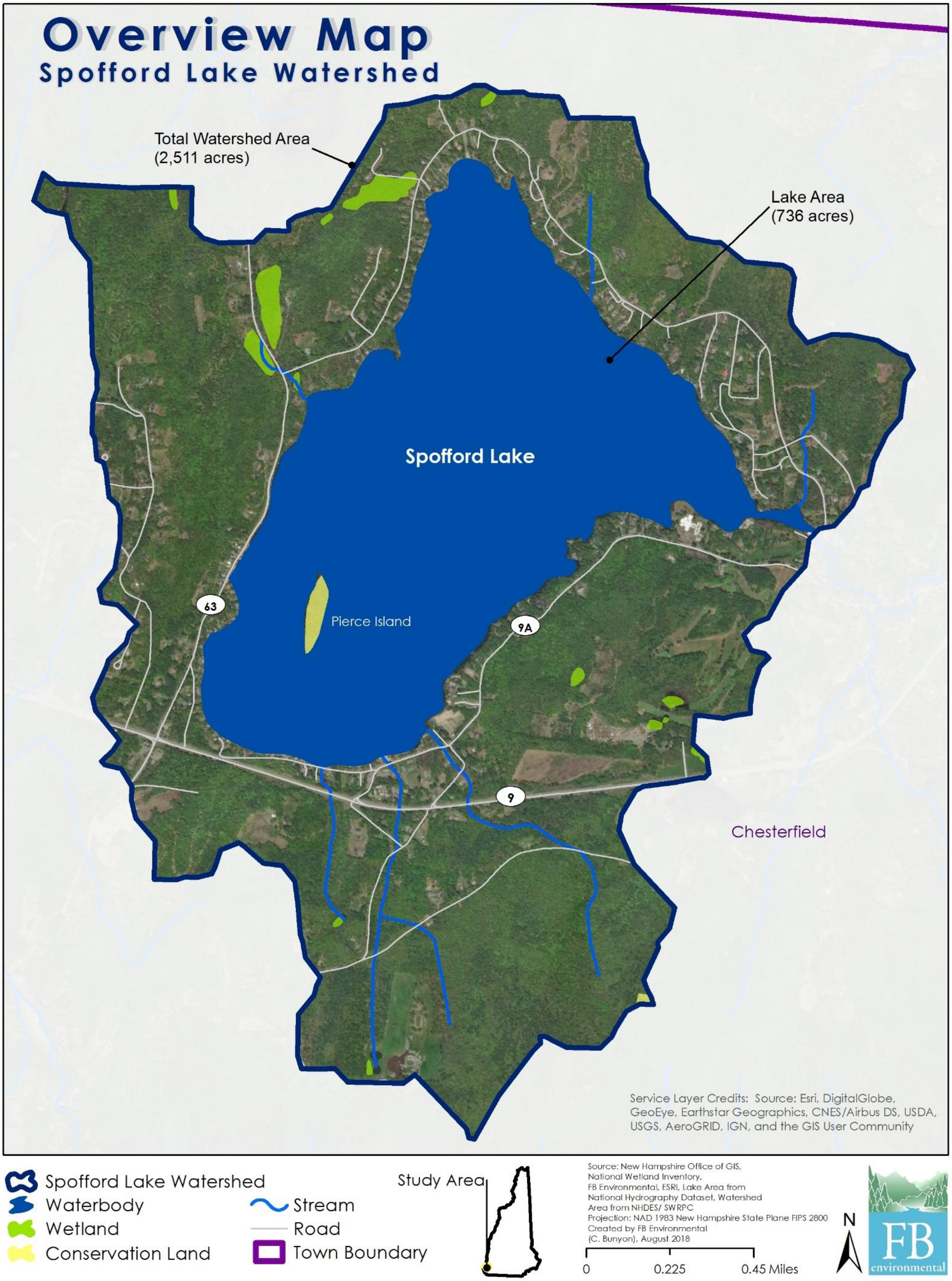
New Hampshire Department of Environmental Services



Overview Map
Spofford Lake Watershed
Total Watershed Area (2,511 acres)
Lake Area (736 acres)
Spofford Lake
Pierce Island
63
9A
9
Chesterfield
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Spofford Lake Watershed
Waterbody
Wetland
Conservation Land
Stream
Road
Town Boundary
Study Area
Source: New Hampshire Office of GIS, National Wetland Inventory, FB Environmental, ESRI, Lake Area from National Hydrography Dataset, Watershed Area from NHDES/ SWRPC
Projection: NAD 1983 New Hampshire State Plane FIPS 2800
Created by FB Environmental (C. Bunyon), August 2018
0
0.225
0.45 Miles
N
FB environmental

SPOFFORD LAKE

WATERSHED MANAGEMENT PLAN

Prepared by **FB ENVIRONMENTAL ASSOCIATES**
in cooperation with the Southwest Region Planning Commission
and the New Hampshire Department of Environmental Services

FINAL | NOVEMBER 2018

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EXECUTIVE SUMMARY

The water quality of Spofford Lake is threatened by low concentrations of dissolved oxygen in the hypolimnion (i.e., bottom waters), recent excessive plant growth in shallow littoral areas of the lake, and elevated levels of chloride. The desirability of Spofford Lake as a recreational destination and increasingly as a permanent residence for newcomers will likely stimulate continued population growth in the future. Thus, taking proactive steps to properly manage and treat harmful pollutants such as nutrients and chloride in nonpoint source (NPS) pollution in the Spofford Lake watershed is essential for continued ecosystem health and recreational enjoyment by future generations.

> The Spofford Lake Watershed Management Plan provides a roadmap for improving the water quality of Spofford Lake and a mechanism for procuring funding (e.g., Section 319 grants) to secure actions needed to achieve the water quality goal. USEPA requires that a watershed plan (or an acceptable alternative plan) be created so that communities become eligible for watershed assistance grants.

As part of the development of this plan, a build-out analysis, water quality and assimilative capacity analysis, and shoreline/watershed surveys were conducted (Section 3). Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the pre-development, current, and projected future amount of total phosphorus being delivered to the lake from the watershed (Section 3.3). An Action Plan (Section 5.2) with associated timeframes, responsible parties, and estimated costs was developed based on feedback from community members that attended the public forum in August 2018.

WATER QUALITY ASSESSMENT

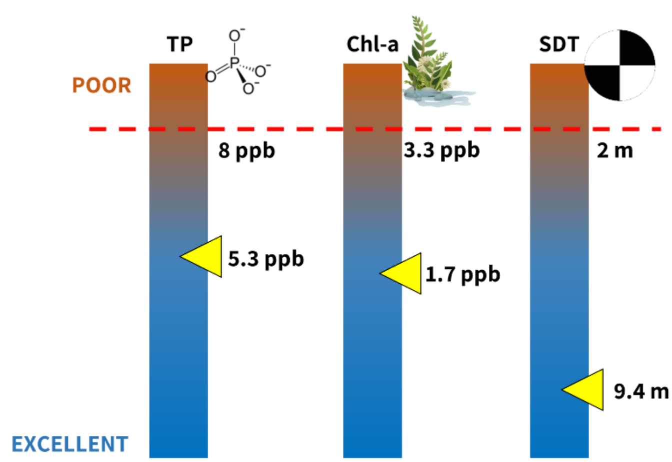
Overall, total phosphorus, chlorophyll-a, and water clarity are excellent in Spofford Lake and well within the state criteria for oligotrophic lakes. However, Spofford Lake is impaired for aquatic life use due to low dissolved oxygen (NHDES, 2016b). Low levels of oxygen in the hypolimnion, especially below 15 m, are common in Spofford Lake, impacting 53-62% of lake volume in summer, and are likely triggering a release of phosphorus from lake sediments, also known as internal phosphorus loading. Given the low in-lake nutrient concentrations, the dissolved oxygen impairment is likely driven by high sediment oxygen demand because of excess organic matter loading from legacy human activities (e.g., logging or farming) or current shoreline erosion. However, concerns over recent excessive plant growth in

LAKE QUICK FACTS

Town/State:	Chesterfield, NH (100%)
Total Watershed Area:	3.9 sq. mi. (2,511 ac.)
Lake Area:	1.14 sq. mi. (736 ac.)
Shore Length:	6.3 miles
Max Depth:	66 ft. (20.1 m)
Mean Depth:	30 ft. (9.1 m)
Lake Volume:	29,502,740 cu.m.
Flushing Rate:	0.24 times per year
Lake Elevation:	716 ft.
Trophic Classification:	Oligotrophic
Lake Impairments:	Dissolved Oxygen
Invasives:	None

Tributaries: Watershed water load (which includes runoff and tributary flow and groundwater baseflow) from the Spofford Lake watershed accounts for 70% of the total water entering Spofford Lake on an annual basis.

Other Notes: The low flushing rate of 0.24 means that the entire volume of the lake is replaced every 4 years, which allows pollutants more time to settle in lake bottom sediments and/or be taken up by biota.

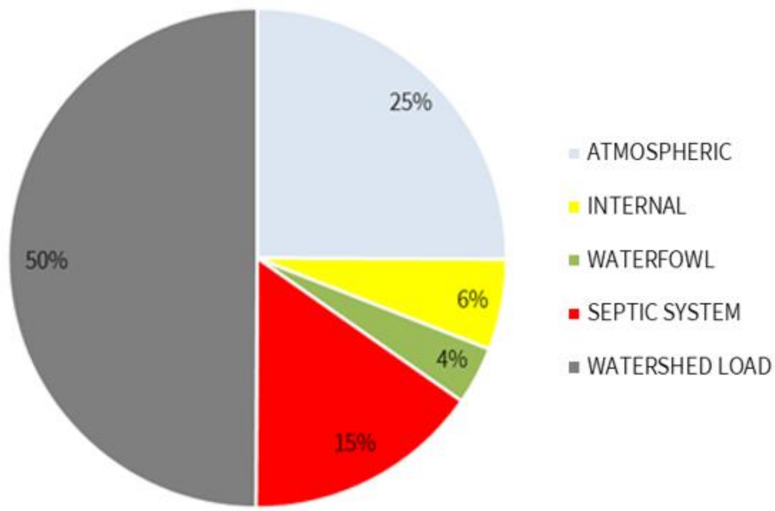


Visual summary of current water quality in Spofford Lake. Data represent recent (2008-2017) and seasonal (May 24-Sept 15) median or mean calculations. TP = total phosphorus; Chl-a = chlorophyll-a; SDT = Secchi Disk Transparency or water clarity. SDT is based on data collected with a scope.

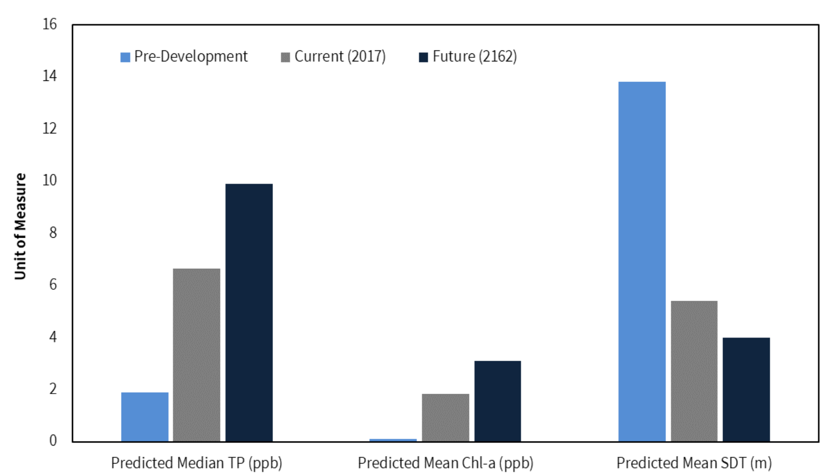
shallow littoral areas of the lake suggest that excess nutrient loading from the watershed may be driving observed ecosystem imbalances, which may be further exacerbated with new inputs of nutrient loading from anticipated future development in the watershed. Additionally, specific conductivity and chloride levels in Spofford Lake and its tributaries are elevated for a high-quality lake and show a statistically significant increase (degradation) over the record from 1977-2017, giving rise to concern that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lake. These water quality concerns were incorporated as specific objectives to achieve the water quality goal for Spofford Lake (see Water Quality Goal & Objectives).

WATER QUALITY MODELING

The land use model results indicate that watershed runoff and baseflow (50%) was the largest loading contribution across all sources to Spofford Lake, followed by atmospheric deposition (25%), septic systems (15%), internal loading (6%), and waterfowl (4%). Relatively higher phosphorus loading from the watershed and atmosphere were expected given the small watershed area (compared to lake surface area) and the short hydrologic residence time from land cover types in the watershed to the lake. Development in the watershed is most heavily concentrated 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. The septic system loading estimate was likely underestimated, given the potential bias of survey respondents to seasonal residences on newer systems (<20 years old).



Current percentage of total phosphorus (TP) loading (kg/yr) by source (atmospheric, internal loading, waterfowl, septic systems, and watershed load).



Predicted total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi Disk Transparency (SDT) for pre-development, current, and future loading conditions to Spofford Lake.

The direct shoreline area to Spofford Lake had the highest phosphorus export by total mass, followed distantly by Camp Spofford Inlet and Wares Grove Inlet. Drainage areas directly adjacent to waterbodies do not have adequate treatment time and are usually targeted for development, thus increasing the possibility for phosphorus export. Normalizing for the size of a tributary (i.e., accounting for its annual discharge and contributing drainage area) better highlights sub-basins with elevated pollutant exports relative to their drainage area. Sub-basins with moderate-to-high phosphorus mass exported by area (> 0.1 kg/ha/yr) generally had more development or agriculture. Camp Spofford Inlet and the direct shoreline area had the highest phosphorus mass exported by area.

The build-out analysis identified an estimated 949 acres (59%) of the 1,655-acre study area as developable. Up to 300 new buildings (a 74% increase from 2018) could be added at full build-out by the year 2162, using the 30-year compound annual growth rate of 1.15%. This predicted increase in development was then input to the model for the Spofford Lake watershed; the future phosphorus load was estimated at 334 kg/yr, with an in-lake phosphorus concentration of 9.9 ppb. This future load is 42% more than the current load and represents an estimate of the worst possible water quality for the lake. The direct shoreline and Wares Grove Inlet sub-basins were identified as most vulnerable to increases in future phosphorus loading.

Based on model analysis of pre-development, current, and future water quality conditions, Spofford Lake is at risk for water quality degradation from future development under current zoning constraints. Additional phosphorus loading from the watershed and internal sediments will likely accelerate water quality degradation of the lake. Using the maximum oligotrophic limit for chlorophyll-a at 3.3 ppb as a guide for surpassing favorable water quality conditions (per NHDES), it appears that Spofford Lake's possible "at-risk" threshold for total phosphorus ranges from 6.5-11.5 ppb, which will be met under the predicted future loading scenario. Given Spofford Lake's recreational and aquatic habitat value in the region, it will be crucial to both maximize land conservation of intact forestland and consider zoning ordinance amendments that encourage LID techniques on existing and new development. Land-use and zoning ordinances are among the most powerful tools municipalities can use to protect their natural resources.

WATER QUALITY GOAL & OBJECTIVES

The goal of the Spofford Lake Watershed Management Plan is **to improve water quality in Spofford Lake**. This goal will be achieved by accomplishing three objectives, with the first two objectives targeting the dissolved oxygen impairment. More detailed action items to achieve these objectives are provided in Section 5.2.

Objective 1: Investigate the cause of low dissolved oxygen in Spofford Lake.

- A sediment core at the deep spot of Spofford Lake should be collected and analyzed for organic matter content and dissolved oxygen should be monitored more frequently during critical time periods (late summer prior to turnover) to determine the cause and extent of the dissolved oxygen impairment and inform any adjustments to the water quality objectives.

Objective 2: Reduce pollutant loading to Spofford Lake by 19 kg/yr to improve in-lake median total phosphorus concentration (from 5.3 ppb to 5.0 ppb).

- Reducing current phosphorus loading by 5% (12 kg/yr) and preventing future phosphorus loading anticipated from new development in the next 10 years (7 kg/yr) can be achieved by implementing LID regulations on new development and/or implementing stormwater or septic system improvements to reduce pollution from existing development (such as a combination of the watershed sites and high/medium-impact shoreline sites identified; refer to Section 3.5).

Objective 3: Manage and reduce chloride loading to Spofford Lake to improve in-lake mean chloride concentration.

- Because chloride was not modeled in greater detail based on known road salt application rates in the watershed (or other sources to the watershed), it is difficult to set an appropriate reduction target without understanding the limits set by public safety standards. Therefore, any measured improvement to in-lake mean chloride concentration following implementation of salt management action items will be considered a success.

POLLUTANT SOURCE IDENTIFICATION

Watershed and shoreline surveys are first-phase, screening-level assessments designed to locate potential sources of NPS pollution within areas that drain to a waterbody. Watershed and shoreline areas are assessed by foot or car or by boat, respectively, from public access points (e.g., public roads, common areas) unless information is provided by private landowners. Results of these surveys are essential to the watershed-based planning process because they identify individual NPS sites and prioritize BMP implementation projects throughout the watershed. **Full-scale designs and cost estimates will need to be completed for each of the identified watershed survey sites. Technical assistance visits and BMP recommendations will also be needed for individual shoreline properties.**

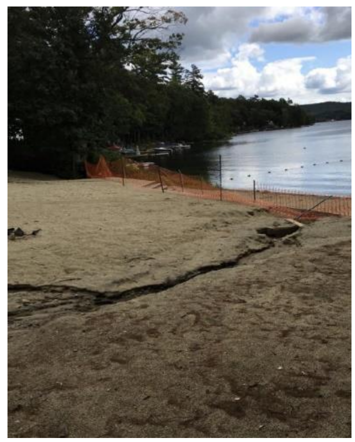
Sixteen (16) watershed NPS sites and 194 high to medium priority shoreline properties were identified and documented to have some impact on water quality through the delivery of phosphorus-laden sediment. A subset of NPS sites in the Spofford Lake watershed are identified below.

Ware's Grove Beach (Site 7)

Runoff from the unpaved parking lot of Ware's Grove Beach is conveyed to a catch basin which discharges to a drainage swale to Spofford Lake. Significant sediment from the gravel parking lot was found to be entering the catch basin and discharging untreated to the swale and lake. Engineered designs have been drafted for this site, which is slated for implementation work for spring 2019.

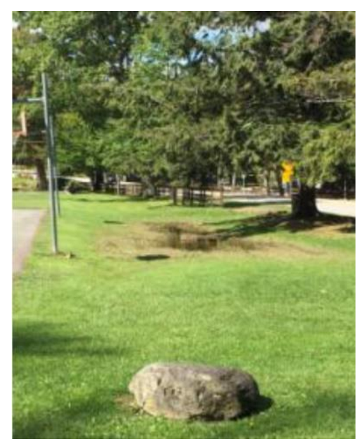
North Shore Beach (Site 1)

Significant erosion with gully formation was found at the entrance and along the beach at North Shore Beach. Erosion was caused by concentrated stormwater runoff coming across the street and onto municipal beach property. Engineered designs have been drafted for this site, which is slated for implementation work for spring 2019.



Camp Spofford (Site 6)

Untreated runoff from unpaved parking areas at Camp Spofford was found discharging to Spofford Lake. Recommend installing a large demonstration rain garden between the basketball court and the road (parallel to the lake shoreline) to treat runoff from the parking lot. This area is already a natural depression with standing water, is highly visible, and receives significant foot traffic, making it an ideal demonstration site.



PLAN IMPLEMENTATION STRATEGY & RECOMMENDATIONS

Management strategies for achieving the water quality goal and objectives involve using a combination of structural and non-structural BMPs, as well as an adaptive management approach (refer to Section 4). The recommendations of this plan should be carried out by a steering committee like the one assembled for development of the plan. A steering committee should include the leadership of SLA, representatives from the town (e.g., board of select, planning board), members of the conservation commission, schools and community groups, local business leaders, and landowners. The following presents short-term recommendations for achieving the goal and objectives (refer to Section 5.2 for the complete Action Plan):

- **WATER QUALITY MONITORING (OBJ. 1-3):** Investigate the cause of the low-oxygen impairment. Establish and/or continue a regular lake and tributary monitoring program. Consider adjusting the dam management plan. Maintain or expand the current Lake Host and Weed Watcher programs.

- **WATERSHED AND SHORELINE BMPS (OBJ. 2):** Work with landowners to encourage and implement stormwater controls, with initial focus on the highest priority survey sites. Apply for grant funding through NHDES to implement action items. Create a subcommittee that develops a fundraising strategy and determines how funding is spent.
- **PLANNING AND LAND CONSERVATION (OBJ. 2):** Present the watershed management plan to the Board of Select and incorporate recommendations to the town master plan. Host training about use of proper stormwater controls and LID practices. Enhance education of local land ordinances and BMPs. Consider improving municipal ordinance language to better protect water resources by implementing smarter development standards.
- **SEPTIC SYSTEMS (OBJ. 2):** Reach out to landowners that did not or could not respond to the 2017 survey. Develop and maintain a septic system database for the watershed/town. Enforce occupancy loads, have septic system inventories in the town master plan, and inspect all home conversions from seasonal to permanent residences or property transfers. Enhance awareness of proper septic system maintenance and regulations.
- **ROADS AND DRIVEWAYS (OBJ. 2):** Inventory, prioritize, and remediate culverts in the watershed. The SWRPC obtained a NHDOT grant to inventory culverts (based on size and condition) in the town for 2018-19. Work with road agents and landowners to create, map, and manage drainage easements on public and private properties.
- **SALT MANAGEMENT (OBJ. 3):** Ensure the town and other contractors working in the watershed are certified with the NH Green SnowPro Program and are implementing best practices when applying road salts.

ESTIMATED COSTS

The cost of successfully implementing the plan is estimated at around $1,200,00-$1,400,00 over the next ten years (2019-2028). **However, many costs are still unknown and should be incorporated to the Action Plan as information becomes available.** A sustainable funding plan should be developed within the first year and revisited on an annual basis to ensure that the major planning objectives can be achieved over the long-term. This funding strategy would outline the financial responsibilities at all levels of the community (landowners, town officials and staff, community groups, and state and federal governments).

