Province Lake

Watershed Management Plan

October 2014

Province Lake

AWWA

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

SC UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

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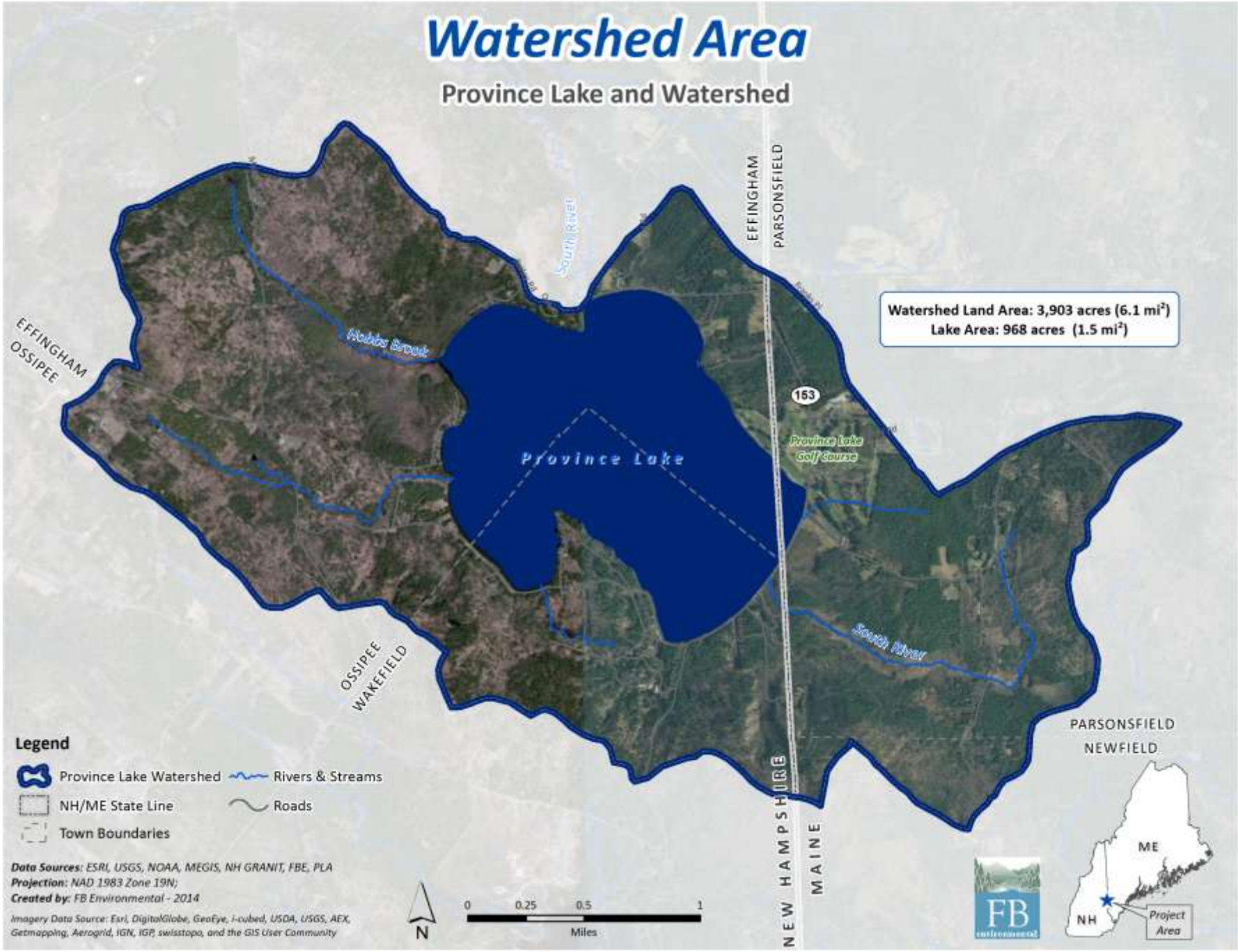
Watershed Area

Province Lake and Watershed



Province Lake