Estimated ten-year costs for implementation of the Action Plan.

Category	Estimated 10-Year Total
Water Quality Monitoring	$463,635
Watershed and Shorefront BMPs	$603,000 - $780,000
Planning & Land Conservation	$66,500
Septic Systems*	$69,500
Roads & Driveways	$10,000
Salt Management	$15,000
Total Cost	**$1,227,635 - $1,404,635**

**Septic system recommendations do not include design or replacement costs because these should be covered by landowners. Recommendations cover assistance to secure grant funding for those individuals who cannot afford these costs.*

EVALUATING PLAN SUCCESS

The success of this plan is dependent on the continued effort of volunteers, and a strong and diverse steering committee (like the one established for plan development) 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 benchmarks. Measurable milestones (number of BMP sites, volunteers, funding received, etc.) should be tracked by a steering committee and reported to NHDES on a regular basis.

A reduction in phosphorus loading is no easy task, and because there are many diffuse sources of phosphorus reaching the lake from existing residential 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.

ACKNOWLEDGMENTS

SPOFFORD LAKE WATERSHED MANAGMENT PLAN STEERING COMMITTEE

Steve McGrath, Spofford Lake Association
Pam Walton, Chesterfield Conservation Commission
Bayard Tracy, Spofford Lake Association
Larry LaChance, Spofford Lake Association
James Corliss, Chesterfield Planning Board
Davis Peach, Chesterfield Planning Board
Norman VanCor, Chesterfield Board of Selectmen
John Kallfelz, NH Department of Transportation
Jeffrey Marcoux, NH Department of Environmental Services

COMMUNITY FORUM ATTENDEES

Michael Abbott, NH State Representative, B+K Aqua Club
Jon McKeon, Chesterfield Board of Selectmen
Lyle Foley, Spofford Lake Association
Frank Turner, Spofford Lake Association
Art Huggins, Spofford Lake Association
Susan Donahue, Spofford Lake Association
Bob Brockmann, Spofford Lake Association
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Nina Abelardo, Resident
Steve Peterson, Resident
Bill Manter, Resident
Rich Kalich, Resident
Judy Kalich, Resident
Don Brehm, Resident
Jill Brehm, Resident
Brad Roscoe, Resident
Charles Perry, Resident
Ken Walton, Resident
Casey Downes, Resident
Jim Donaher, Resident
Ginger Donaher, Resident
Karen Hanrahan, Resident
Charlie Donahue, Resident
Lois Bradstreet, Resident
Jack Medford, Resident
Also in attendance: James Corliss, Steve McGrath, Pam Walton, Bayard Tracy, Lisa Murphy, Todd Horner, Laura Diemer, Christine Bunyon, & Jeffrey Marcoux

SHORELINE / WATER QUALITY SURVEY VOLUNTEERS

Kathryn Cox
Terry Cox
James Dupee
Joe Hanzalik
Larry LaChance
Todd LaChance
Meaghan Rafferty

Joe Ragusa
Bob Seeman
Georgia Seeman
Also participating: Steve McGrath, Bayard Tracy, Frank Turner, Bob Brockmann, Art Huggins

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Richard Brereton, Project Manager and Water Resources Scientist, FB Environmental Associates
Christine Bunyon, Project Scientist, FB Environmental Associates
Richard Claytor, P.E., President, Horsley Witten Group
Renee Bourdeau, P.E., Water Resources Engineer, Horsley Witten Group

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Figure 3-2. **LEFT:** Average dissolved oxygen and temperature profile of the deep spot of Spofford Lake. Error bars represent standard deviation or spread of the data at each depth interval. **RIGHT:** Summary of data distribution for total phosphorus samples collected from the epilimnion and hypolimnion of the deep spot of Spofford Lake. The top and bottom of the gray area in each boxplot represent the 75th and 25th percentiles of the data, respectively. The solid horizontal line in each box represents the median or 50th percentile of the data. The top and bottom whiskers represent the maximum and minimum non-outliers of the data, respectively. Any points above or below the whiskers are outliers, defined as 1.5 times the interquartile range (or the width of the gray box). Total phosphorus concentrations in the hypolimnion are significantly higher than total phosphorus concentrations in the epilimnion, suggesting that internal phosphorus loading (stimulated by anoxia in bottom waters that releases sediment-bound phosphorus) is a concern for Spofford Lake. 16

Figure 3-3. **LEFT:** Yearly median of monthly medians for chloride and specific conductivity in the deep spot of Spofford Lake. Dashed line indicates a statistically significant increasing (degrading) trend in specific conductivity. There are not enough data to assess a similar trend in chloride, but chloride is likely driving the trend in specific conductivity. **RIGHT:** Chloride and specific conductivity are positively correlated; chloride accounts for 82% of the variation in specific conductivity. Dashed line (and gray 95% confidence intervals) indicates a statistically significant linear correlation. 17

Figure 3-4. Chlorophyll-a (measure of algae) generally increases in response to higher in-lake total phosphorus concentration. The relationship between chlorophyll-a and total phosphorus in Spofford Lake for yearly data (left panel) and monthly data (right panel) shows a possible threshold of chlorophyll-a response (set at the upper oligotrophic limit of 3.3 ppb) at 6.5-11.5 ppb for total phosphorus. Gray shaded areas show confidence intervals around locally-weighted regression. Chlorophyll-a response to phosphorus is weak at Spofford Lake, suggesting that other factors may more strongly control (i.e., limit) productivity in the lake.. 20

LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
ALU	Aquatic Life Use
BMP	Best Management Practices
CHL-A	Chlorophyll-a
CWA	Clean Water Act
DO	Dissolved Oxygen
EMD	Environmental Monitoring Database
FBE	FB Environmental Associates
HWG	Horsley Witten Group
LID	Low Impact Development
LLRM	Lake Loading Response Model
NCEI	National Centers for Environmental Information
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GIS Clearinghouse)
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHDOT	New Hampshire Department of Transportation
NHFGD	New Hampshire Fish and Game Department
NPS	Nonpoint Source Pollution
NWI	National Wetlands Inventory
PCR	Primary Contact Recreation
ppb, ppm	parts per billion, parts per million
SDT	Secchi Disk Transparency
SLA	Spofford Lake Association
SWRPC	Southwest Region Planning Commission
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
VLAP	Volunteer Lake Assessment Program

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 is a term used to describe the amount of water entering a lake on an annual basis divided by the lake's surface area.

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 amount of algae in the lake.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Oligotrophic lakes are less productive or have less 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 corridor 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).

Sediment oxygen demand is the rate of oxygen removal from the overlying water column due to the decomposition of organic matter in lake bottom sediments. Removal can be from biological or chemical oxidation processes.

Specific conductance is a measure of water's ability to conduct an electrical current, which varies with the amount of ions present in solution. Though conductance varies with local geology, conductance values exceeding 100 µS/cm generally indicate human disturbance.

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.

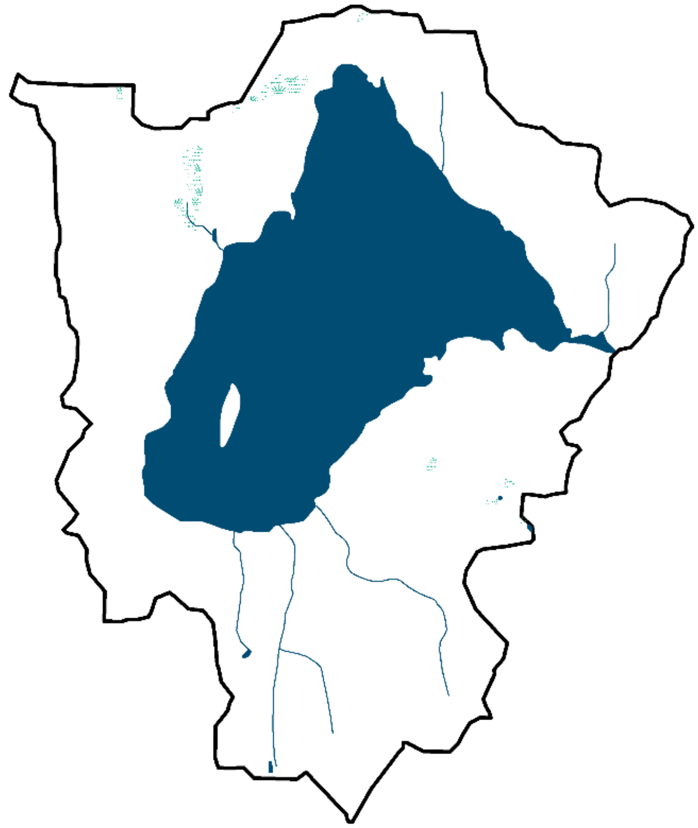
Thermocline or **metalimnion** is the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

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

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

1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE



Located in southwestern New Hampshire in the Town of Chesterfield, Spofford Lake is an important water resource that supports a diverse abundance of plants and animals and has attracted visitors to its shores for over 100 years. Lake residents, transient boaters, and summer tourists alike enjoy the lake's scenic beauty and quiet, rural character. However, the water quality of Spofford Lake is threatened by low concentrations of **dissolved oxygen** in the **hypolimnion** (bottom 10-15 m), recent excessive plant growth in shallow littoral areas of the lake, and elevated levels of chloride. Thus, taking proactive steps to properly manage and treat legacy and current **nonpoint source (NPS) pollution** in the Spofford Lake watershed is essential for continued ecosystem health and recreational enjoyment by future generations.

The Spofford Lake Watershed Management Plan is the culmination of a major effort by many individuals who care about the long-term protection of water quality in the lake. With the assistance and encouragement of the Spofford Lake Association (SLA), the Southwest Region Planning Commission (SWRPC) pursued and was awarded funding for a Water Quality Planning Grant from the New Hampshire Department of Environmental Services (NHDES) with **Clean Water Act (CWA)** Section 604(b) funds from the United States Environmental Protection Agency (USEPA).

The plan provides a roadmap using USEPA's nine key planning elements for preserving the excellent water quality of Spofford Lake and a mechanism for acquiring funding for implementation of management actions (e.g., Section 319 grants). USEPA requires that a watershed plan (or an acceptable alternative plan) be created so that communities become eligible for watershed assistance implementation grants. In addition, this plan sets the stage for ongoing dialogue among key stakeholders in the community and promotes coordinated action to address future development in the watershed. Plan success is dependent on the continued effort of volunteers, as well as a strong and diverse steering committee (like the one established for plan development) that meets regularly to review progress and make any necessary adjustments to the plan.

As part of the development of this plan, a **build-out analysis**, water quality and **assimilative capacity** analysis, and shoreline/watershed surveys were conducted (Section 3). Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the pre-development, current, and projected future amount of **total phosphorus** being delivered to the lake from the watershed (Section 3.3). An Action Plan (Section 5.2) with associated timeframes, responsible parties, and estimated costs was developed based on feedback from community members that attended the public forum. The forum was designed to provide stakeholders with information on the watershed and water quality of Spofford Lake, to solicit stakeholder input on action items, and to discuss the timing and elements of the plan.

1.2 STATEMENT OF GOAL

The goal of the Spofford Lake Watershed Management Plan is to improve water quality in Spofford Lake. This goal will be achieved by accomplishing three objectives, with the first two objectives targeting the dissolved oxygen impairment. More detailed action items to achieve these objectives are provided in the Action Plan (Section 5.2).

Objective 1: Investigate the cause of low dissolved oxygen in Spofford Lake.

- A sediment core at the deep spot of Spofford Lake should be collected and analyzed for organic matter content and dissolved oxygen should be monitored more frequently during critical time periods (late summer prior to turnover) to determine the cause and extent of the dissolved oxygen impairment and inform any adjustments to the water quality objectives.

Objective 2: Reduce pollutant loading to Spofford Lake by 19 kg/yr to improve in-lake median total phosphorus concentration (from 5.3 ppb to 5.0 ppb).

- Reducing current phosphorus loading by 5% (12 kg/yr) and preventing future phosphorus loading anticipated from new development in the next 10 years (7 kg/yr) can be achieved by implementing low-impact development regulations on new development and/or implementing stormwater or septic system improvements to reduce pollution from existing development.

Objective 3: Manage and reduce chloride loading to Spofford Lake to improve in-lake mean chloride concentration.

- Because chloride was not modeled in greater detail based on known road salt application rates in the watershed (or other sources to the watershed), it is difficult to set an appropriate reduction target without understanding the limits set by public safety standards. Therefore, any measured improvement to in-lake mean chloride concentration following implementation of salt management action items will be considered a success.

1.3 INCORPORATING EPA'S NINE ELEMENTS

USEPA guidance lists nine components that are required within a watershed plan to restore waters impaired or likely to be impaired by NPS pollution. These guidelines highlight important steps in restoring and protecting water quality for any waterbody affected by human activities. The following locates and describes the nine required elements found within this plan:

A. **IDENTIFY CAUSES AND SOURCES: Section 3.5** highlights known sources of NPS pollution to Spofford Lake and describes the results of the watershed and shoreline surveys conducted in 2017. These sources of pollution 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:** described under (C) below: **Sections 3.5 and 4.1.1** describe the calculation of pollutant load to Spofford Lake and the amount of reduction needed to meet the water quality goal. **Section 4** describes how estimated phosphorus load reductions to Spofford Lake can be met using specific management measures, including **structural Best Management Practices (BMPs)** for existing development, **non-structural BMPs** for future development, and an **adaptive management approach**.

C. **DESCRIPTION OF MANAGEMENT MEASURES: Sections 4 and 5.2** identify ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on six major topic areas that address NPS pollution, including: water quality monitoring, watershed and shorefront BMPs, municipal planning and conservation, septic systems, roads and driveways, and salt management. 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 5.1, 5.2, and 5.4** include a description of the associated costs, sources of funding, and primary authorities responsible for implementation. Sources of funding need to be diverse and should include local, state, and federal granting agencies (Town of Chesterfield, NHDES, and USEPA), local groups (SLA), private donations, and landowner contributions for BMP implementation on private property. SLA, the Town of Chesterfield, and other core stakeholders, led by a steering committee, should oversee the planning effort by meeting regularly and efficiently coordinating resources to achieve the objectives set forth in this plan.

E. **INFORMATION & EDUCATION & OUTREACH: Sections 1.5 and 5.5** describe how the Education and Outreach component of the plan is already being or will be implemented to enhance public understanding of the project, because of leadership from SWRPC, SLA, and the Town of Chesterfield.

F. **SCHEDULE FOR ADDRESSING PHOSPHORUS REDUCTIONS: Section 5.2** provides a list of action items and recommendations to reduce stormwater and phosphorus runoff to Spofford Lake. 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 a steering committee on an annual basis (see Section 4.3 on Adaptive Management).

G. **DESCRIPTION OF INTERIM MEASURABLE MILESTONES: Section 5.3** outlines indicators of implementation success that should be tracked annually. Using indicators to measure progress makes the plan relevant and helps sustain the action items. The indicators are divided into three different categories: Environmental, Programmatic, and Social Indicators. Environmental indicators are a direct measure of environmental conditions, such as improvement in water clarity or reduced median in-lake phosphorus concentration. Programmatic indicators are indirect measures of restoration activities in the watershed, such as how much funding has been secured or how many BMPs have been installed. Social indicators measure change in social behavior over time, such as the number of new lake monitoring volunteers.

H. **SET OF CRITERIA: Sections 3.4 and 5.3** 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 5.2.1** of the Action Plan describes the long-term water quality monitoring strategy for Spofford Lake, 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 goal of this plan is to improve water quality by lowering the in-lake median phosphorus concentration and reducing the extent and duration of low oxygen. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

1.4 PLAN DEVELOPMENT AND COMMUNITY PARTICIPATION PROCESS

The plan was developed through the collaborative efforts of numerous steering committee meetings, public presentations, and conference calls between SWRPC, FB Environmental Associates (FBE), SLA, NHDES, the Town of Chesterfield, Chesterfield Conservation Commission, NH Department of Transportation (NHDOT), and private landowners (see Acknowledgments).

The Town of Chesterfield sponsored an intern (Meaghan Rafferty) for the 2017 fall semester. She helped gather important information for the plan, including septic system information for 96 watershed properties, a summary of lake host and weed watcher programs, a summary of watershed development and water quality history with anecdotal references from long-term residents, location information for major inflows to the lake, and a quote from the SLA president.

Five **steering committee meetings** were held.

- **August 22, 2017:** This was the kick-off meeting for the steering committee to give a broad overview of the project and to discuss the upcoming survey events. It was explained that the survey events were timely and an important source of data collection for lake loading analyses. Members were asked to assist with the surveys and to ask other volunteers to come to the event. The ways to reach homeowners within the watershed were also discussed so that they would be aware of the survey and could opt to take the water quality survey on-line.

- **April 4, 2018:** New members joined the committee, so the meeting started with a project overview and a brief description of the roles of those involved in the project, including SWRPC, FBE, and NHDES. FBE gave a project status of the work that had been done over the winter months, including the modeling and build-out analysis.

- **June 20, 2018:** FBE provided a project status of the work that had been done on the draft plan and an overview of the remaining work to complete the project. The committee participated in a priority ranking exercise of the identified erosion sites in the draft BMP Matrix. The committee discussed ways to notify the public about the upcoming public events in August.

- **August 8, 2018:** SWRPC gave a summary report of the two outreach events that had been held. FBE provided a project status of the work that had been done on the draft plan and an overview of the remaining work to complete the project. FBE presented the draft water quality goal and objectives. The committee discussed and provided final feedback on the goal and objectives.

- **November 7, 2018:** A final steering committee was held to solicit final feedback on the draft plan.

Three **public presentations** were given to the Spofford Lake community.

- **July 6, 2017:** At the SLA Annual Meeting, FBE gave a brief introduction to the watershed management plan development process and ways in which community members can be involved.

- **July 12, 2018:** At the SLA Annual Meeting, SWRPC gave a project status report to 110 SLA members and explained the next steps to complete the management plan. Educational material was provided at each table.

- **August 16, 2018.** A community forum and public presentation of the draft plan was held. The forum was designed to provide local stakeholders with information on the watershed and water quality of Spofford Lake, to solicit stakeholder concerns, identify threats to water quality, and prioritize actions to mitigate identified threats. Over 30 people attended the community forum and provided valuable input to the plan. Attendees were broken out into four focus groups based on areas of concern (septic systems/roads, watershed and shorefront BMPs, municipal planning and conservation, and water quality monitoring/salt management). From group discussions and additional actions items provided by FBE, a total of 74 recommendations for achieving action items were identified and prioritized. Recommendations from the forum were incorporated to the Action Plan (Section 5.2).

SWRPC and FBE presented the draft watershed management plan to the Spofford Lake community in August 2018.

Two **workshops** were held for watershed residents.

- **July 26, 2018:** A NHDES SOAK up the Rain NH presentation was given on managing residential stormwater runoff. Methods from the NH Homeowners Guide to Stormwater Management were highlighted in the presentation and handout material was made available. Many participants had questions about their own properties. Approximately 25 people attended the event.

- **August 2, 2018:** A presentation was given by NHDES on maintaining a healthy drinking water well and septic system for the protection of drinking water and lake water quality. Handout material was made available. Approximately 25 people attended the event.

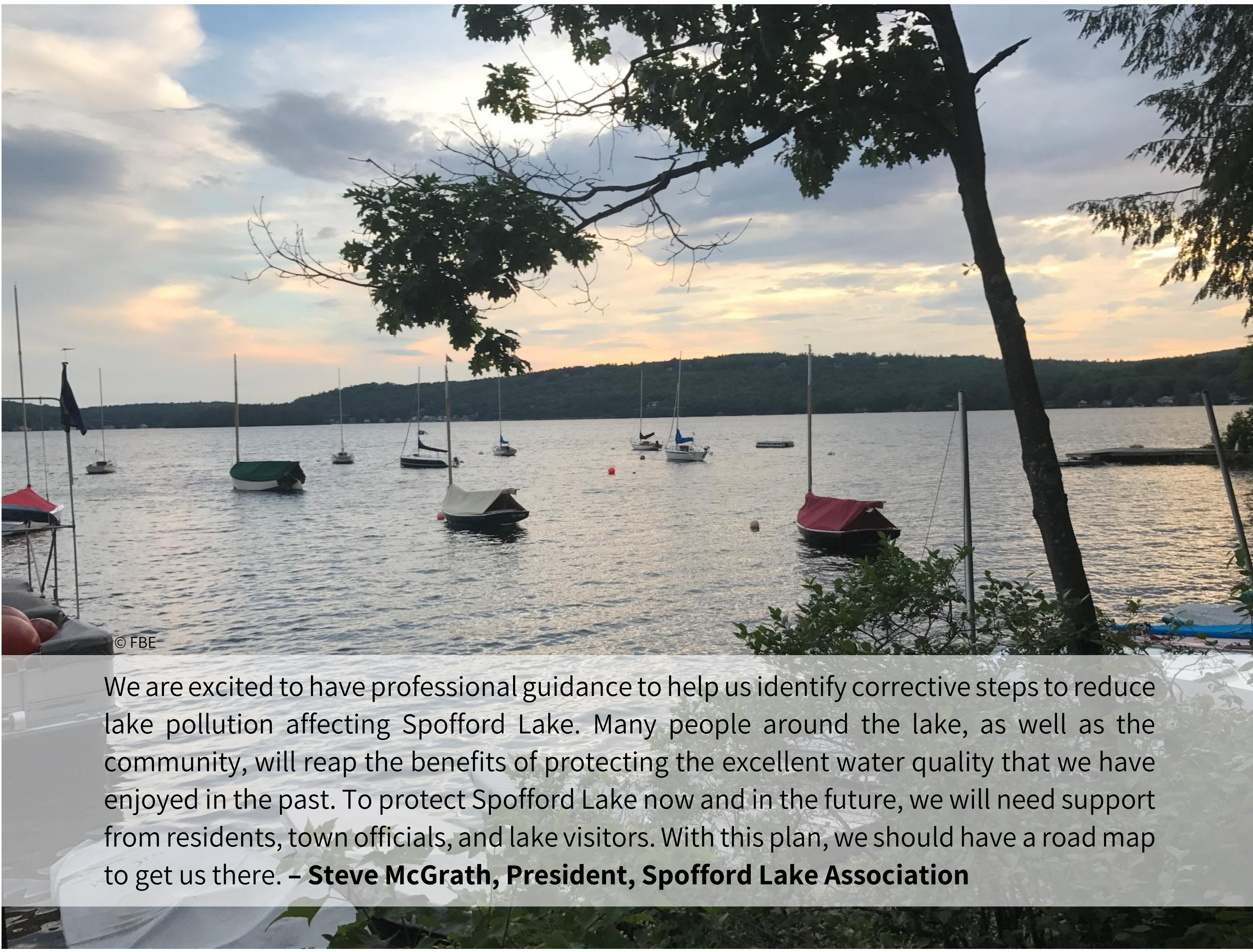
One **informational session** was held during a meeting of the Chesterfield Board of Selectmen.

- **August 22, 2018:** The Chesterfield Board of Selectmen Informational Session was held to provide information to residents on a variety of community-wide topics and projects. SWRPC attended the meeting and gave a presentation on the Spofford Lake watershed management plan. This reached a different audience than some of the other events and created additional interest in the project.

1.5 WATERSHED PROTECTION GROUPS

The SWRPC is one of New Hampshire's nine regional planning agencies established by RSA 36. The SWRPC covers a planning district made up of 34 towns and covering approximately 1,000 square miles of the southwest region of the state. Their mission is to "work in partnership with the communities of the Southwest Region to promote sound decision-making for the conservation and effective management of natural, cultural, and economic resources." This mission is accomplished through six major program areas: local planning assistance, natural resources planning, community and economic development, transportation planning, hazard mitigation planning, and regional and geographic information systems. The SWRPC is funded through municipal member dues, as well as federal, state, and local grants and contracts.

The SLA protects the natural resources and ecological conditions of Spofford Lake by supporting the Lake Host and Weed Watcher programs, along with water quality testing through the Volunteer Lake Assessment Program (VLAP). The Lake Host program is a courtesy boat inspection program implemented by NH LAKES in cooperation with volunteers. Lake Host volunteers monitor boats coming in and out of the lake to identify and prevent the introduction of invasive aquatic plants, such as variable milfoil. The Weed Watcher program uses trained volunteers assigned to areas of the lake to monitor monthly (May-September) for changes in weed growth and presence of invasive species. SLA also hires Solitude Environmental to complete annual weed inventories at the end of each season when invasive species are most evident. VLAP is a cooperative program between NHDES and lake associations that trains volunteers to collect lake and tributary water quality data.



We are excited to have professional guidance to help us identify corrective steps to reduce lake pollution affecting Spofford Lake. Many people around the lake, as well as the community, will reap the benefits of protecting the excellent water quality that we have enjoyed in the past. To protect Spofford Lake now and in the future, we will need support from residents, town officials, and lake visitors. With this plan, we should have a road map to get us there. **– Steve McGrath, President, Spofford Lake Association**

2. WATERSHED CHARACTERIZATION

This section provides information on the local climate, demographic history, past and present land cover, underlying soil and geographical characteristics, and habitat features in the Spofford Lake watershed.

2.1 POPULATION, GROWTH TRENDS, AND LAND COVER

2.1.1 DESCRIPTION, LOCATION, AND CLIMATE

The 3.9-square-mile (2,511-acre) Spofford Lake watershed is located entirely within the Town of Chesterfield, Cheshire County in southwestern New Hampshire (Appendix A, Map 1). From the outlet on the northeastern side of Spofford Lake (1.14 square miles, 736 acres), water flows 7.5 miles east then northwest via Partridge Brook to the Connecticut River, bordering New Hampshire and Vermont. The Spofford Lake watershed is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as severe thunder and lightning storms, hurricanes, and heavy snowfalls. The area experiences moderate to high rainfall and snowfall, averaging 42.6 inches of precipitation annually (data collected from 1950-2017 from the Keene, NH weather station; NCEI, 2018; Figure 2-1). Annual air temperature (from average monthly data) generally ranges from 10 °F to 74 °F with an average of 47 °F (NCEI, 2018).

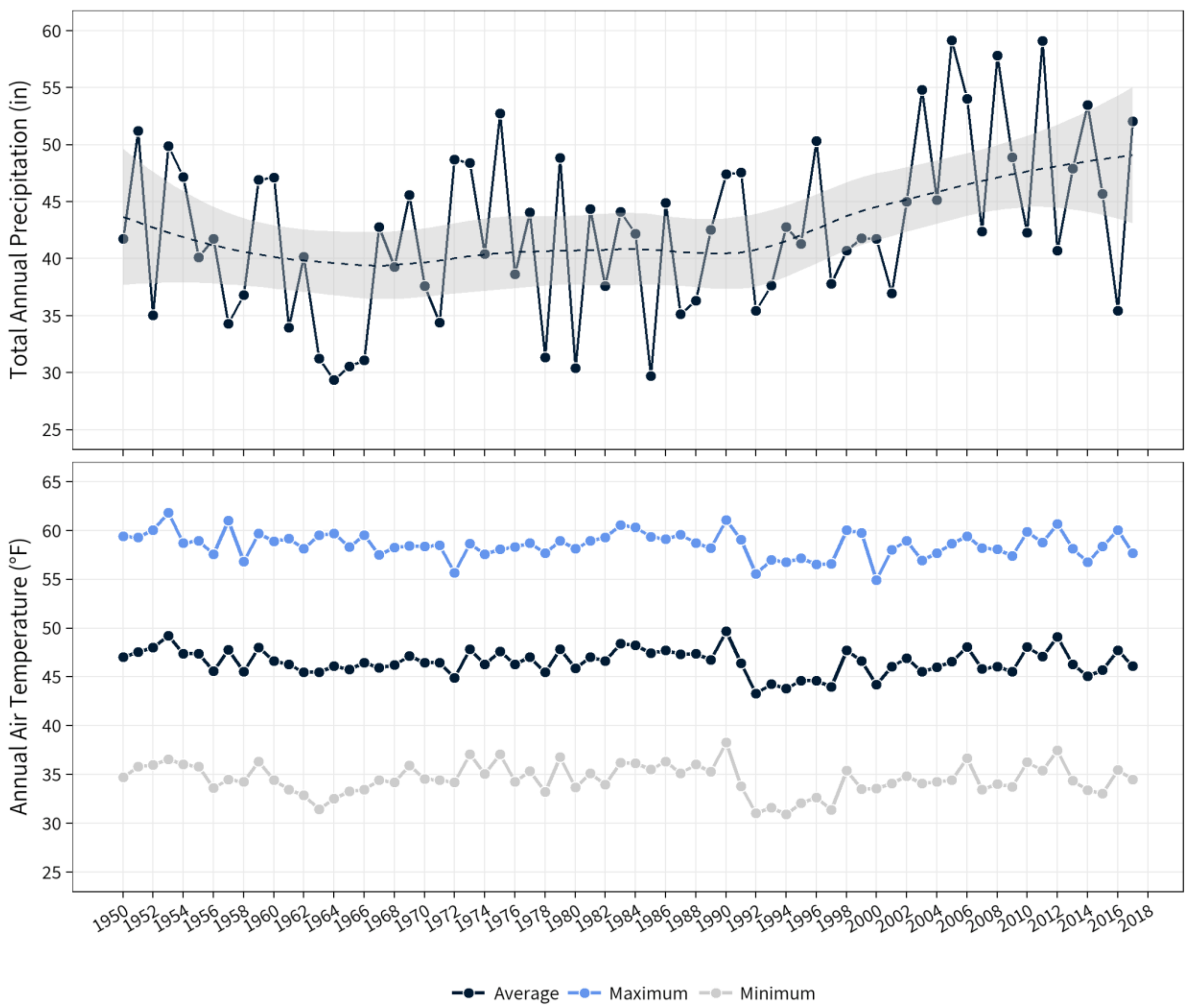


Figure 2-1. Total annual precipitation and annual max, average, and min of monthly air temperature from 1950-2017 for the Keene weather station (Station ID: USC00274399) with data gaps covered by weather stations in Fitzwilliam, NH (USC00273024), Marlow, NH (USC00275150), Peterborough, NH (USC00276697), and the Jaffrey Municipal Airport, NH (USW00054770). Dotted lines represent statistically significant trends. Gray shaded areas represent 95% confidence intervals around fitted trend.

2.1.2 POPULATION AND GROWTH TRENDS

Spofford Lake has been long treasured as a recreational haven for summer vacationers and year-round residents. The area is one of the oldest summer vacation spots in New Hampshire and offers lifeguarded beaches, fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, snowshoeing, and snowmobiling in the winter. According to the most recent U.S. Census (2010), most Chesterfield residents enjoy the natural beauty of the town year-round. In the 1960s, there were only ten year-round homes surrounding Spofford Lake; this number has now increased to about 200 year-round homes within the watershed (P. Walton, pers. comm.). Seasonal visitors continue to flock to the Spofford Lake watershed (from May to October, though historically from Memorial Day to Labor Day) to utilize various amenities around the lake, including private and public beaches, a town yacht club, a boat launch, a family camp, cottages, a public golf course, and a horsemanship farm. There is limited public transportation in the area, and most people use personal vehicles in their daily commute.

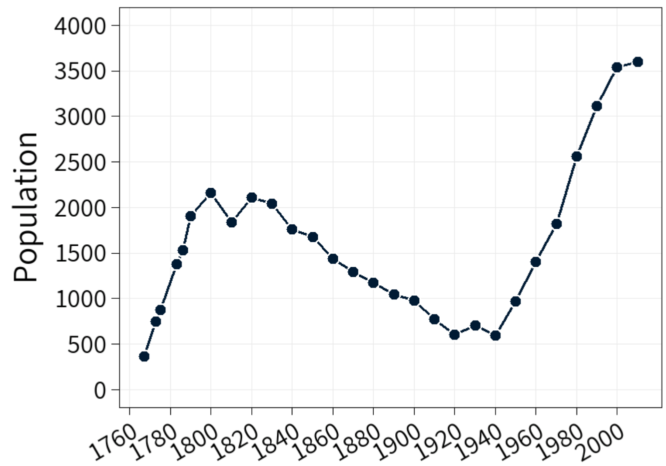


Figure 2-2. Historical demographic data for the Town of Chesterfield. The population of this community has grown dramatically over the last 60 years.

Understanding population growth and demographics, and ultimately development patterns, provide critical insight to watershed management, particularly as it pertains to lake water quality. According to the U.S. Census Bureau, the population of Chesterfield grew exponentially from 1940 to 2010 at an average rate of 430 residents every decade. From 2000 to 2010, the population of Chesterfield increased by only 1.8% (62 residents; NHOEP, 2011; Table 2-1, Figure 2-2). The desirability of Spofford Lake as a recreational destination will likely stimulate continued population growth in the future. Growth figures and estimates suggest that Chesterfield should 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 (refer to Section 3.3.3 for Build-Out Analysis results).

Table 2-1. Population growth rates for Cheshire County and the Town of Chesterfield.

CITY/TOWN	1960	1970	1980	1990	2000	2010	50-YR ANNUAL GROWTH RATE (1960-2010)	20-YR ANNUAL GROWTH RATE (1990-2010)	10-YR ANNUAL GROWTH RATE (2000-2010)
Cheshire County	43,342	52,364	62,116	70,121	73,825	77,117	1.56%	0.50%	0.45%
Chesterfield	1,405	1,817	2,561	3,112	3,542	3,604	3.13%	0.79%	0.18%

Most of the population of Chesterfield falls within the 20-64 age category. Residences in Chesterfield comprise a high percentage of owner-occupied homes (86%) compared to renter-occupied homes (14%; Table 2-2). Of the total occupied homes, 18% are seasonal (Table 2-2). However, the Spofford Lake watershed covers only 8% of the total land area within the Town of Chesterfield; thus, these demographic statistics likely do not reflect conditions specific to the Spofford Lake watershed, as lake communities have a more diverse mix of seasonal, renter, and year-round residences. A water quality survey conducted by SWRPC in September 2017 found that 55% of residents that responded (145 surveys, 47% return rate) were year-round, 31% were seasonal (2-5 months), and 14% were 3-seasons (6-8 months).

Table 2-2. 2010 population demographics for Cheshire County and the Town of Chesterfield.

State/County/Town	Total Pop	Aged 0-19	Aged 20-64	Aged 65+	Total Housing Units	Total Occ. Houses	Owner Occ. Houses[1]	Renter Occ. Houses[1]	Seasonal Houses[1]
Cheshire County	77,117	18,697	47,078	11,342	34,773	30,204	70%	30%	9%
Chesterfield	3,604	795	2,257	552	1,802	1,459	86%	14%	18%

[1]*Percentage of total occupied housing units*

2.1.3 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 lake via stormwater runoff and baseflow (see Section 3.3 on Watershed Modeling).

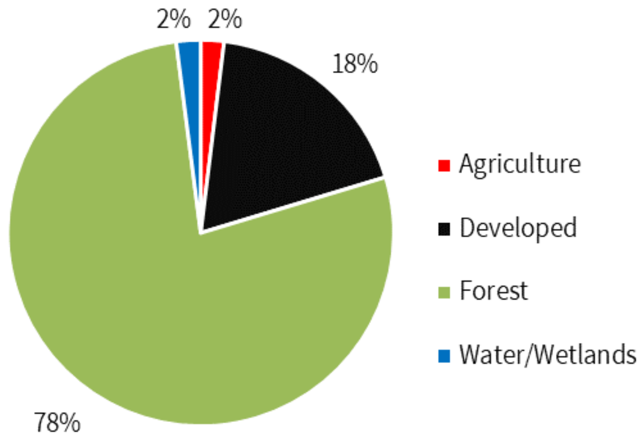
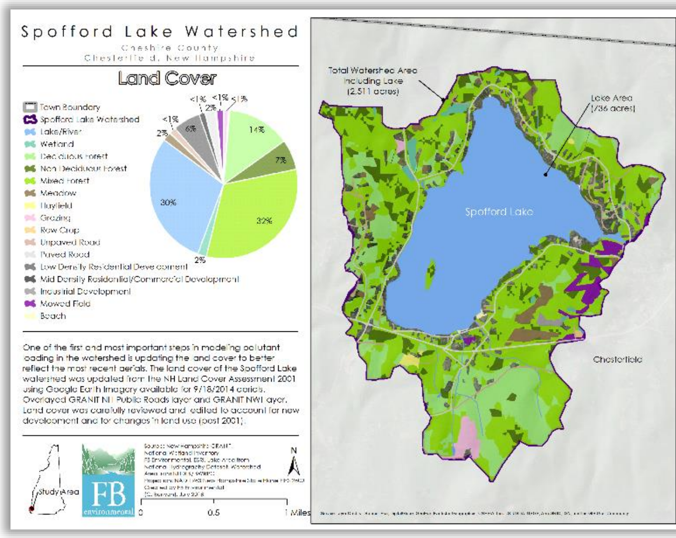


Figure 2-3. Watershed land cover in the Spofford Lake watershed. Does not include lake surface area.

Current land cover in the Spofford Lake watershed was determined using a combination of land cover data from NH GRANIT's New Hampshire Land Cover Assessment 2001 [NHLC01], National Wetlands Inventory (NWI) wetlands, National Hydrography Dataset (NHD) waterbodies, 2015 1-ft color aerial photos from NH GRANIT, and Google Earth satellite images from September 18, 2014. For more details on methodology, see the Spofford Lake - Lake Loading Response Model Report (FBE, 2018a).



Land cover within the Spofford Lake watershed is dominated by forest. Refer to Appendix A, Map 2.

The watershed has undergone significant changes since early European settlers came to the area around 1761. From 1810-1840, the outlet stream to Spofford Lake, known as Partridge Brook, was dammed at several locations to provide water power to factories and mills. The area became known as Factory Village and was located in the current High Street area of Chesterfield. By the late 1800's, the area began to support tourism and recreation as prominent hotels such as the Spofford House and the Prospect House were built. Tourists arrived by stage coach from the nearby train station and could enjoy a steam boat trip around the lake. More buildings, such as a boathouse with skating rink, a dining hall, and a lodging house, were built to accommodate the increasing numbers of tourists to the area.

Today, development accounts for 18% (132 acres) of the watershed, while forested areas dominate at 78% (558 acres) (Figure 2-3). Wetlands and open water represent 2% (15 acres) of the watershed, not including Spofford Lake. Agriculture represents 2% (14 acres) and includes row crops, hayfields, and grazing pastures. Developed areas within the Spofford Lake watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, and rooftops that force rain and snow that would otherwise soak into the ground to runoff as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals. The build-out analysis conducted for the watershed, coupled with projected population growth trends, indicates that the percentage of developed area will continue to increase. Therefore, it is imperative that watershed communities incorporate **low impact development** (LID) techniques into new development projects. More information on LID strategies and BMP implementation can be found in the Action Plan in Section 5.2.

2.1.4 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 lake water quality for future generations. Only 6.3 acres, (0.25%) of the Spofford Lake watershed have been classified as conservation land (Appendix A, Map 3). The largest parcel of conserved land within the watershed is Pierce

Island (5 acres). The Spofford Lake watershed also includes a small corner of the Pisgah State Park to the southeast. Land conservation in the Town of Chesterfield covers 24% of land area and includes the Pisgah State Park (4,694 acres), Madame Sherri Forest (484 acres), Wantastiquet Mountain Natural Area (471 acres), and the Friedsam Memorial Park (209 acres); all outside the watershed boundary of Spofford Lake.

2.2 PHYSICAL FEATURES

2.2.1 TOPOGRAPHY

The highest elevation in the watershed at 1,279 feet above sea level is located at the southernmost point of the watershed, just southeast from the Road's End Farm Horsemanship Camp. Spofford Lake and the direct shoreline drainage area are at approximately 713 feet above sea level. These elevation measurements were derived from Google Earth. Similar lake surface elevation measurements were found by NHDES at 716 feet above sea level (NHDES, 2017).

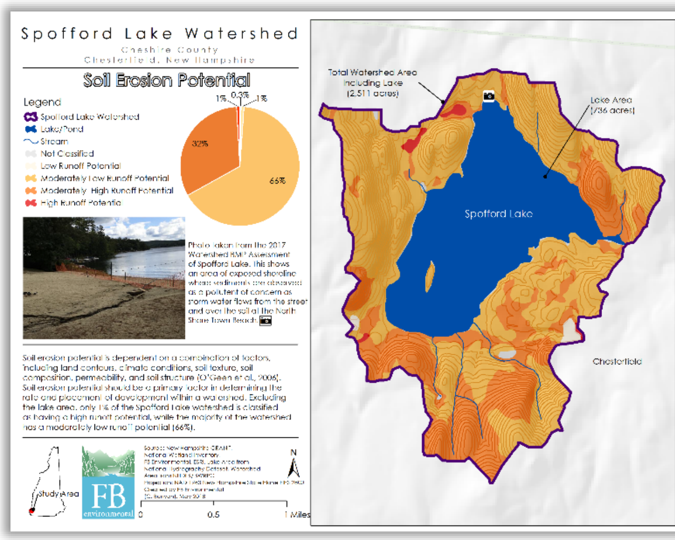
2.2.2 SOILS AND GEOLOGY

Surficial Geology

The composition of soils surrounding Spofford Lake 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 invading vegetation and meandering streams as the depression basins throughout the region began to fill with water (Goldthwait, 1951).

Soils

The soils in the Spofford Lake watershed (Appendix A, Map 4) are a direct result of geologic processes. The most prevalent soil group in the watershed is Cardigan-Kearsarge-Rock outcrop complex (523 acres, 25%), closely followed by Dutchess silt loam (361 acres, 18%) and Bernardston silt loam, very stony (326 acres, 13%). These soils are all classified with having moderately low to moderately high runoff potential and are comprised of well-drained, silty loam soil.



Moderately-high to high soil erosion potential areas cover 33% of the watershed. Refer to Appendix A, Map 5.

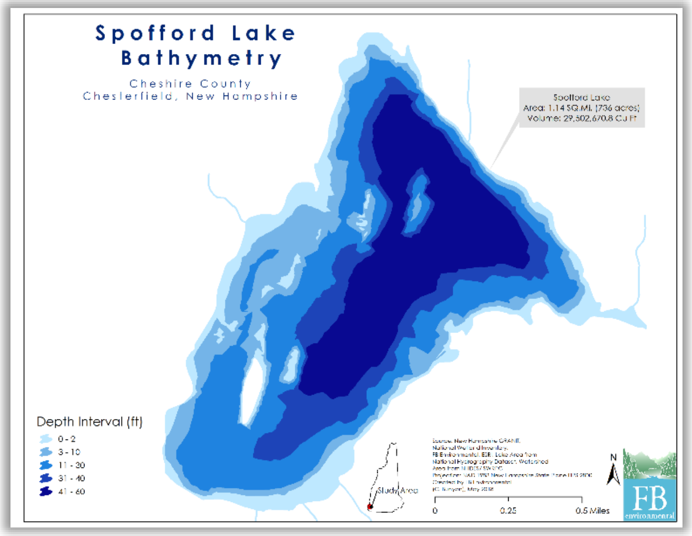
Soil Erosion Potential

Soil erosion potential 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 potential should be a primary factor in determining the rate and placement of development within a watershed. The soil erosion potential for the Spofford Lake watershed was determined from the soil hydrologic group (A-D), with group A soils having a low runoff potential (high infiltration and transmission rates with low runoff volume, typically deep, well-drained sands) and group D soils having a high runoff potential (low infiltration and transmission rates with high runoff volume, typically clay soils with a high water table.

Excluding the lake area, moderately-high and high soil erosion potential areas, which account for 33% of the watershed (589 acres), are concentrated mostly in the southwestern areas of the watershed on the northeastern steep slopes (Appendix A, Map 5). Low to moderately-low erosion potential areas, which account for 66% (1,185 acres) of the watershed, are found throughout most of the watershed. Development should be restricted in areas with highly erodible soils due 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 soil stability and function within the landscape, particularly from practices that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources.

2.2.3 LAKE MORPHOLOGY AND MORPHOMETRY

The morphology (shape) and bathymetry (depth) of lakes 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 Spofford Lake is 1.14 square miles (736 acres) with a mean depth of 30 feet (9.1 m) and a maximum depth of 66 feet (20.1 m) at the deep spot (NHDES, 2017; NH GRANIT bathymetry file, Appendix A, Map 6). There are 6.3 miles of shoreline, and the volume of Spofford Lake is 29,502,740 m^3 (this volume, calculated from NH GRANIT bathymetry file, is 13% larger than the 2017 VLAP report which estimates the volume at 26,020,500 m^3). The **areal water load** is 7.9 ft/yr (2.4 m/yr), and the flushing rate is 0.24 times per year (2017 VLAP report estimates 0.2). The low flushing rate of 0.24 means that the entire volume of Spofford Lake is replaced every 4 years, which greatly increases time for pollutants to settle in lake bottom sediments or be taken up by biota. Lake flushing rate and water level is impacted by a dam on Canal Street at the outlet to Spofford Lake, downstream of which begins Partridge Brook. The area just upstream of the dam was regularly dredged of accumulated sediment from 1851-1966, widening the outlet from 20 feet in width historically to 96 feet in width today (Bernier, 2013).



Bathymetry of Spofford Lake (NH GRANIT). Refer to Appendix A, Map 6.

2.2.4 HABITATS AND WILDLIFE

New Hampshire Fish and Game Department (NHFGD) 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, which serves as a blueprint for prioritizing conservation actions to protect Species of Greatest Conservation Need in New Hampshire. The Spofford Lake watershed is part of the Northern Connecticut River Valley ecoregional subsection (NFGD, 2015). Over 1,150 acres (46%) of the Spofford lake watershed are considered Highest Ranked Habitat in New Hampshire. This habitat includes Spofford Lake and a 200-meter buffer surrounding the lake. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map 3.

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 enjoy these rich forested resources include land and water mammals (deer, fox, raccoon, porcupine, chipmunks, squirrels, among many others), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, and birds (loons, gulls, ducks, turkeys, bald eagles, and song birds). Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Spofford Lake supports a diversity of both warmwater and coldwater fish species. These species include rainbow trout, small and largemouth bass, blueback herring, white and yellow perch, northern pike, rock bass, and rainbow smelt, among others. Long-time residents have noticed a decline in fish populations, with more tolerant species like northern pike becoming more prevalent compared to less tolerant, coldwater species like trout (P. Walton & B. Tracy, pers. comm.). Canada geese and ducks may also be more common today than 50 years ago, which may be contributing to an increased prevalence of swimmer's itch (P. Walton, pers. comm.).

2.3 INVASIVE SPECIES

The introduction of non-indigenous invasive aquatic plant species to New Hampshire's waterbodies has been on the rise. These invasive aquatic plants are responsible for habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, and high removal costs. Once established, invasive species are difficult and costly to remove.

Aquatic plants in Spofford Lake have been inventoried and monitored by the local volunteers through the Weed Watcher program, as well as professional contractors through Solitude Environmental (refer to Section 1.5 for more details). **As of 2018, no aquatic invasive species have been found.** All aquatic plant species have been identified as native to the region and have been found to suppress the success of invasive species due to prior establishment and resource dominance. Native species identified include Robbins pondweed, large leaf pondweed, tape grass, spike grass, pipewort, colonial algae, pickerel weed, water shield, thin leaved pondweed, along with apple snails and freshwater mussels. The volunteer-led Lake Host program continues to inspect boats entering and departing from Spofford Lake to prevent the possible introduction of invasive species. Although native, aquatic plants have been noted as increasing in recent years, particularly in the southern shallow areas of the lake. This may reflect increased nutrient loading from development in the watershed.

Spofford Lake is enjoyed by the community for a variety of recreational purposes. Photo Credit: SLA website.

3. ASSESSMENT OF WATER QUALITY

This section provides an overview of the water quality standards that apply to Spofford Lake, the methodology used to assess water quality, the past, current, and future state of water quality based on the modeling assessment, the established water quality goal and objectives, and the potential pollutant sources in the watershed.

3.1 APPLICABLE WATER QUALITY STANDARDS AND CRITERIA

The State of New Hampshire is required to follow federal regulations under the Clean Water Act (CWA) with some flexibility as to how those regulations are enacted. The main components of water quality regulations include designated uses, water quality criteria, and antidegradation provisions. The Federal CWA, the NH *RSA 485-A Water Pollution and Waste Control*, and the NH Surface Water Quality Regulations (Env-Wq 1700) are the regulatory bases for governing water quality protection in New Hampshire. These regulations form the basis for New Hampshire's regulatory and permitting programs related to surface waters. States are required to submit biennial water quality status reports to Congress via the USEPA. The reports provide an inventory of all waters assessed by the state and indicate which waterbodies exceed the state's water quality standards. These reports are commonly referred to as the "Section 303(d) list" and the "Section 305(b) report."

3.1.1 DESIGNATED USES & WATER QUALITY CLASSIFICATION

The 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 aquatic life, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife (Table 3-1). Surface waters can have multiple designated uses.

In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Env-Wq 1700). A brief description of these classes is provided in Table 3-2 (NHDES, 2016a). Water quality criteria are then developed to protect these designated uses. 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. Water quality criteria for lakes are discussed in Section 3.1.2. **Spofford Lake is considered a Class A waterbody.**

Table 3-1. Designated uses for New Hampshire surface waters (adapted from NHDES, 2016a).

Designated Use	NHDES Definition	Applicable Surface Waters
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated, and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply After Adequate Treatment	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the **riparian corridor** to support wildlife as well as aquatic life.	All surface waters

Table 3-2. New Hampshire surface water classifications.

Classification	Description (RSA 485-A:8)
Class A	Class A waters shall be of the highest quality. There shall be no discharge of any sewage or wastes into waters of this classification. The waters of this classification shall be considered as being potentially acceptable for water supply uses after adequate treatment.
Class B	Class B waters shall be of the second highest quality. The waters of this classification shall be considered as being acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as water supplies.

3.1.2 LAKE WATER QUALITY CRITERIA

New Hampshire's water quality standards provide a baseline measure of water quality that surface waters must meet to support designated uses. Water quality standards are the "yardstick" for identifying water quality exceedances and for determining the effectiveness of state regulatory pollution control and prevention programs. Water quality criteria are designed to protect those designated uses. To determine if a waterbody is meeting its designated uses, water quality thresholds for various water quality parameters (e.g., **chlorophyll-a**, **total phosphorus**, **dissolved oxygen**, **pH**, and toxics) are applied to the water quality data. If a waterbody meets or is better than the water quality criteria, the designated use is supported. If the waterbody does not meet water quality criteria, it is considered impaired for the designated use.

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. Aquatic Life Use (ALU) and Primary Contact Recreation (PCR) are the two major uses for Spofford Lake, with ALU being the focus of the watershed management plan.

Aquatic Life Use (ALU)

Criteria for ALU ensure that waters provide suitable habitat for the survival and reproduction of desirable fish, shellfish, and other aquatic organisms. For ALU assessment, the state has narrative nutrient criteria with a numeric translator or threshold, consisting of a "nutrient indicator" or total phosphorus and a "response indicator" or chlorophyll-a (see also: Env-Wq 1703.03, Env-Wq 1703.04, Env-Wq 1703.14, and Env-Wq 1703.19). The nutrient and response indicators are intricately linked since increased phosphorus loading frequently results in greater algal concentrations, which can be estimated by measuring chlorophyll-a levels in the lake. More algae may lead to decreased oxygen at the bottom of the lake, decreased water clarity, and possibly changes in aquatic species composition.

As shown in Table 3-3, ALU criteria vary by lake trophic state, since each trophic state has a certain algal biomass (chlorophyll-a) that represents a balanced, integrated, and adaptive community. Exceedances of the chlorophyll-a criterion suggests that the algal community is out of balance. Since phosphorus is the primary limiting nutrient for growth of freshwater algae (chlorophyll-a), phosphorus is included in this assessment process. For ALU assessment, phosphorus and chlorophyll-a are combined per the decision matrix presented in Table 3-4. The chlorophyll-a concentration will dictate the assessment if both chlorophyll-a and phosphorus data are available and the assessments differ.

Dissolved oxygen is also used as an indicator for ALU assessment and is critical to the balanced, integrative, and adaptive community of organisms (see Env-Wq 1703.19). For Class A waters, non-support use determinations are based on a daily average measurement of 75% dissolved oxygen saturation or less and an instantaneous dissolved oxygen measurement of 6 ppm or less, which apply to any depth in a vertical profile (except within 1 meter of lake bottom) collected from June 1 to September 30 (see Env-Wq 1703.07).

From 1974-2010, 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 Spofford Lake, the trophic state was determined to be oligotrophic during all four surveys (1976-7, 1988-9, 1995-6, 2003). This means that in-lake water quality was consistent with the standards for oligotrophic lakes.

Table 3-3. Aquatic life use (ALU) 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 3-4. Decision matrix for aquatic life use (ALU) 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

3.1.3 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.

3.2 WATER QUALITY SUMMARY

3.2.1 STUDY DESIGN AND DATA ACQUISITION

Water quality monitoring data was accessed through the NHDES Environmental Monitoring Database (EMD) and analyzed by FBE for several key water quality parameters, including total phosphorus, chlorophyll-a, **Secchi disk transparency**, dissolved oxygen, temperature, **chloride**, and **specific conductance**. All data used in this analysis were collected by trained volunteer monitors through the NHDES VLAP and validated as final by NHDES. The analysis included statistical analysis of historical water quality trends, determination of median/mean in-lake water quality, and modeling of the assimilative capacity for Spofford Lake. Detailed descriptions of analysis methods and assessment of water quality parameters can be found in the Spofford Lake Water Quality Analysis (FBE, 2018b).

3.2.2 TOTAL PHOSPHORUS, CHLOROPHYLL-A, AND SECCHI DISK TRANSPARENCY

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. 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.

Since 1977, total phosphorus in the **epilimnion** (collected 3 meters below the surface) of Spofford Lake has ranged from 1.0 to 16.0 ppb, with an all monthly data median of 5.2 ppb (Table 3-5; Figure 3-1). In the last 10 years, total phosphorus in Spofford Lake has ranged from 2.5 to 13.0 ppb, with a monthly data median of 5.3 ppb (i.e., the Existing Median Water Quality applied to the assimilative capacity analysis). Spofford Lake has low phosphorus compared to average phosphorus levels in New Hampshire lakes and has shown no statistically-significant trend over the sampling record or in recent years. Total phosphorus measured in the **metalimnion** and hypolimnion are progressively higher than in the epilimnion; total phosphorus in the hypolimnion showed a statistically significant degrading (worsening) trend historically from 1977-2007, but no trend in recent years.

Since 1977, chlorophyll-a in Spofford Lake has ranged from 0.2 to 8.5 ppb, with an all monthly data median of 1.7 ppb (Table 3-5; Figure 3-1). In the last 10 years, chlorophyll-a in Spofford Lake has ranged from 0.8 to 4.8 ppb, with a monthly data median of 1.6 ppb (i.e., the Existing Median Water Quality applied to the assimilative capacity analysis). Spofford Lake has low chlorophyll-a compared to average chlorophyll-a levels in New Hampshire lakes and has shown a possible improving trend over the sampling record, but no statistically-significant trend in recent years.

Since 1977, Secchi disk transparency (without a scope) in Spofford Lake has ranged from 5.5 to 12.5 m, with an all monthly data median of 8.5 m (Table 3-5; Figure 3-1). In the last 10 years, Secchi disk transparency (without a scope) in Spofford Lake has ranged from 5.5 to 10.6 m, with a monthly data median of 8.1 m. Since 2006, Secchi disk transparency has also been measured with a scope; these readings were separated from readings taken without a scope because readings with a scope are significantly deeper than readings without a scope. The recent 10-year median Secchi disk transparency for readings taken with a scope is 9.4 m. Spofford Lake has deep water clarity compared to average water clarity in New Hampshire lakes and has shown no statistically-significant trend over the sampling record or in recent years. Moderate inter-annual variability in Secchi disk transparency likely reflects year-to-year weather influences. Wetter years may increase the amount of sediment delivered to the lake and cause lower Secchi disk transparency readings.

Table 3-5. Summary statistics for total phosphorus (TP) in the epilimnion, metalimnion, and hypolimnion (discrete grab samples at mid-layer depth), chlorophyll-a (Chl-a) in the metalimnion (composite sample of multiple depths), and Secchi disk transparency (SDT) with and without a viewscope for Spofford Lake, based on seasonal (May 24 – Sept 15) samples. NA = not enough data for Mann-Kendall (M-K) trend analysis, y = years (used in M-K analysis), n = total number of monthly sampling events (used in summary statistics).

TP - EPILIMNION	**n**	**Mean (ppb)**	**Median (ppb)**	**Min. (ppb)**	**Max. (ppb)**	**MK Score**	**Trend**
All Years (y = 30)	86	5.94	5.15	1.00	16.00	-26	No trend
Historic (1976-2007, y = 20)	56	6.33	5.00	1.00	16.00	19	No trend
Recent (2008-2017, y = 10)	30	5.22	5.33	2.50	13.00	-17	No trend
TP - METALIMNION	**n**	**Mean (ppb)**	**Median (ppb)**	**Min. (ppb)**	**Max. (ppb)**	**MK Score**	**Trend**
All Years (y = 30)	86	7.41	7.00	1.00	21.00	89	No trend
Historic (1976-2007, y = 20)	56	7.26	7.00	1.00	21.00	37	No trend
Recent (2008-2017, y = 10)	30	7.70	7.53	2.50	11.20	-13	No trend
TP - HYPOLIMNION	**n**	**Mean (ppb)**	**Median (ppb)**	**Min. (ppb)**	**Max. (ppb)**	**MK Score**	**Trend**
All Years (y = 30)	85	17.39	14.50	2.50	66.00	92	No trend
Historic (1976-2007, y = 20)	55	16.34	14.00	2.50	39.00	63	Worsened
Recent (2008-2017, y = 10)	30	19.33	16.75	7.64	66.00	-11	No trend
Chl-a	**n**	**Mean (ppb)**	**Median (ppb)**	**Min. (ppb)**	**Max. (ppb)**	**MK Score**	**Trend**
All Years (y = 30)	87	1.97	1.73	0.17	8.49	-117	Improving
Historic (1977-2007, y = 20)	56	2.14	1.81	0.17	8.49	12	No trend
Recent (2008-2017, y = 10)	31	1.67	1.58	0.75	4.81	-15	No trend
SDT (Viewscope)	**n**	**Mean (m)**	**Median (m)**	**Min. (m)**	**Max. (m)**	**MK Score**	**Trend**
All Years (y = 12)	32	9.33	9.33	7.10	11.40	14	No trend
Historic (2006-2007, y = 2)	3	8.96	8.63	7.50	10.75	NA	NA
Recent (2008-2017, y = 10)	29	9.37	9.40	7.10	11.40	7	No trend
SDT (No Viewscope)	**n**	**Mean (m)**	**Median (m)**	**Min. (m)**	**Max. (m)**	**MK Score**	**Trend**
All Years (y = 30)	86	8.48	8.50	5.50	12.50	-61	No trend
Historic (1977-2007, y = 20)	56	8.67	8.50	5.80	12.50	4	No trend
Recent (2008-2017, y = 10)	30	8.13	8.10	5.50	10.60	13	No trend

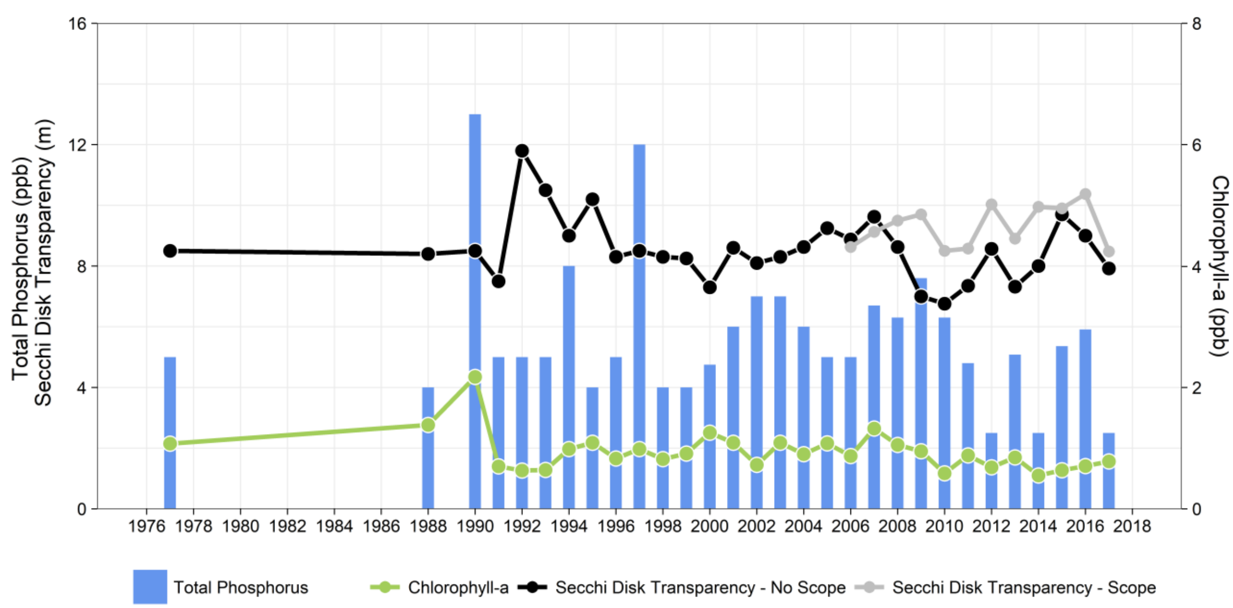


Figure 3-1. Annual median of monthly, seasonal (May 24-Sept 15) water quality data for total phosphorus (epilimnion), chlorophyll-a, and Secchi disk transparency (with and without a scope) for Spofford Lake from 1977-2017.

3.2.3 TEMPERATURE AND DISSOLVED OXYGEN

A common phenomenon for New England lakes is the depletion of dissolved oxygen in bottom waters throughout the summer months. This occurs when **thermal stratification** prevents warmer, oxygenated surface waters from mixing with cooler, oxygen-depleted bottom waters in a lake. Dissolved oxygen concentrations can change dramatically with lake depth as oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis) and oxygen is consumed near the bottom of a lake (where organic matter accumulates and decomposes). Dissolved oxygen levels below 5-6 ppm (and water temperatures above 24 °C) can stress and reduce habitat for cold-water fish and other sensitive aquatic organisms. The minimum water quality criterion is 6 ppm dissolved oxygen for Class A waters. In addition, **anoxia** (low dissolved oxygen) at lake bottom can result in the release of sediment-bound phosphorus (otherwise known as **internal phosphorus loading**), which becomes a readily available food source for algae. While thermal stratification and depletion of oxygen in bottom waters are natural phenomena, it is important to keep tracking these parameters to make sure the extent and duration of low oxygen are not exacerbated by human activities and do not inhibit aquatic life use.

Dissolved oxygen and temperature profiles from the deep spot of Spofford Lake show midsummer thermal stratification, with high dissolved oxygen and warm water temperatures near the surface followed by a marked decrease in temperature and dissolved oxygen below the metalimnion (i.e., **thermocline**) around 10-12 m below the surface (Figure 3-2). Spofford Lake's dissolved oxygen profiles also show metalimnion maxima (i.e., supersaturation or dissolved oxygen greater than 10 ppm) around 8-12 m below the surface (Figure 3-2). Free-floating phytoplankton (e.g., algae) can settle just above the metalimnion where sunlight is still plentiful, nutrients are rich, and the organisms are neutrally buoyant with the thermo-density stratification of water.

Low levels of oxygen (<6 ppm) in the hypolimnion (e.g., bottom waters), especially below 15 m, are common in Spofford Lake (Figure 3-2). Overall, about 53% and 62% of the lake volume in mid to late summer does not meet the Class A criteria of 6 ppm and 75% dissolved oxygen for the protection of aquatic life, respectively. Extremely low dissolved oxygen (anoxia, <1 ppm) in the hypolimnion is likely triggering a release of phosphorus from lake sediments, also known as internal loading, given that hypolimnion total phosphorus in Spofford Lake is significantly higher than epilimnion total phosphorus (Figure 3-2). When thermal stratification of the lake breaks down in the fall, these phosphorus-rich waters are mixed and re-distributed throughout the rest of the water column (a.k.a., **fall turnover**), which can stimulate algae and/or **cyanobacteria** growth for the next season. The dissolved oxygen impairment at Spofford Lake (despite low in-lake epilimnion total phosphorus) is likely driven by high **sediment oxygen demand** because of excess organic matter loading from legacy human activities (e.g., logging, farming) or current shoreline erosion (see Section 3.5).

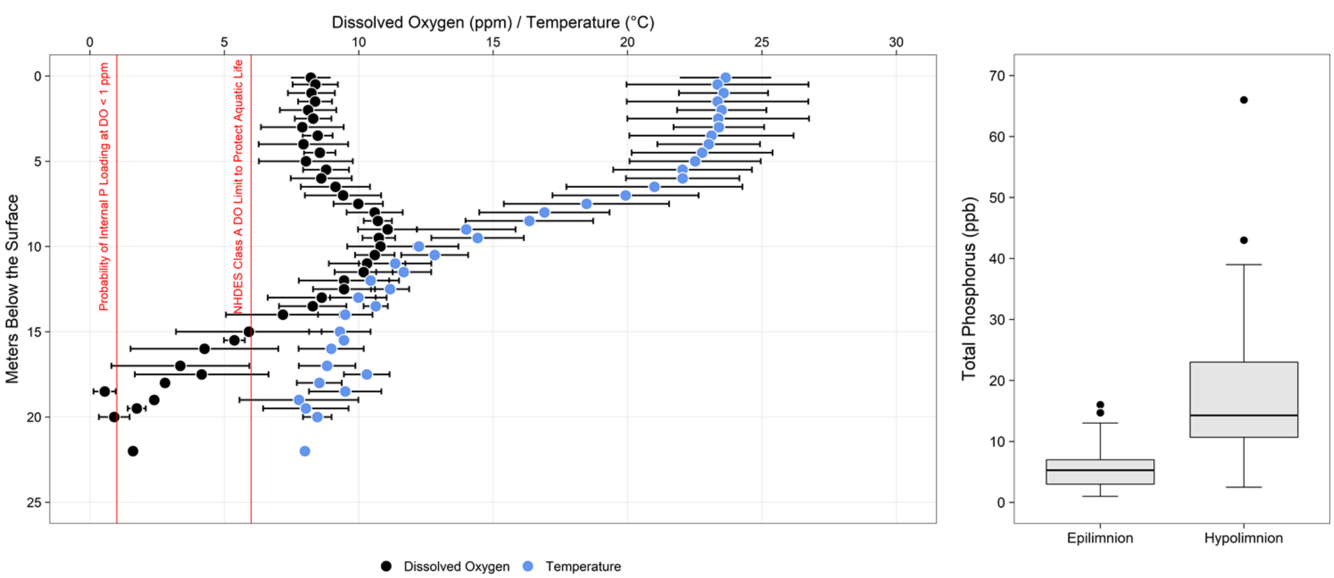


Figure 3-2. LEFT: Average dissolved oxygen and temperature profile of the deep spot of Spofford Lake. Error bars represent standard deviation or spread of the data at each depth interval. **RIGHT:** Summary of data distribution for total phosphorus samples collected from the epilimnion and hypolimnion of the deep spot of Spofford Lake. The top and bottom of the gray area in each boxplot represent the 75th and 25th percentiles of the data, respectively. The solid horizontal line in each box

represents the median or 50th percentile of the data. The top and bottom whiskers represent the maximum and minimum non-outliers of the data, respectively. Any points above or below the whiskers are outliers, defined as 1.5 times the interquartile range (or the width of the gray box). Total phosphorus concentrations in the hypolimnion are significantly higher than total phosphorus concentrations in the epilimnion, suggesting that internal phosphorus loading (stimulated by anoxia in bottom waters that releases sediment-bound phosphorus) is a concern for Spofford Lake.

3.2.4 CHLORIDE & SPECIFIC CONDUCTIVITY

Specific conductivity and chloride levels in Spofford Lake and its tributaries are elevated for a high-quality lake, giving rise to concern that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lake. Chloride pollution can cause harm to aquatic organisms when chloride concentrations reach toxic levels. The State of New Hampshire sets a chronic threshold of 230 ppm for chloride (which roughly equates to 835 µS/cm for specific conductivity). Although chloride concentrations in Spofford Lake remain well below the chronic threshold, chloride and specific conductivity (a surrogate measure for chloride) are elevated for a high-quality lake (most New Hampshire lakes are around 4 ppm or 40 µS/cm). Specific conductivity also shows a statistically significant increase (degradation) over the record from 1977-2017, with some interannual variation that may correspond to “wet” or “dry” years (Figure 3-3).

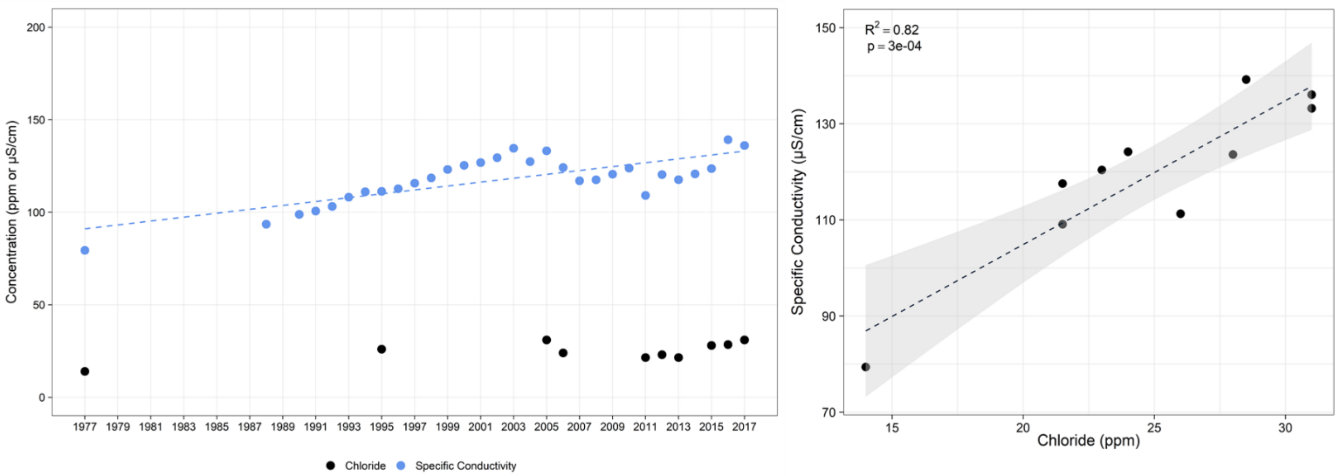


Figure 3-3. LEFT: Yearly median of monthly medians for chloride and specific conductivity in the deep spot of Spofford Lake. Dashed line indicates a statistically significant increasing (degrading) trend in specific conductivity. There are not enough data to assess a similar trend in chloride, but chloride is likely driving the trend in specific conductivity. **RIGHT:** Chloride and specific conductivity are positively correlated; chloride accounts for 82% of the variation in specific conductivity. Dashed line (and gray 95% confidence intervals) indicates a statistically significant linear correlation.

3.2.5 TRIBUTARY WATER QUALITY ANALYSIS

Several small tributaries feed into Spofford Lake and contribute to the lake’s water quality. Elevated total phosphorus has been measured at LaChance Inlet and Seamans Inlet, as well as at Clarkdale Pipe and Camp Spofford Inlet (FBE, 2018b; NHDES, 2017). Elevated turbidity was also measured at LaChance Inlet and Seamans Inlet following a large storm event in August 2017, suggesting that phosphorus-laden, eroding sediment is impacting these sites and the lake (FBE, 2018b; NHDES, 2017). Similarly, elevated chloride and/or specific conductivity have been measured at Seamans Inlet and Rt. 63 #1, as well as at Clarkdale Pipe, Silverdale Inlet, and Camp Spofford Inlet (NHDES, 2017). Seamans Inlet exceeded the chronic threshold for chloride in July 2017. **LaChance Inlet, Seamans Inlet, Clarkdale Pipe, Camp Spofford Inlet, Silverdale Inlet, and Rt. 63 #1 should be prioritized for future monitoring and land use investigation of potential NPS pollution issues.**

3.3 WATERSHED MODELING

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 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. USEPA guidelines for watershed plans require that both the assimilative capacity of the waterbody and pollutant loads from the watershed be estimated.

3.3.1 ASSIMILATIVE CAPACITY

A lake receives natural and human-derived inputs of nutrients, such as phosphorus, in runoff or groundwater inputs from its watershed. This phosphorus can be taken up by aquatic life within the lake, settle in the bottom sediments, or flow out of the lake to downstream waterbodies. In this sense, there is a natural balance between the amount of phosphorus flowing in and out of a lake system, also known as the ability of a lake to "assimilate" phosphorus. The assimilative capacity is based on factors such as lake volume, watershed area, precipitation, and runoff/baseflow export coefficients. If a lake is receiving more phosphorus from the watershed than it can assimilate, then its water quality will decline over time as algae or cyanobacteria blooms become more frequent. Decomposition of accumulated organic matter from dead algae or cyanobacteria and plants can result in anoxia in bottom waters, which can release phosphorus back into the water column (i.e., internal loading) as food for cyanobacteria, algae, and plants and can also be lethal to fish and other aquatic organisms.

The assimilative capacity analysis, including calculations for total assimilative capacity, reserve assimilative capacity, and remaining assimilative capacity, were conducted in accordance with the Standard Operating Procedure for Assimilative Capacity Analysis for New Hampshire Waters (Appendix B in the NHDES Guidance for Developing Watershed Management Plans in New Hampshire for Section 319 Nonpoint Source Grant Program Project, revised April 14, 2010).

For New Hampshire waters, water quality thresholds used in assimilative capacity analyses are based on a waterbody's trophic class. The trophic class for Spofford Lake is oligotrophic. For oligotrophic waterbodies, the nutrient indicator (phosphorus) threshold is 8.0 ppb and the response indicator (chlorophyll-a) threshold is 3.3 ppb. NHDES recommends 10% of the water quality threshold be kept in reserve; therefore, the Existing Median Water Quality should remain below 7.2 ppb for total phosphorus and below 3.0 ppb for chlorophyll-a to be in the Tier 2 High Quality Water category for an oligotrophic waterbody.

Results of the assimilative capacity analysis for Spofford Lake (Deep Spot – SPOCHED) show that Spofford Lake is Tier 2 for high quality waters (for both total phosphorus and chlorophyll-a assessments; Table 3-6). Tier 2 waters have one or more water quality parameters that are better than the water quality standard and that also exhibit a reserve capacity of at least 10% of the waterbody's total assimilative capacity. Both total phosphorus and chlorophyll-a in Spofford Lake are well within the NHDES ALU criteria for oligotrophic lakes and reflect excellent water quality.

Table 3-6. Assimilative capacity (AC) analysis results for Spofford Lake (Deep Spot – SPOCHED).

Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)	Remaining AC (ppb)	Analysis Results
Total Phosphorus	7.2	5.3	+1.9	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.6	+1.4	Tier 2 (High Quality)

3.3.2 LAKE LOADING RESPONSE MODEL (LLRM) RESULTS

A second analysis was used to link watershed loading conditions with in-lake total phosphorus and chlorophyll-a concentrations to predict past, current, and future water quality in Spofford Lake. An Excel-based model, known as the Lake Loading Response Model (LLRM), was used to develop a water and phosphorus loading budget for the lake and its tributaries by using environmental data. 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 land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and internal phosphorus loading, combined with many coefficients and equations from scientific literature on lakes and nutrient cycling. The outcome of this model can be used to identify current and future pollution sources, estimate pollution limits and water quality goals, and guide watershed improvement projects.

The direct shoreline area to Spofford Lake had the highest phosphorus export by total mass, followed distantly by Camp Spofford Inlet and Wares Grove Inlet (Table 3-7). Drainage areas directly adjacent to waterbodies do not have adequate treatment time and are usually targeted for development, thus increasing the possibility for phosphorus export. Normalizing for the size of a tributary (i.e., accounting for its annual discharge and contributing drainage area) better highlights sub-basins with elevated pollutant exports relative to their drainage area. Sub-basins with moderate-to-high phosphorus mass exported by area (> 0.1 kg/ha/yr) generally had more development or agriculture (i.e., all sub-basins except 290 North Shore Rd, Rt. 63 #3, and Shield Inlet; refer to Appendix A, Map 7). Camp Spofford Inlet had the highest phosphorus mass exported by area. One sub-basin (Silverdale Inlet) did not have a predicted phosphorus concentration that matched well with the measured phosphorus concentration, likely due to limited data (n=3). More data are needed to better adjust the coefficients and attenuation factors used for those sub-basins.

Table 3-7. Summary of pre-development, current (2017), and future (2162) watershed total phosphorus (TP) loads by sub-basin to Spofford Lake.

			Watershed Load					
			Pre-Development		Current (2017)		Future (2162)	
Sub-Basin	Land Area (ha)	Water Flow (m^3/year)	TP Load (kg/yr)	TP Load (kg/ha/yr)	TP Load (kg/yr)	TP Load (kg/ha/yr)	TP Load (kg/yr)	TP Load (kg/ha/yr)
Camp Spofford Inlet	65.7	455,159	2.0	0.03	18.8	0.29	22.9	0.35
Clarkdale Pipe	27.7	193,618	0.8	0.03	3.8	0.14	6.4	0.23
Direct Shoreline	247.3	1,704,290	8.7	0.04	52.9	0.21	76.4	0.31
290 North Shore Rd	21.5	149,579	0.7	0.03	1.7	0.08	3.2	0.15
RT.63 #3	91.7	632,035	3.0	0.03	8.9	0.10	10.2	0.11
Seamans Inlet	30.3	211,915	0.9	0.03	3.6	0.12	5.8	0.19
Shield Inlet	33.0	229,173	0.9	0.03	3.0	0.09	7.8	0.24
Silverdale Inlet	15.7	109,279	0.5	0.03	3.1	0.20	4.1	0.26
Unknown Trib Drainage	39.6	274,819	1.2	0.03	6.0	0.15	8.9	0.23
Wares Grove Inlet	146.9	1,019,247	5.5	0.04	16.1	0.11	25.0	0.17

Overall, watershed runoff and baseflow (50%) was the largest loading contribution across all sources to Spofford Lake, followed by atmospheric deposition (25%), septic systems (15%), internal loading (6%), and waterfowl (4%) (Table 3-8). Relatively higher phosphorus loading from the watershed and atmosphere were expected given the small watershed area (compared to lake surface area) and the short hydrologic residence time from land cover types in the watershed to the lake. Development in the watershed is most heavily concentrated 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. The septic system loading estimate was likely underestimated, given the potential bias of survey respondents to seasonal residences on newer systems (<20 years old).

Internal loading is also a concern for Spofford Lake given that low dissolved oxygen in bottom waters is causing a significant release of phosphorus from bottom sediments (as evidenced by the large difference between bottom and surface phosphorus concentrations (13.9 ppb)). Spofford Lake's low flushing rate and high settling rate may further exacerbate internal loading as both the duration of anoxia and the residence time for nutrients are prolonged.

Table 3-8. Total phosphorus (TP) and water loading summary by source and scenario (pre-development, current, and future).

SOURCE	PRE-DEVELOPMENT			CURRENT			FUTURE (2162)		
	P (KG/YR)	%	WATER (CU.M/YR)	P (KG/YR)	%	WATER (CU.M/YR)	P (KG/YR)	%	WATER (CU.M/YR)
ATMOSPHERIC	33	50%	2,113,520	59	25%	2,113,520	89	27%	2,113,520
INTERNAL	0	0%	0	14	6%	0	18	5%	0
WATERFOWL	9	13%	0	9	4%	0	9	3%	0
SEPTIC SYSTEM	0	0%	0	36	15%	32,572	47	14%	42,242
WATERSHED LOAD	24	37%	5,008,312	118	50%	4,979,114	171	51%	4,957,538
TOTAL LOAD TO LAKE	**66**	**100%**	**7,121,832**	**236**	**100%**	**7,125,206**	**334**	**100%**	**7,113,301**

The model predicted within 4% (relative percent difference) of observed median total phosphorus, within 9% of observed mean chlorophyll-a, and within 54% of mean Secchi disk transparency (Table 3-9). Predicted and observed total phosphorus and chlorophyll-a were in good agreement. It is important to note that the LLRM does not fully account for all the biogeochemical processes occurring within the lake that contribute to the overall water quality condition and is less accurate at predicting chlorophyll-a and Secchi disk transparency than total phosphorus. For example, chlorophyll-a is estimated strictly from nutrient loading, but other factors strongly affect algae growth, including 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.

Table 3-9. In-lake water quality predictions for Spofford Lake. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency.

Scenario	Median TP (ppb)	Predicted Median TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)
Pre-Development	--	1.9	--	0.1	--	13.8
Current (2017)	5.3 (6.4)	6.6	1.7	1.8	9.4	5.4
Future (2162)	--	9.9	--	3.1	--	4.0

Median TP concentration of 5.3 represents existing in-lake epilimnion TP from observed data. Median TP concentration of 6.4 represents 20% greater than actual median values 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.

Based on model analysis of pre-development, current, and future water quality conditions, Spofford Lake is at risk for water quality degradation from future development under current zoning constraints. Additional phosphorus loading from the watershed and internal sediments will likely accelerate water quality degradation of the lake. Using the maximum oligotrophic limit for chlorophyll-a at 3.3 ppb as a guide for surpassing favorable water quality conditions (per NHDES), it appears that Spofford Lake's possible "at-risk" threshold for total phosphorus ranges from 6.5-11.5 ppb, which will be met under the predicted future loading scenario (Figure 3-4). Given Spofford Lake's recreational and aquatic habitat value in the region, it will be crucial to both maximize land conservation of intact forestland and consider zoning ordinance amendments that encourage LID techniques on existing and new development. Specific recommendations for protecting the water quality of Spofford Lake are provided in Section 5.2. Refer to FBE (2018a) for the full modeling report.

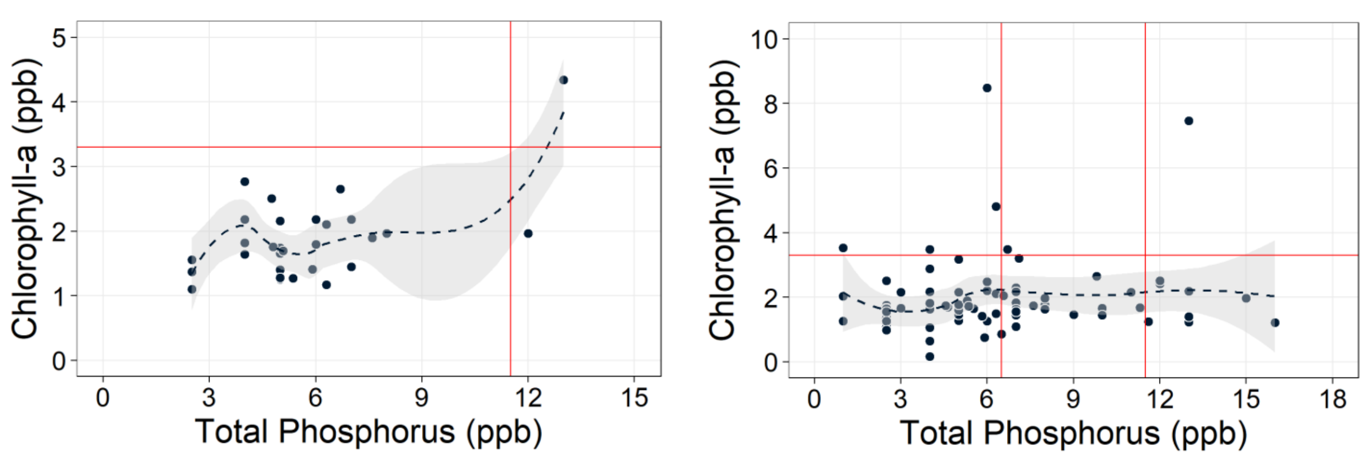


Figure 3-4. Chlorophyll-a (measure of algae) generally increases in response to higher in-lake total phosphorus concentration. The relationship between chlorophyll-a and total phosphorus in Spofford Lake for yearly data (left panel) and monthly data (right panel) shows a possible threshold of chlorophyll-a response (set at the upper oligotrophic limit of 3.3 ppb) at 6.5-11.5 ppb for total phosphorus. Gray shaded areas show confidence intervals around locally-weighted regression. Chlorophyll-a response to phosphorus is weak at Spofford Lake, suggesting that other factors may more strongly control (i.e., limit) productivity in the lake.

3.3.3 HISTORICAL & FUTURE PHOSPHORUS LOADING: BUILD-OUT ANALYSIS

Once the model is calibrated for current in-lake total phosphorus concentration, we can then manipulate land cover and other factor loadings to estimate pre-development and future phosphorus loading (e.g., what in-lake total phosphorus concentration was prior to human development and what in-lake total phosphorus concentration will be following full buildout of the watershed under current zoning constraints). A comparison of pre-development, current, and future in-lake total phosphorus loadings and concentrations for Spofford Lake is shown in Tables 3-7, 3-8, and 3-9.

To predict the pre-development phosphorus load, FBE manipulated the model so that all development was converted back to natural vegetation, septic system inputs were set to zero, and internal loading estimates were smaller (assuming anoxic conditions observed today are the result of excess organic matter and nutrient loading from human activities in the watershed). The phosphorus load for pre-development conditions was estimated at 66 kg/yr, with an in-lake phosphorus concentration of 1.9 ppb. This pre-development load is 72% less than the current load and represents an estimate of the best possible water quality for the lake.

To predict the future phosphorus load from increased development, FBE first performed a build-out analysis for the Spofford Lake watershed in the Town of Chesterfield (FBE, 2018c). The build-out analysis identified an estimated 949 acres (59%) of the entire 1,655-acre study area as developable. Up to 300 new buildings (a 74% increase from 2018) could be added at **full build-out** by the year 2162, using the 30-year compound annual growth rate of 1.15% (Appendix A, Map 8). This predicted increase in development was then input to the model for the Spofford Lake watershed; the future phosphorus load was estimated at 334 kg/yr, with an in-lake phosphorus concentration of 9.9 ppb. This future load is 42% more than the current load and represents an estimate of the worst possible water quality for the lake. The direct shoreline and Wares Grove Inlet sub-basins were identified as most vulnerable to increases in future phosphorus loading. Any new increases in phosphorus to a lake can disrupt the ecological balance in favor of increased algae growth, resulting in degraded water clarity. The impact from new buildings and septic systems can be greatly reduced by implementing LID techniques and ensuring that all new septic systems are well separated from surface waters both horizontally and vertically (above seasonal high groundwater in suitable soil).

Results of the build-out analysis and future load modeling reinforce the concept of comprehensive planning at the watershed level to address future development and its effect on the water quality of Spofford Lake. Future development will increase the amount of polluted runoff that drains to Spofford Lake. **Therefore, it is recommended that town officials revisit zoning ordinances to ensure that existing laws encourage LID techniques** (see Section 5.2).

3.4 ESTABLISHMENT OF WATER QUALITY GOAL

The committee met to discuss the water quality goal and objectives on August 8, 2018. It was noted that the reduction estimates for current and future loadings are impacted by underlying assumptions that are both overestimating and underestimating contribution of possible sources. For example, the build-out analysis was unable to model the complexities of road frontage restrictions to parcel subdivisions, generating a possible overestimate of the number of new buildings at full build-out. Conversely, the current loading model may be underestimating the contribution of aging septic systems, inadequate site designs on steep slopes, and fertilized lawns. It was also noted that there have been significant stormwater runoff issues from new development, suggesting weaknesses in proper site design requirements and/or enforcement. The committee selected an intermediate target for Objective 2 as a good balance between committing to a small effort (i.e., maintaining current water quality) that sends a poor message to the public that current lake conditions are acceptable (given low oxygen conditions, stormwater runoff concerns, and recent excessive plant growth in shallow areas) and a large effort that may not be feasible to achieve in 10 years (given the substantial funding required). The following provides the final water quality goal and objectives agreed on by the committee.

The goal of the Spofford Lake Watershed Management Plan is **to improve water quality in Spofford Lake**. This goal will be achieved by accomplishing three objectives, with the first two objectives targeting the dissolved oxygen impairment. More detailed action items to achieve these objectives are provided in Section 5.2.

Objective 1: Investigate the cause of low dissolved oxygen in Spofford Lake.

- A sediment core at the deep spot of Spofford Lake should be collected and analyzed for organic matter content and dissolved oxygen should be monitored more frequently during critical time periods (late summer prior to turnover) to determine the cause and extent of the dissolved oxygen impairment and inform any adjustments to the water quality objectives.

Objective 2: Reduce pollutant loading to Spofford Lake by 19 kg/yr to improve in-lake median total phosphorus concentration (from 5.3 ppb to 5.0 ppb).

- Reducing current phosphorus loading by 5% (12 kg/yr) and preventing future phosphorus loading anticipated from new development in the next 10 years (7 kg/yr) can be achieved by implementing LID regulations on new development and/or implementing stormwater or septic system improvements to reduce pollution from existing development (such as a combination of the watershed sites and high/medium-impact shoreline sites identified; refer to Section 3.5).

Objective 3: Manage and reduce chloride loading to Spofford Lake to improve in-lake mean chloride concentration.

- Because chloride was not modeled in greater detail based on known road salt application rates in the watershed (or other sources to the watershed), it is difficult to set an appropriate reduction target without understanding the limits set by public safety standards. Therefore, any measured improvement to in-lake mean chloride concentration following implementation of salt management action items will be considered a success.

The interim goals for each objective allow flexibility in re-assessing water quality objectives following more data collection and expected increases in phosphorus loading from new development in the watershed over the next 10 or more years (Table 3-10). Understanding where water quality will be following watershed improvements compared to where water quality should have been 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 due to lack of funding or other resources for implementation projects versus due to increases in phosphorus loading from new development outpacing reductions in phosphorus loading from improvements to existing development, then this creates much different conditions from which to adjust interim goals. For each interim goal year, the committee should meet to update the water quality data and model and assess why goals are or are not being met. The group will then decide on how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

Table 3-10. Interim benchmarks for the water quality objectives. Refer to Action Plan (Section 5.2) for specific recommendations related to each objective.

Water Quality Objective	Interim Goals/Benchmarks		
	2020	2023	2028
1. Investigate the cause of low dissolved oxygen in Spofford Lake.			
	Revise and implement annual monitoring program; team up with university or consultant to sample sediments and study cause of low oxygen	Continue annual monitoring program; re-evaluate water quality and determine if cause of low oxygen warrants revision of objectives	Continue annual monitoring program; re-evaluate water quality and track any improvement in oxygen if able to remediate cause of low oxygen
2. Reduce pollutant loading to Spofford Lake by 19 kg/yr to improve in-lake median total phosphorus concentration (from 5.3 ppb to 5.0 ppb).			
	Achieve 1% (2 kg/yr) reduction in TP loading; prevent or offset 3 kg/yr in TP loading from new development	Achieve 3% (7 kg/yr) reduction in TP loading; prevent or offset 5 kg/yr in TP loading from new development; re-evaluate water quality and track progress	Achieve 5% (12 kg/yr) reduction in TP loading; prevent or offset 7 kg/yr in TP loading from new development; re-evaluate water quality and track progress
3. Manage and reduce chloride loading to Spofford Lake to improve in-lake mean chloride concentration.			
	Achieve measurable reduction in chloride loading	Achieve measurable reduction in chloride loading	Achieve measurable reduction in chloride loading

3.5 POLLUTANT SOURCE IDENTIFICATION

3.5.1 SEPTIC SYSTEM SURVEY

Septic systems, outhouses, and even portable toilets help manage our wastewater and prevent harm to human health, aquatic life, and water resources. However, aging, poorly-maintained, and/or improperly-sited systems pose a threat to the health of Spofford Lake. Within a septic system, approximately 20% of the phosphorus is removed in the septic tank (due to settling of solid material) and a further 23-99% is removed in the leachfield and surrounding soils (Lombardo, 2006; Lusk et al., 2011). The degree of phosphorus removal efficiency of a septic system depends on site-specific soil and groundwater characteristics, including pH and mineral composition. Depending on the circumstances, older systems may still retain up to 85% of the input phosphorus in the top 30 cm of the soil (Zanini et al., 1998), though a slow, long-term transport of phosphate over long distances in the groundwater table can also occur in older systems (Harman et al., 1996). Phosphorus generally migrates through the soil slower than other dissolved pollutants in groundwater, but studies have shown that this degree of phosphorus reduction and movement is correlated with unsaturated infiltration distance (Weiskel and Howes, 1992), suggesting it is important to have septic systems well above the seasonal high groundwater table.

SWRPC, along with 15 volunteers, conducted a water quality survey of households within the watershed. The group split up into teams of two and went door-to-door asking homeowners questions related to lake usage, septic age, pump-out history, and seasonal use, lawn care maintenance, and more. During the survey event, 90 surveys were completed and another 55 were mailed to SWRPC or completed online, totaling 145 completed surveys (a 47% return rate). Results of the survey were incorporated to the watershed loading model conducted by FBE (2018a) to estimate the total phosphorus loading to the lake from wastewater systems.

Of the 145 respondents, 121 (83%) had a septic system and 24 (17%) had a holding tank. Out of 137 responses, most septic systems were reported as either as <10 years old or between 10 and 20 years old at 25% and 39%, respectively. About 36% of septic systems were reported as more than 20 years old, with 9 of those 50 systems greater than 40 years old. Out of 132 responses, 52% (or 68 systems) were pumped within the last two years and 39% (or 52 systems) were pumped within the past 3 to 5 years. There were 12 respondents that said their system had not been pumped in the past 5 years and several others that did not know when it was last pumped (and did not answer).

Per the watershed loading model, **wastewater systems are the third largest source of phosphorus to Spofford Lake, contributing 15% (36 kg/yr) of the total phosphorus load to the lake**. Recommendations for addressing input from wastewater are provided in the Action Plan (Section 5.2).

3.5.2 WATERSHED AND SHORELINE SURVEYS

Watershed and shoreline surveys are first-phase, screening-level assessments designed to locate potential sources of NPS pollution within areas that drain to a waterbody. Watershed and shoreline areas are assessed by foot or car or by boat, respectively, from public access points (e.g., public roads, common areas) unless information is provided by private landowners. Results of these surveys are essential to the watershed-based planning process because they identify individual NPS sites and prioritize BMP implementation projects throughout the watershed. **Full-scale designs and cost estimates will need to be completed for each of the identified watershed survey sites. Technical assistance visits and BMP recommendations will also be needed for individual shoreline properties.** These follow-up actions are detailed in the Action Plan (Section 5.2).

A watershed survey was completed on September 9, 2017 by Horsley Witten Group (HWG) to identify and document hotspots of NPS pollutant loading to Spofford Lake. The survey focused on areas of significant sediment erosion; sediment can carry nutrients, such as phosphorus, to surface waters during runoff events. Documentation included describing the problem, estimating the impact/treatment area, making recommendations for fixing the problem, rating the site's impact to water quality, logging the site's geoposition, and taking photographs. Following review of the identified sites by the steering committee, several more sites (largely on private property) were added for a total of 16 sites (Appendix A, Map 9). Primary erosion hotspots identified included the Ware's Grove Beach parking lot, the North Shore Town Beach parking area and beach, Camp Spofford gravel roads and parking areas, the Lake Spofford Family Recreation Beach, and the intersection of Echo Cove Way and Barn Road.. Preliminary pollutant load reduction and cost estimates were assigned for each site based on the scale of recommended fixes; a full-scale design and cost estimate should be completed for each site prior to implementation. Based on each site's impact rating, estimated cost, and potential pollutant load reduction, the 16 sites were ranked 1-16 from highest to lowest priority for implementation. Refer to Appendix B for the prioritized BMP matrix.

The Town of Chesterfield has already taken initiative to remedy the runoff issues at Ware's Grove Beach and North Shore Beach. Project partners also submitted a pre-proposal for a 319 Watershed Assistance Grant through NHDES to fund implementation work at 11 shoreline and watershed sites throughout the watershed, as well as fund several education outreach workshops. If awarded, the project would be completed from 2019-2021.

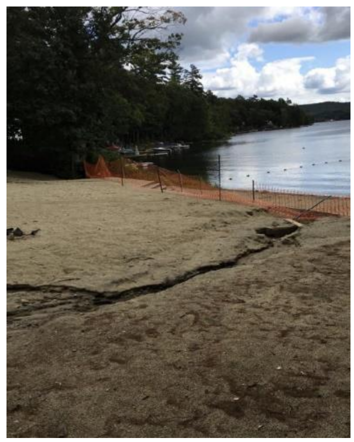
PRIMARY EROSION HOTSPOT SITES

Ware's Grove Beach (Site 7)

Runoff from the unpaved parking lot of Ware's Grove Beach is conveyed to a catch basin which discharges to a drainage swale to Spofford Lake. Significant sediment from the gravel parking lot was found to be entering the catch basin and discharging untreated to the swale and lake. Engineered designs have been drafted for this site, which is slated for implementation work for spring 2019.

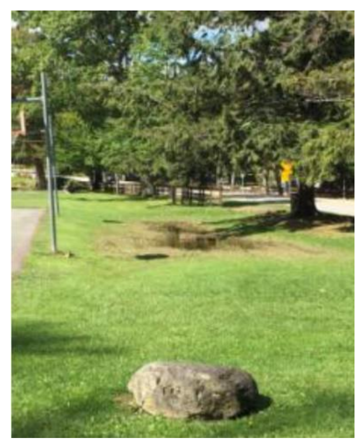
North Shore Beach (Site 1)

Significant erosion with gully formation was found at the entrance and along the beach at North Shore Beach. Erosion was caused by concentrated stormwater runoff coming across the street and onto municipal beach property. Engineered designs have been drafted for this site, which is slated for implementation work for spring 2019.



Camp Spofford (Site 6)

Untreated runoff from unpaved parking areas at Camp Spofford was found discharging to Spofford Lake. Recommend installing a large demonstration rain garden between the basketball court and the road (parallel to the lake shoreline) to treat runoff from the parking lot. This area is already a natural depression with standing water, is highly visible, and receives significant foot traffic, making it an ideal demonstration site.



Lake Spofford Family Recreation Beach (Site 16)

Significant sheet flow along sloped grassy area from parking lot to beach area was observed, along with gully formation at the beach. Evidence of high flows throughout grassy and picnic area with exposed tree roots. Drainage channel diverts some parking lot flow towards woods. Recommend installing a bioswale with underdrain around parking lot and improve existing culvert to collect and divert flows away from sloped area. May also install terraced infiltration landscaping along grassy slope.

Intersection of Echo Cove Way and Barn Rd (Site 8)

Gravel road surface and ditch erosion was observed near the intersection of Echo Cove Way and Barn Rd. Hay bales were installed in an existing roadside drainage swale, but downstream erosion was still observed. Recommend installing a bioretention cell in the grassed area at the corner of Echo Cove Way and Barn Rd to collect drainage prior to discharging across the street towards the existing hay bales, installing check dams in the roadside drainage swale, and installing water bars along both roads to convey flows to the bioretention cell.

A shoreline survey was conducted on September 9, 2017 by FBE, NHDES, and local volunteers to document the condition of each shoreline 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. These scores were summed to generate an overall “Shoreline Disturbance Score” for each parcel, with high scores indicating poor shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos serve as 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 222 parcels were evaluated along the shoreline of Spofford Lake. The average Shoreline Disturbance Score for the entire lake was 11.1. About 87% of the shoreline (or 194 parcels) scored 10 or greater (Appendix A, Map 10). A disturbance score of 10 or above indicates shoreline conditions that may be detrimental to lake water quality. These shoreline properties tended to have steep slopes, structures within 75 feet of the shoreline, minimal vegetated buffers, and evidence of bare soil.

The information obtained from this survey was used to plan next steps for improving the shoreline of Spofford Lake and inform the watershed management plan. The survey map and database highlight areas that are possibly contributing to polluted runoff, and the shoreline disturbance scores should be used to prioritize areas of the shoreline for remediation. Each shoreline property should be visited by a technical consultant for BMP recommendations. 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. It should be noted that natural steep slopes are responsible for some high scores in the watershed. These slopes are poor habitat for vegetation growth and other remediation efforts should be pursued on these properties.

Examples of good vegetated shoreline buffers:

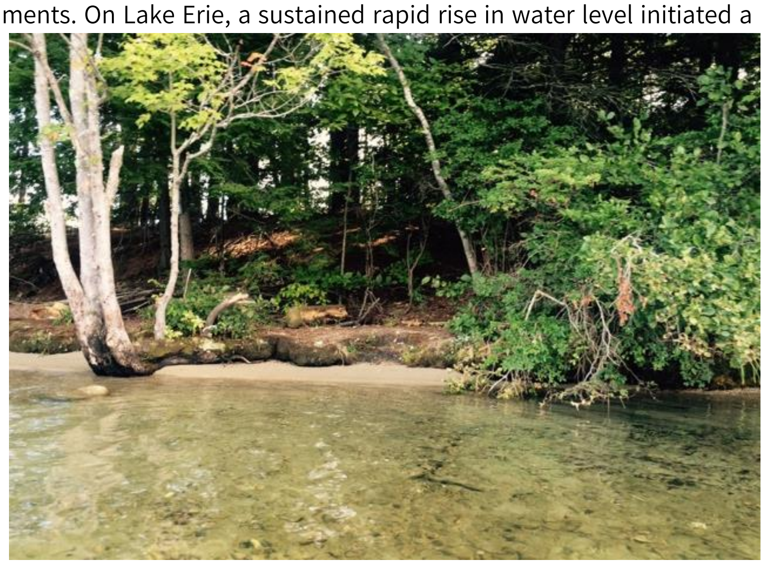
Spofford Lake parcel receiving a final score of 7 due to significant vegetation planted along the shoreline.

Spofford Lake parcel receiving a final score of 9 with a moderate vegetated buffer.

3.5.3 LAKE WATER LEVEL

Water level fluctuation in lakes can cause or worsen shoreline erosion in times of elevated water level, as well as cause or worsen lakebed erosion in times of low water level. In shallow, gently sloping lakes, raising the water level redistributes wave energy from the nearshore (i.e., the shallow area between the mean and low water level) to the foreshore (i.e., the shallow area between the high and mean water level where beaches are located), thus causing potential shoreline retreat (Lorang et al., 1993). During times of water level drawdown, wave energy is focused on the exposed section of lakebed that dries out and becomes prone to erosion and ice scouring during winter (Carmignani and Roy, 2017). High and low water levels can have detrimental effects on lake systems, so finding a balance in managing water level at appropriate times throughout the year is critical to maintaining a healthy lake 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 lake water level.

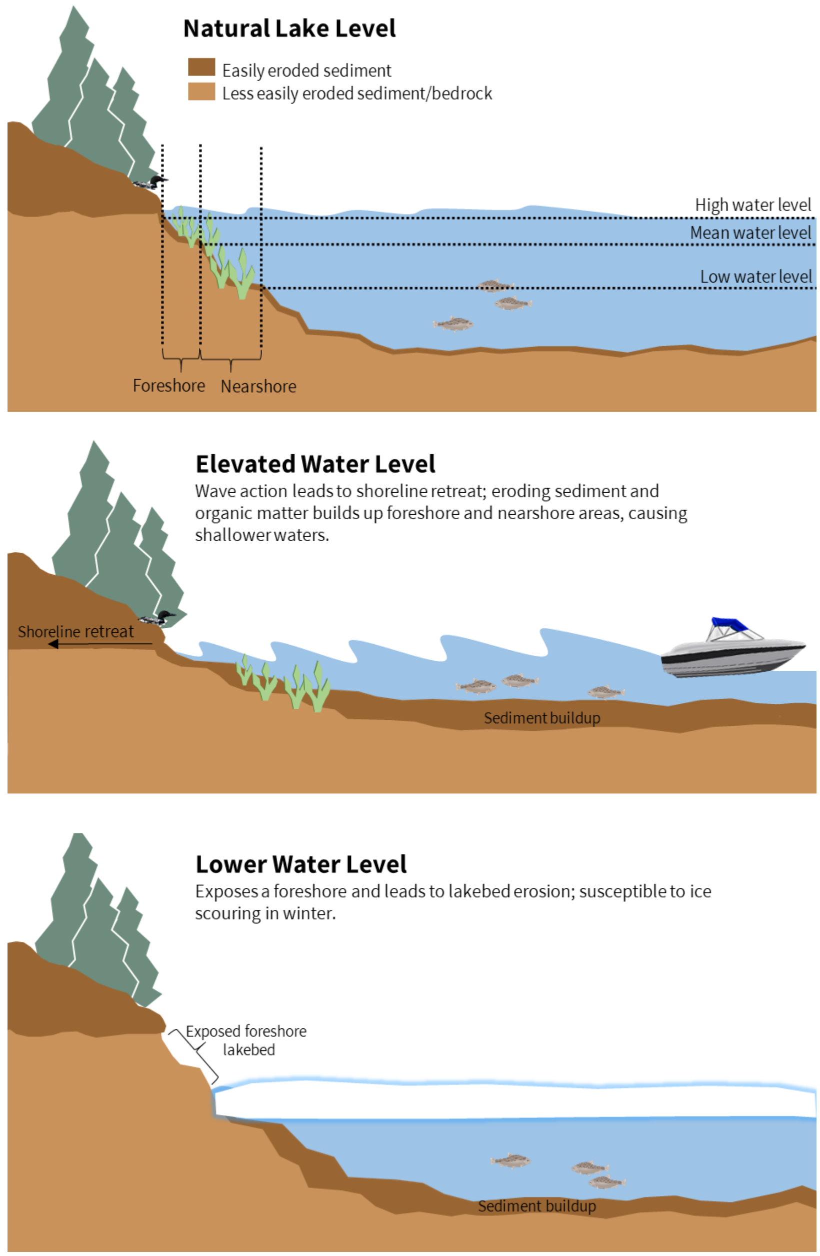
One widely-applied theory of shoreline erosion in response to water level rise is the Bruun Rule (Bruun, 1962), which states that the shape of the shore profile will gradually adjust to a rise in water level until it reaches an equilibrium slope, at least down to a depth where waves no longer influence sediments. On Lake Erie, a sustained rapid rise in water level initiated a multi-year sequence of erosion and shoreline retreat even after water levels began lowering, suggesting that manipulating lake water level can have long-lasting consequences that are hard to predict or reverse (Lavalle and Lakhan, 2000). Lorang et al. (1993) and Carmignani and Roy (2017) recommend gradually lowering lake water level in dammed lakes before fall storms as a management practice so that wave energy can be more readily dissipated along the shallow slope of the nearshore shelf, potentially preventing larger erosive events.



Visible shoreline retreat around Pierce Island from elevated water levels in Spofford Lake. Photo Credit: P. Walton.

Spofford Lake has a long history of fluctuating lake water levels, beginning with its impoundment in 1810 to power factories along the outlet stream, Partridge Brook, and later for municipal use to flush out sewage. Following disputes between lake residents and factory owners, a Natural Mean Low Water Elevation was set at 711.6 feet (NAVD88) in a 1984 NH Supreme Court case. A 2013 report by T.F. Bernier, Inc. found that lake water level today is higher than it was from 1905-1950 due to a lack of naturally-occurring shoreline; the Natural Mean High Water Elevation was therefore set at 712.5 feet (NAVD88). Spofford Lake residents have reported shoreline erosion and retreat, especially around Pierce Island, due to elevated lake water levels. Residents claim that the lake water level was about 6 inches lower than today and possibly up to 1 foot lower before the 1999 spillway construction. Many shore areas have become shallower with fill-in from eroded shorelines. Photographs of undercut tree roots around Pierce Island indicate that historic lake water levels were indeed lower than current lake water levels.

A sediment core sample with 12 inches of "muck" overlaying a sand/gravel bed was collected on October 20, 2018 from Spofford Lake near the Lake Spofford Family Recreation Beach (see above photo by SLA/PSU). This was one of four coring samples that were collected by Plymouth State University (PSU) with assistance by SLA. Analysis of these dated sediment core samples (anticipated for May 2019) may show when major changes in sediment and organic matter loading occurred in the lake in relation to changes in lake water level. Enhanced shoreline erosion may be contributing organic matter to the lake, which generates high sediment oxygen demand and thus anoxia in bottom waters – one proposed theory for the dissolved oxygen impairment. Refer to Section 5.2 for recommendations.



Conceptual diagram showing the impact of high and low water level on lake shorelines. ©FBE

4. MANAGEMENT STRATEGIES

The goal of the Spofford Lake Watershed Management Plan is to improve the water quality in Spofford Lake through treatment of current NPS pollution from existing development and prevention of future NPS pollution from anticipated new development. This goal will be achieved by accomplishing the following objectives: 1) investigate the cause of low dissolved oxygen; 2) reduce or prevent phosphorus loading by 19 kg/yr to improve in-lake median total phosphorus concentration (from 5.3 ppb to 5.0 ppb) over the next 10 years (2019-2028); and 3) manage and reduce chloride loading to improve in-lake mean chloride concentration over the next 10 years (2019-2028). A key component of this effort 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, government, and others. The following section details management strategies for achieving the water quality goal and objective using a combination of structural and non-structural BMPs, as well as an adaptive management approach. Specific action items are provided in the Action Plan (Section 5.2).

4.1 STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Sixteen (16) watershed NPS sites and 194 high to medium priority shoreline properties were identified and documented to have some impact on water quality through the delivery of phosphorus-laden sediment (refer to Section 3.5.2). As such, structural BMPs are a necessary and important component for the protection of Spofford Lake water quality. The best approach to treating these NPS sites is to:

- Address high priority watershed and shoreline survey sites with an emphasis on cost-efficient fixes that have a high impact to low cost per kg of phosphorus treated. The BMP matrix (Appendix B) sorts watershed NPS sites by impact-weighted cost to phosphorus reduction ratio. The shoreline survey results are sorted from highest to lowest Shoreline Disturbance Scores.
- Work with landowners to get commitments for treating and maintaining sites. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property.
- Work with experienced professionals on sites that require a high level of technical knowledge (engineering) to install and ensure proper functioning of the BMP.
- Estimate pollutant load reduction for each BMP installed.

This approach will help guide the proper installation of structural BMPs in the watershed. More specific and additional recommendations (including public outreach) are included in the Action Plan in Section 5.2. For helpful tips on implementing residential BMPs, see the NHDES Homeowner's Guide to Stormwater Management (See Additional Resources).

4.1.1 ESTIMATION OF POLLUTANT LOAD REDUCTIONS NEEDED

Remediation of the 16 NPS sites identified in the watershed survey could reduce the phosphorus load to Spofford Lake by an estimated 7.9 kg/yr of phosphorus[1] and cost an estimated $700,000 to $1,200,000 to implement (Table 4-1; refer to Section 3.5.2 and Appendix B). **Full-scale designs and cost estimates will need to be completed for each of the identified watershed survey sites.**

Using a simple scoring method, the shoreline survey served as an excellent tool for highlighting shoreline properties around the lake that exhibited significant erosion (refer to Section 3.5.2). This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone, but it does not allow for making specific BMP recommendations. **Therefore, high priority shoreline properties (10 parcels) should be resurveyed in person for specific BMP recommendations and more accurate estimated phosphorus reductions and implementation costs by site.** However, given some broad assumptions, the 10 high priority properties (with scores of 14 or greater) would cost about $30,000 ($3,000 each) to revegetate and mulch with volunteer labor, which could reduce the phosphorus load by 9.5 kg/yr. Remediation of the 184 medium priority properties (with scores of 10-13) would each cost about $1,500 to revegetate and mulch with volunteer labor and could result in the reduction of an additional 26.5 kg/yr of phosphorus. Note that the total

[1] Based on the NHDES Simple Method Pollutant Loading Spreadsheet Model and the USEPA Region 5 model.

phosphorus load calculated by the Region 5 model method differs from the LLRM output for direct shoreline drainage. This is due to the large assumptions made in the models and the fact that Urban 1 Low Density Residential phosphorus export coefficients are generalized and do not consider specific shoreline condition and proximity to the lake.

If all identified trouble areas were addressed, total phosphorus load to the lake could be reduced by 44 kg/yr. The water quality goal and objective require that the total phosphorus load to Spofford Lake be reduced or offset by 19 kg/yr by 2028. Success will be achieved by remediating a combination of both watershed and shoreline survey sites, as well as improving land use ordinances to better protect water resources (see Section 4.2). The strategy for reducing pollutant loading to Spofford Lake will be dependent on available funding and labor resources but will likely include a combination of approaches (larger watershed BMP sites and smaller residential shoreline BMP sites). Refer to Section 5.2 for specific recommendations.

Table 4-1. Summary of total phosphorus (TP) reductions for BMP implementations at Spofford Lake.

BMP Site Categories	TP Reduction (kg/yr)
Watershed Survey Sites (16)	7.9
Shoreline Survey – High Impact Sites (10)	9.5
Shoreline Survey – Medium Impact Sites (184)	26.5
Total	**43.9**

It is important to note that, while the focus of the objective 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:

1) Nutrients (e.g., nitrogen)
2) Petroleum products
3) Bacteria
4) Road salt/sand
5) 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 lake response.

4.2 NON-STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Current zoning in the Spofford Lake watershed presents considerable opportunity for continued development, as an estimated 59% of the Spofford Lake watershed is still developable (see the build-out analysis in Section 3.3.3). The area's popularity as a permanent residence is growing with seasonal homes being upgraded to year-round single-family dwellings. This may result in a 42% increase in phosphorus loading to Spofford Lake by 2162, with in-lake phosphorus concentrations climbing to 9.9 ppb (see Section 3.3.3). Given this future development potential, **it is critical for municipalities to develop and enforce stormwater management measures that prevent an increase in pollutant loadings from new and re-development projects**, particularly as future development may offset reduced loads from other plan implementation actions. The impact of future development can be mitigated with the implementation of non-structural BMPs, such as land use planning, zoning ordinances, and LID requirements**. Though non-structural BMPs often receive little emphasis in watershed planning, it can be argued that local land use planning and zoning ordinances are the most critical components of watershed protection.** Refer to Section 5.2 for specific planning recommendations.

4.3 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by a steering committee, is highly recommended for protecting the Spofford Lake watershed. 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 an 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 (an expansion of the current steering committee overseeing plan development) should be assembled to coordinate watershed management actions. This group should include representatives from the Town of Chesterfield, SWRPC, SLA, Chesterfield Conservation Commission, local businesses, and other interested groups or private landowners. Refer to Section 5.1: Plan Oversight.
- **Establishing a Funding Mechanism.** A long-term funding mechanism to be guided by a steering committee should be established to provide financial resources for management actions. A sub-committee of the steering committee can be dedicated to prioritizing and seeking out funding opportunities. 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 management 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 5.4 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, including structural and non-structural restoration actions. The proposed actions in this plan should be used as a starting point for grant proposals. Once a funding mechanism is established, detailed designs for priority restoration actions on a project-area basis can be completed and their implementation scheduled. Refer to Section 5.2: Action Plan.
- **Continuing and Expanding the Community Participation Process.** Plan development has included active involvement of a diversity of watershed stakeholders. Several watershed stakeholders participated in the community forum to develop the Action Plan (refer to Section 1.4). Plan implementation will require continued and ongoing participation of stakeholders, as well as additional outreach efforts to expand the circle of participation. Long-term community support and engagement is vital to successfully implement this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 5.2: Action Plan and Section 5.5: Educational Component.
- **Continuing the Long-Term Monitoring Program.** An annual water quality monitoring program (including ongoing monitoring of watershed tributaries) is necessary to track the health of the lake. Information from the monitoring program will provide feedback on the effectiveness of management practices at the sub-basin level and help optimize management actions through the adaptive management approach. Refer to Section 5.2.1: Water Quality Monitoring.
- **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 5.3: Indicators to Measure Progress and Section 3.4: Establishment of Water Quality Goal for interim benchmarks.

5. PLAN IMPLEMENTATION

5.1 PLAN OVERSIGHT

The recommendations of this plan should be carried out by a steering committee like the one assembled for development of this plan. A steering committee should include the leadership of SLA, representatives from the town (e.g., board of select, planning board), members of the conservation commission, schools and community groups, local business leaders, and landowners. The committee will need to meet regularly and work hard to coordinate resources across stakeholder groups to implement management actions. The watershed management plan (especially the Action Plan) will need to be updated periodically (typically every five 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 a steering committee and reported to NHDES on a regular basis.

5.2 ACTION PLAN

The Action Plan was developed through the collective efforts of the current steering committee, as well as the public by way of feedback provided during the community forum held in August 2018. The Action Plan outlines responsible parties, approximate costs[2], and an implementation schedule for each recommendation within six major categories: (1) Water Quality Monitoring; (2) Watershed and Shorefront BMPs; (3) Municipal Planning and Conservation; (4) Septic Systems; (5) Roads and Driveways; and (6) Salt Management. Accompanying narrative sections also provide “short-term recommendations” or actions to be included in the first, immediate phase of plan implementation.

5.2.1 WATER QUALITY MONITORING (OBJECTIVES 1-3)

An annual monitoring program is critical to evaluating the effectiveness of watershed restoration activities and determining if the water quality goal and objective are being achieved over time (per interim benchmarks set in Section 3.4). The Action Plan includes recommendations for enhancing current water quality monitoring efforts at Spofford Lake and its tributaries. The recommendations build on SLA’s current monitoring program and collaboration with VLAP. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#1:** Investigate the cause of the low-oxygen impairment by teaming up with Plymouth State University (PSU) to collect and analyze a sediment core sample of the deep spot of Spofford Lake. SLA has already partnered with PSU to collect four sediment core samples around the lake in fall 2018.
- **#4:** Establish a regular lake monitoring program that (at a minimum) samples the deep spot of Spofford Lake three times per year in summer for dissolved oxygen, temperature, and conductivity profile readings, Secchi disk transparency readings, hypolimnion and metalimnion grab samples for total phosphorus and chloride, and epilimnion core samples for total phosphorus, chlorophyll-a, and chloride.
- **#8:** Continue a regular tributary monitoring program that (at a minimum) samples nine sites and the outlet three-four times per year in summer for total phosphorus, conductivity, temperature, and chloride. Target LaChance Inlet, Clarkdale Pipe, Outlet, Wares Grove Inlet, Camp Spofford Inlet, Boat Launch, Shield Inlet, Seamans Inlet, Silverdale Inlet, and Rt. 63 #3.
- **#10:** Assess the impact of water level on shoreline erosion and consider adjusting the dam management plan.
- **#17:** Maintain or expand the current Lake Host and Weed Watcher programs.

5.2.2 WATERSHED AND SHOREFRONT BMPS (OBJECTIVE 2)

Stormwater is a major contributor of pollution to surface waters. Most larger sources of runoff from commercial development or roads are regulated, but single lot residential properties go unregulated (which cumulatively can potentially be a significant stormwater runoff contributor). Roofs can contribute heavy metals and animal waste (birds); driveways can contribute sediment, oil, and warmed water; and lawns can contribute fertilizer, pesticides, sediment, and pet waste – all of which can

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

flow off a property untreated to a surface water like Spofford Lake. Direct shoreline areas are typically among the highest for pollutant loading given their proximity to lakes and desirability for development. The 2017 shoreline survey found that 87% of shoreline parcels showed characteristics potentially detrimental to lake water quality. There are many resources available to help private property owners capture and infiltrate runoff, such as the New Hampshire Homeowner's Guide to Stormwater Management. Examples of stormwater controls include rain gardens, dripline trenches, driveway infiltration trenches, infiltration steps, porous pavers, and dry wells. Coordination with landowners will be crucial for successful implementation of the BMPs identified in the Action Plan because many mitigation measures will need to be implemented on private land. A well-executed demonstration BMP in a populated area may inspire friends and neighbors to implement similar practices.

Pollutant load reductions will best be achieved through a combination of the smaller-scale shoreline and larger-scale watershed BMPs, and both will depend on available financial resources and feasibility. A steering committee should develop a long-term strategy to fund these and other action items from the plan. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#21, #23, #24, #25:** Work with shorefront and watershed landowners to encourage and implement stormwater controls, with initial focus on the highest priority survey sites.
- **#31:** Apply for 319 Watershed Assistance Grant funding through NHDES to implement action items. SWRPC, on behalf of SLA, has already submitted a pre-proposal application to NHDES for 2019-2021 implementation funding.
- **#29:** Create a subcommittee that develops a fundraising strategy and determines how funding is spent.

5.2.3 MUNICIPAL PLANNING AND CONSERVATION (OBJECTIVE 2)

Municipal land-use regulations are a guiding force for where and what type of development can occur in a watershed, and therefore, how water quality is affected because of this development. The build-out analysis indicated that there is room for improvement in protecting water quality through non-structural BMPs such as municipal ordinance adoption or revisions, especially as they relate to new development (e.g., impervious acreage, septic system design, and steep slopes). Efforts to balance development and water quality protection are important to watershed management goals and future water quality.

Stakeholders stated concerns about drainage and erosion issues associated with runoff from new development on steep slopes in the watershed. Site plans should require better standards for LID practices. However, stakeholders also expressed concerns about enforcement challenges with existing or proposed new regulations. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#33, #34:** Present the watershed management plan to the Board of Select and incorporate recommendations to the town master plan.
- **#35:** Host training for public works, road agents, code enforcement officers, ZBAs, and landscapers in town about use of proper stormwater controls and LID practices.
- **#36:** Enhance education of local land ordinances and BMPs by creating and distributing an outreach brochure to landowners and landscapers.
- **#44, #46:** Consider improving municipal ordinance language to better protect water resources by implementing smarter development standards.

5.2.4 SEPTIC SYSTEMS (OBJECTIVE 2)

Watershed modeling indicated that septic systems are the third largest source of phosphorus, contributing 15% of the total phosphorus load to Spofford Lake. To make significant reductions in phosphorus load from wastewater, landowners will need to take responsibility to check their systems and make necessary upgrades, especially to old systems and cesspools. Code enforcement could assist by tracking occupancy loads and having septic system inventories in the town master plan. A comprehensive septic system inventory (or database) could be used to track maintenance and replacement history of systems within the watershed; this would be managed by the town, especially if a wastewater inspection and maintenance program was put into effect and enforced by the town. The 2017 septic survey completed by SWRPC and volunteers is a good first-step in gathering site-specific septic system data (see Section 3.5.1).

"Septic socials" are a great outreach tool to spread awareness of proper septic maintenance. Socials are an opportunity for neighbors to come together to socialize, while also learning about keeping healthy septic systems. Socials could be held for willing groups of landowners, such as road or campground associations. Landowner groups can also benefit by coordinating septic system pumping discounts. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#49:** Reach out to landowners that did not or could not respond to the 2017 survey.
- **#51:** Develop and maintain a septic system database for the watershed/town, to be maintained by the Code Enforcement Office.
- **#55, #56:** Enforce occupancy loads, have septic system inventories in the town master plan, and inspect all home conversions from seasonal to permanent residences or property transfers for proper septic system size and design (replace all cesspools).
- **#57, #58, #59:** Enhance awareness of proper septic system maintenance and regulations through pamphlets and workshops or "septic socials."

5.2.5 ROADS AND DRIVEWAYS (OBJECTIVE 2)

Stakeholders expressed concerns about management of road drainage easements throughout the watershed. Steep road grades are vulnerable to gully and rill formation along roadsides, which act as conduits for sediment erosion and runoff. Many of the NPS sites identified in the watershed survey addressed runoff from private, town, and state roads. Landowners were concerned that properties with drainage easements were shouldering a significant share of drainage management responsibilities. In a few cases, drainage easements for new development were not adequately created to treat new runoff volumes. The steering committee should team up with landowners, local road agents, and the NHDOT to ensure that landowners and state and local authorities are working to best maintain roads and associated runoff within the watershed. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#28, #63:** Inventory, prioritize, and remediate culverts in the watershed. The SWRPC obtained a NHDOT grant to inventory culverts (based on size and condition) in the town for 2018-19.
- **#64:** Work with road agents and landowners to create, map, and manage drainage easements on public and private properties.

5.2.6 SALT MANAGEMENT (OBJECTIVE 3)

Specific conductivity and chloride levels in Spofford Lake and its tributaries are elevated for a high-quality lake, giving rise to concern that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lake. Steep road grades in proximity to surface waters make winter sand and salt applications even more vulnerable to quickly washing off. Refer to Table 5.1.

SHORT-TERM RECOMMENDATIONS

- **#68, #69:** Ensure the town and other contractors working in the watershed are certified with the NH Green SnowPro Program and are implementing best practices when applying road salts.

Table 5-1. Action Plan for the Spofford Lake Watershed Management Plan.

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
		Water Quality Monitoring (Objectives 1-3)										
Investigate the cause of the low-oxygen impairment (Objective 1)	1	Team up with university to sample sediments (at the deep spot and possibly tributary outlets) and deploy a 4-season continuous temperature monitoring buoy. Suggest assessing sediments for at least Al-Fe-P ratios, C:N ratios, particle size, chloride, and organic matter content. Cost obtained from Lisa Donor of PSU and includes equipment, materials, and student stipends.		✓	✓					✓	2019-20	$26,635
	2	Deploy continuous DO loggers for 3 seasons at the deep spot. Assumes loggers are attached to university mooring. Cost includes initial setup, equipment, materials, and 5 years of maintenance by consultant.		✓	✓				✓	✓	2019-23	$50,000
	3	Following data collection and analysis from the two previous action items, determine the cause of low oxygen and whether revision of objectives is warranted.		✓	✓				✓	✓	2020-23	$5,000
Establish regular lake monitoring program to gather more consistent water quality data	4	Conduct at least three annual sampling events at the deep spot in July, August, and September (prior to Sept 15) to include DO, temperature, and specific conductivity profile readings, Secchi Disk Transparency readings, hypolimnion and metalimnion grab samples for total phosphorus and chloride, and epilimnion core samples for total phosphorus, chlorophyll-a, pH, alkalinity, color, and chloride. Aim for biweekly Secchi Disk Transparency readings and monthly DO and temperature profile readings from May 24-Sept 15. Use laboratory that can analyze total phosphorus samples down to 1 ppb (such as the UNH WQAL).		✓			✓		✓	✓	2019-28	$100,000
	5	Re-evaluate water quality (total phosphorus, DO) at regular intervals based on interim benchmarks.		✓					✓		2020,2023, 2028	$7,500
Consider expanding the regular lake monitoring program	6	Add additional parameters to collect from the epilimnion during the regular sampling events, including total nitrogen and total organic carbon.		✓					✓		2019-28	$4,000
	7	Expand sampling outside normal season (June-Sept) to include spring and fall turnover. Cost assumes two extra sample events at the deep spot for the base program.		✓					✓		2019-28	$50,000
Continue & expand tributary monitoring program	8	Sample 9 tributary sites and the outlet for at least total phosphorus, specific conductivity, and chloride and also consider turbidity, pH, total nitrogen, and total organic carbon 3-4 times per year from June-September. Target LaChance Inlet, Clarkdale Pipe, Outlet, Wares Grove Inlet, Camp Spofford Inlet, Boat Launch, Shield Inlet, Seamans Inlet, Silverdale Inlet, and Rt. 63 #3. Assumes volunteer labor.		✓							2019-28	$80,000

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	9	Consider installing continuous data loggers measuring flow, DO, conductivity, and temperature at key tributary locations. These data would be useful in understanding water quality processes in the watershed. Coupled with water chemistry data, loading rates of nutrients may be calculated using the continuous flow data and used to update the land use model. Cost assumes initial setup at 3 sites and 5 years of maintenance by consultant.		✓					✓		2019-28	$100,000
Monitor undercutting of lake shoreline (especially around Pierce Island)	10	Team up with university or consultant to monitor shoreline undercutting as a result of higher lake levels. Assess if changes to local boating regulations or water level setting by dam could remediate shoreline erosion due to wake action.		✓					✓	✓	2019-28	$25,000
Enhance awareness of water quality issues in the watershed	11	Contact local representatives and attend selectman meetings to voice concerns and stay informed.		✓		✓		✓			2019-28	N/A
	12	Create flyers/brochures for shorefront homes regarding BMPs and septic systems. Consider also creating a "new homeowner" packet that covers water quality related issues and ordinances in the watershed. Cost does not cover printing.	✓	✓	✓	✓			✓		2019-28	$2,000
	13	Contribute interesting articles about water quality and watershed protection efforts to various media sources. Assumes volunteer labor.		✓		✓					2019-28	N/A
	14	Work with SOAK Up the Rain NH to implement small scale BMPs and host concurrent residential stormwater workshops. Cost estimate does not include actual BMP implementation. Cost assumes printing, mailing to advertise events.		✓			✓	✓			2019-28	$5,000
	15	Create educational annual "report cards" about Spofford Lake water quality, presented in a format that is approachable to lay persons. Cost assumes initial consultant setup for $2,000, then $500/yr to update for 9 additional years.		✓					✓		2019-28	$6,500
Maintain and/or improve current invasives and/or weed management program	16	Support State legislation that increases funds for aquatic invasive plant (e.g., milfoil) eradication.		✓	✓	✓		✓			2019-28	N/A
	17	Increase the number of volunteer inspectors for the Lake Host and Weed Watcher programs.		✓				✓			2019-28	N/A
	18	Continue to fund annual weed monitoring by consultant.		✓					✓		2019-28	$2,000
	19	Expand invasive species monitoring programs to include insects and other animals not currently monitored (e.g., spiny waterflea).		✓							2019-28	N/A
Obtain more funding	20	Obtain funding from sources such as municipal contributions, NHDES grants, lake associations, targeted fundraising, and other grants related to climate change or invasive species studies.	✓	✓	✓	✓		✓			2019-28	N/A

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
		Watershed & Shorefront BMPs (Objective 2)										
Encourage expanded participation in fostering a healthy shoreline buffer	21	Work with all shoreline residents to implement at least one conservation practice on their land. Goal: 75% participation. Assumes $500 cost-share for 167 properties.		✓	✓		✓	✓			2019-28	$83,500
	22	Consider giving a local tax credit to watershed landowners that make significant improvements to protect water quality on their property.			✓						2019-28	N/A
Address priority BMPs identified in surveys	23	Implement BMPs at the 10 high impact sites identified in the shoreline survey with disturbance scores of 14 or greater. Assumes cost of $3,000 per site to revegetate and mulch with volunteer labor. Expected to reduce pollutant load by 9.5 kg/yr.		✓	✓		✓	✓			2019-28	$30,000
	24	Implement BMPs at 7 of the 16 sites identified in the watershed survey. Cost is roughly estimated based on <10% design completion. Expected to reduce pollutant load by 6.1 kg/yr. Two public beach sites are currently being addressed by the town.		✓	✓		✓	✓			2019-28	$438,000 - $615,000
	25	Implement BMPs at 24 of the 184 medium impact sites identified in the shoreline survey with disturbance scores of 10-13. Assumes cost of $1,500 per site to revegetate and mulch with volunteer labor. Expected to reduce pollutant load by 3.4 kg/yr.		✓	✓		✓	✓			2019-28	$36,000
	26	Develop a method of tracking and monitoring BMP implementation progress (e.g., NPS Site Tracker).		✓	✓		✓	✓	✓		2019-28	$5,000
	27	Investigate possible structural or non-structural solutions (see Action Item #45) to reducing shoreline damage from boat wakes or lake water level.		✓	✓				✓		2019-28	$10,000
	28	a. Complete culvert survey of state, municipal, and private crossings in the watershed and prioritize for repair/replacement. SWRPC obtained a NHDOT grant to inventory culverts (based on size and condition) for 2018-19.			✓		✓	✓			2018-19	TBD
		b. Investigate major outfalls and tributary inlets to the lake where sediment is accumulating. Address contributing land uses upstream and/or install treatments at the sites just before the lake (e.g., sediment traps).			✓		✓	✓			2018-19	TBD
Garner funding for action items	29	Create a subcommittee that develops a fundraising strategy and determines how funding is spent.		✓	✓	✓					2019-28	N/A
	30	Establish a capital reserve fund for town to spend on lake protection initiatives.			✓	✓					2019-28	N/A
	31	Apply to grants and solicit residents for individual donations.	✓	✓				✓			2019-28	N/A
	32	Develop a "Friends of the Watershed" program for donations from local businesses. A business can receive a sticker or plaque recognizing their support for protecting Spofford Lake. Cost covers sticker/plaque purchase.		✓	✓			✓			2019-28	$1,000

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
		Municipal Planning & Conservation (Objective 2)										
Adopt plan recommendations	33	Present the watershed plan to the BOS/planning board of Chesterfield.	✓	✓	✓				✓		ASAP	$1,500
	34	Incorporate watershed plan recommendations into town master plan and encourage regular review of action plan.			✓						2019-20	N/A
Host trainings for public works, road agents, code enforcement officers, ZBAs, and landscapers	35	Host training and investigate certification opportunities (including salt application) for public works, road agents, code enforcement officers, ZBAs, and landscapers in town, where applicable.			✓			✓			2019-28	$5,000
Enhance watershed resident education of local land ordinances and best management practices	36	Create and distribute outreach brochure to homeowners and landscapers for developing and maintaining residential property. Cost does not include printing.		✓	✓				✓		2019-20	$2,000
	37	Hold informational workshops for new landowners, towns, and developers on relevant town ordinances, conservation easements, and watershed goals. Goal: Host 1-2 workshops.	✓	✓	✓			✓			2019-28	$5,000
	38	Utilize online points of contact (town and SLA websites) to provide information on ordinances, LID, and BMPs for landowners (e.g., fact sheets).	✓	✓	✓				✓		2019-28	$3,000
	39	Reach out to residents converting camp properties to year-round single family homes to educate on watershed issues, LID, and BMPs.	✓	✓	✓			✓			2019-28	N/A
Improve municipal permitting process	40	Create list of BMP and LID descriptions for Town Selectman, ZBA, Planning Boards, and landowners. Encourage LID by providing incentives to use LID.		✓	✓				✓		2019-20	$1,500
Identify opportunities for land protection and conservation within the watershed	41	Collaborate with local conservation partners on land conservation initiatives within the watershed. Assign a liaison from SLA to communicate with conservation groups, and promote community conservation education.		✓		✓					2019-28	N/A
	42	Fund tools, such as natural resource inventories, to help identify and target critical land for protection.	✓	✓	✓	✓			✓		2019-28	$15,000
	43	Create a priority list of watershed areas that need protection based on natural resource inventory and identify potential conservation buyers and property owners interested in easements within the watershed.	✓	✓	✓	✓			✓		2019-28	$2,000
Improve municipal ordinances (to help mitigate the anticipated 7 kg P/yr loading increase due to predicated future development in the next 10 years)	44	Meet with town staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, LID, and open space.	✓		✓				✓		2019-28	$1,500
		a) Lot Coverage: adopt requirements on Stormwater Management Plans for subdivisions, commercial, and multi-family development, and redevelopment disturbing 20,000 sq. feet or more.	✓		✓						2019-28	N/A
		b) Setbacks (Shoreland Zoning): increase the setback distance to 100 feet within the shoreland zone.	✓		✓						2019-28	N/A
		c) Wetland Buffers: increase the setback distance from all wetlands (not just prime wetlands) to 100 feet.	✓		✓						2019-28	N/A
		d) Steep Slopes: require design and implementation of BMPs on all development on slopes >15%.	✓		✓						2019-28	N/A

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
		e) Conservation/Cluster Subdivisions: encourage conservation subdivisions and increase the amount of land set aside in conservation subdivisions to min. 50% of the development area. [Does not include shoreland zone]	✓		✓						2019-28	N/A
		f) LID: Amend Stormwater Management ordinances to state that the use of LID techniques is preferred and shall be implemented to the maximum extent possible.	✓		✓						2019-28	N/A
Investigate additional municipal ordinances relating to lake activities	45	Assess if more stringent wake restrictions may have a positive impact on the lake shoreline. Currently, the lake is governed by state law (RSA 270-D:2 - boats shall maintain headway (no wake) speed within 150 ft of the shoreline, docks, and mooring fields. See Water Quality Monitoring. (http://www.gencourt.state.nh.us/rsa/html/XXII/270-D/270-D-2.htm)	✓	✓	✓				✓	✓	2019-28	$20,000
	46	Complete a full-scale ordinance review that includes working with the planning board to recommend changes, such as site plan review regulations, road and right of way standards, minimum lot sizes, minimum shore frontage per lot, steep slope ordinance, and others.	✓	✓	✓				✓		2019-28	$10,000
Enhance enforcement of proper land management practices	47	Create better enforcement of forestry rules and regulations.			✓						2019-28	TBD
	48	Encourage easement holders to be notified and present at closings.			✓						2019-28	N/A
		Septic Systems (Objective 2)										
Inventory status of septic and greywater systems in watershed	49	Reach out to landowners that did not or could not respond to the 2017 survey to gather additional information. Cost assumes printing and mailing only.	✓	✓					✓		2019-20	$10,000
	50	Conduct voluntary dye testing of high impact septic systems. Goal: 5 systems.		✓	✓			✓			2019-20	$500
	51	Develop and maintain a septic system database for the watershed. Code Enforcement Office for town to maintain database. Cost estimate based on initial setup by SWRPC or consultant.	✓	✓	✓				✓		2019-28	$4,000
	52	Assess the impact of elevated lake levels on the water table and potential interception of low-lying septic systems.		✓	✓				✓	✓	2019-20	$30,000
	53	Conduct an inventory of greywater systems in the watershed.		✓	✓				✓		2019-20	$5,000
	54	Hire canine scent detection team to investigate shoreline septic systems.		✓	✓				✓		2019-20	$10,000
Enforce town septic system regulations	55	Communicate with town departments to enforce occupancy loads and have septic system inventories in Master Plans.			✓						2019-28	TBD
	56	Inspect all home conversions from seasonal to permanent residences and property transfers for proper septic system size and design (remove all cesspools). Cost responsibility of property owner.			✓			✓			2019-28	TBD
Enhance awareness of proper septic system maintenance and regulations	57	Distribute educational pamphlets on septic system function and maintenance in tax bills to both landowners and short-term renters (to include recommended pumping schedules, proper leach field maintenance, and new/alternative septic system designs such as community septic or site-limited homes, etc.). Cost does not include printing.		✓	✓				✓		2019-20	$2,000

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	58	Create and distribute a list of septic service providers (create magnets, etc.).		✓	✓						2019-20	$1,000
	59	Host multiple "septic socials" in key neighborhoods near the lake to address link between septic system maintenance and water quality. Target educational campaign in areas with minimally-maintained or aging septic systems. Already held one septic system outreach event as part of planning process.	✓	✓				✓	✓		2019-28	$5,000
Garner funding or discounts that support and encourage septic system maintenance	60	Coordinate group septic system pumping discounts. Assumes volunteer labor to coordinate. Pump-out costs responsibility of landowners.		✓				✓			2019-28	N/A
	61	Investigate grants and low-interest loans (e.g., NHDES Clean Water State Revolving Fund, Section 319 Implementation Grant) to provide cost-share opportunities for septic system upgrades. Cost estimate based on resources to apply for grant.	✓	✓	✓				✓		2019-20	$2,000
	62	Encourage towns, conservation commissions, or local conservation partners to reserve a portion of conservation dollars for the watershed that can be used for septic system upgrades.		✓	✓	✓					2019-28	N/A
		Roads & Driveways (Objective 2)										
Coordinate culvert improvements	63	Work with NHDOT and town to communicate known problems with culvert function along roads so that they can be remediated. Publicize results of culvert priority list. See Action Item #28.			✓		✓				2019-20	TBD
Create and manage drainage easements on roads	64	Work with road agents and landowners to create, map, and manage drainage easements on public and private properties. This will help ensure that culverts and other drainage structures that cross private property are being properly maintained to control salt/sand and stormwater runoff from roads.		✓	✓			✓			2019-28	TBD
Develop maintenance priorities for roads within the watershed	65	Approach current ad-hoc "road association" leaders about identifying their goals for stormwater management and four-season maintenance for their roads.		✓	✓			✓			2019-20	N/A
Require training of road agents	66	Require training for road agents on proper salt, sand, and equipment use (e.g., UNH Technology Transfer Center trainings for snow plow operators). See Action Item #35 and #68).			✓						2019-28	$5,000
Host road maintenance workshops	67	Hold workshops on proper road management.		✓	✓			✓			2019-28	$5,000
		Salt Management (Objective 3)										
Work with town to ensure town and/or contractors are certified with the NH Green SnowPro program	68	Training is $100/person for municipalities; $200/person for private companies.			✓		✓	✓			2019-20	TBD
Implement best management practices when applying salt to roads	69	Plow early and often before applying salt. Mechanically removing snow is the most cost effective and environmentally sound method.			✓		✓				2019-28	TBD
	70	Utilize anti-icing/salt brine techniques. Ensure that brine mixture is 23.3% salt content by weight. Estimate up to 90% cost savings (UNH Technology Transfer Center).			✓		✓				2019-28	TBD

ACTION ITEM	#	RECOMMENDATIONS TO ACHIEVE ACTION ITEM	SWRPC	SLA	Chesterfield	Cons. Comm.	NHDOT/DES/SOAK NH	Landowners & Residents	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	71	If possible, apply a liquid brine to dry salt prior to application. Pre-wetting at the augur/spinner is best.			✓		✓				2019-28	TBD
	72	Use established application rates depending on current weather conditions. Dry salt becomes ineffective below 15°F.			✓		✓				2019-28	TBD
	73	Suggest heated walkways as an alternative to salt application for year-round residents around the lake. Ex. 1,110 sq.ft. area of concrete pavers needs about 206.1 amps. • $12,000 - $15,000 for installation materials • $8-$10/hr to operate (storms are typically 3-4 hours long)			✓			✓			2019-28	TBD
Work with the town to add a Chloride Management Plan to local ordinances	74	Require development subject to site plan review or subdivision review to prepare a Chloride Management Plan as part of their application. Estimate of $12,000 - $15,000 for expert to write.			✓			✓	✓		2019-28	$15,000

5.3 INDICATORS TO MEASURE PROGRESS

The following environmental, programmatic, and social indicators and associated numeric targets (benchmarks) will help to quantitatively measure the progress of this plan in meeting the established goal and objectives for Spofford Lake. These benchmarks represent short-term (2020), mid-term (2023), and long-term (2028) targets derived directly from actions identified in the Action Plan. Setting benchmarks allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. A steering committee should review the benchmarks for each indicator on an ongoing basis to determine if progress is being made, and then determine if the watershed plan needs to be revised because the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions (Table 5-2). They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They assume that BMP recommendations outlined in the Action Plan will be implemented accordingly and will result in the improvement of median in-lake phosphorus concentration, as well as improve water clarity and reduce the frequency of the low-oxygen in bottom waters of the lake. Note that the benchmarks for environmental indicators also reflect protection of water quality from any potential impacts from future development in the watershed.

Table 5-2. Environmental Indicators for Spofford Lake.

ENVIRONMENTAL INDICATORS

Indicators	Benchmarks*		
	2020	2023	2028
Improve median in-lake total phosphorus at the deep spot of Spofford Lake.	Prevent or offset 5 kg/yr in phosphorus loading from new or existing development to achieve 5.2 ppb median in-lake total phosphorus at the deep spot of Spofford Lake	Prevent or offset 12 kg/yr in phosphorus loading from new or existing development to achieve 5.1 ppb median in-lake total phosphorus at the deep spot of Spofford Lake	Prevent or offset 19 kg/yr in phosphorus loading from new or existing development to achieve 5.0 ppb median in-lake total phosphorus at the deep spot of Spofford Lake
Improve dissolved oxygen conditions in bottom waters by reducing the duration and increasing the depth of low oxygen occurrence.	5% fewer occurrences	10% fewer occurrences	20% fewer occurrences
Improve or maintain water clarity at the deep spot of Spofford Lake.	0.1 m	0.2 m	0.4 m
Improve mean in-lake chloride at the deep spot of Spofford Lake.	Any measurable reduction in chloride loading and in-lake concentration	Any measurable reduction in chloride loading and in-lake concentration	Any measurable reduction in chloride loading and in-lake concentration
Reduce the prevalence of excessive plant growth in littoral areas of the lake.	5% less coverage	10% less coverage	20% less coverage
Prevent the introduction of invasive aquatic species to Spofford Lake.	Absence of invasive aquatic species in the lake	Absence of invasive aquatic species in the lake	Absence of invasive aquatic species in the lake

**Benchmarks are cumulative starting at year 1.*

Programmatic indicators are indirect measures of watershed protection and restoration activities (Table 5-3). Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal.

Table 5-3. Programmatic Indicators for Spofford Lake.

PROGRAMMATIC INDICATORS

Indicators	Benchmarks*		
	2020	2023	2028
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$400,000	$800,000	$1,400,000
Number of high priority shoreline sites remediated (10 identified)	2	5	10
Number of medium priority shoreline sites remediated (184 identified)	6	12	24
Number of watershed survey sites remediated (16 identified)	2	4	7
Number of BMP demonstration projects completed	2	3	5
Linear feet of buffers installed in the shoreland zone	500	1,000	2,000
Percentage of culverts assessed and prioritized	50%	100%	100%
Percentage of culverts remediated	5%	25%	50%
Percentage of septic system database complete for watershed	25%	50%	100%
Number of updated or new ordinances that target water quality protection	1	2	3
Number of voluntary septic system inspections (seasonal conversion and property transfer)	3	5	10
Number of voluntary septic system dye tests and inspections (watershed residents)	5	10	20
Number of septic system upgrades	1	3	5
Number of septic/stormwater "socials" or workshops held	3	5	10
Number of informational workshops and/or trainings for landowners, town staff, and/or developers/landscapers on local ordinances, watershed goals, and/or best practices	2	5	10
Number of parcels with new conservation easements	1	2	3
Number of copies of watershed-based educational materials distributed	100	500	1,000
Number of best practices used in road salt applications	1	3	5
Percentage of mapped and properly-managed drainage easements	25%	75%	100%

**Benchmarks are cumulative starting at year 1.*

Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement (Table 5-4).

Table 5-4. Social Indicators for Spofford Lake.

SOCIAL INDICATORS

Indicators	Benchmarks*		
	2020	2023	2028
Number of new association members	5	15	25
Number of volunteers participating in educational campaigns	10	15	20
Number of people participating in workshops, trainings, or BMP demonstrations	20	50	75
Number of new lake hosts	2	5	10
Number of newly-trained VLAP volunteers	1	3	5
Number of new weed watchers	2	5	10
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%
Percentage of shoreline residents installing at least one conservation practice	25%	50%	75%

**Benchmarks are cumulative starting at year 1.*

5.4 ESTIMATED COSTS & TECHNICAL ASSISTANCE NEEDED

The cost of successfully implementing the plan is estimated at around $1,200,00-$1,400,00 over the next ten years (Table 5-5). **However, many costs are still unknown and should be incorporated to the Action Plan as information becomes available.** Estimated costs include both structural BMPs, such as fixing roads and planting shoreline buffers, and non-structural BMPs, such as demonstration tours or workshops and ordinance revisions. Annual BMP costs were included within the cost ranges based on a ten-year total for the initial BMP installation plus ten years of maintenance (refer to Table 4-1).

Table 5-5. Estimated 10-year costs for implementation of the Action Plan. Note: many costs were unknown or dependent on further information; therefore, total estimated costs over the next 10 years are likely underestimated.

Category	Estimated 10-Year Total
Water Quality Monitoring	$463,635
Watershed and Shorefront BMPs	$603,000 - $780,000
Planning & Land Conservation	$66,500
Septic Systems*	$69,500
Roads & Driveways	$10,000
Salt Management	$15,000
Total Cost	**$1,227,635 - $1,404,635**

**Septic system recommendations do not include design or replacement costs because these should be covered by landowners. Recommendations cover assistance to secure grant funding for those individuals who cannot afford these costs.*

Diverse funding sources and strategies will be needed to implement these recommendations. 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 (Section 319, ARM, Moose Plate, etc.), municipalities, SLA, 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 formation of a funding subcommittee, as well as a steering committee, will be a key part in how funds are raised, tracked, and spent to implement and support the plan. The following list summarizes several possible outside funding options available to implement the watershed management plan:

- **USEPA/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 2014) and protect high-quality waters. 319 grants are available for the implementation of watershed-based management plans. http://des.nh.gov/organization/divisions/water/wmb/was/categories/grants.htm

- **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 $24,000. http://agriculture.nh.gov/divisions/scc/grant-program.htm

- **Milfoil and Other Exotic Plant Prevention Grants (NHDES)** – Funds are available each year for projects that prevent new infestations of exotic plants, including outreach, education, Lake Host Programs, and other activities. http://des.nh.gov/organization/divisions/water/wmb/exoticspecies/categories/grants.htm

- **Clean Water State Revolving Loan Fund (NHDES)** – "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 nonpoint source, watershed protection and restoration, and estuary management projects that help improve and protect water quality in New Hampshire." http://des.nh.gov/organization/divisions/water/wweb/grants.htm

5.5 EDUCATIONAL COMPONENT

Awareness through education and outreach is a critical tool to protecting and restoring water quality. Most people want to be responsible watershed stewards and not cause harm to water quality, but many are unaware of best practices to reduce or eliminate contaminants from entering surface waters. As detailed in Sections 1.4 and 1.5, much effort is already being done in the watershed to enhance public understanding of the plan and encourage community participation in watershed restoration and protection activities. SWRPC, SLA, and the Town of Chesterfield are the primary entities for education and outreach campaigns in the watershed and for development and implementation of the plan. These stakeholders should continue all aspects of their education and outreach programs 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 specific to the six categories are detailed in the Action Plan (Section 5.2).

SWRPC, on behalf of SLA and the Town of Chesterfield, submitted a pre-proposal for a 319 Watershed Assistance Grant (2019-2021). As part of the proposed project, SWRPC included a strong outreach component to help homeowners and lake users identify potential stormwater issues and make appropriate fixes. Two outreach presentations on private road maintenance and residential salt management and a workshop on stormwater management were proposed. The presentation at the stormwater management workshop would be given by NHDES SOAK Up the Rain NH with an interactive activity to identify runoff issues and discuss potential solutions with participants.

ADDITIONAL RESOURCES

A Shoreland Homeowner's Guide to Stormwater Management. New Hampshire Department of Environmental Services. NHDES-WD-10-8. Online: https://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/nhdes-wd-10-8.pdf

Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Chase, et al. 1997. NH Audubon Society. Online: https://www.nh.gov/oep/planning/resources/documents/buffers.pdf

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

Gravel road maintenance manual: a guide for landowners on camp and other gravel roads. Maine Department of Environmental Protection, Bureau of Land and Water Quality. April 2010. Online: http://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf

Gravel roads: maintenance and design manual. U.S. Department of Transportation, Federal Highway Program. November 2000. South Dakota Local Transportation Assistance Program (SD LTAP). Online: http://www.gravelroadsacademy.com/media/filer_private/2012/02/14/sd_gravel_roads_brochure_1.pdf

Innovative land use techniques handbook. New Hampshire Department of Environmental Services. 2008. Online: https://www.nh.gov/oep/resource-library/planning/documents/innovative-land-use-planning-techniques-2008.pdf

Landscaping at the water's edge: an ecological approach. University of New Hampshire, Cooperative Extension. 2007. Online: https://extension.unh.edu/resources/files/resource004159_rep5940.pdf

New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home. New Hampshire Department of Environmental Services, Soak Up the Rain NH. Revised March 2016. Online: https://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-11-11.pdf

Open space for New Hampshire: a toolbook of techniques for the new millennium. Taylor, D. 2000. New Hampshire Wildlife Trust. Online: http://clca.forestsociety.org/publications

Protecting water resources and managing stormwater. University of New Hampshire, Cooperative Extension & Stormwater Center. March 2010. Online: https://extension.unh.edu/resources/files/Resource002615_Rep3886.pdf

Stormwater Manual. New Hampshire Department of Environmental Services. 2008. Online: http://des.nh.gov/organization/divisions/water/stormwater/manual.htm

University of New Hampshire Stormwater Center 2009 Biannual Report. University of New Hampshire, Stormwater Center. 2009. Online: https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/2009_unhsc_report.pdf

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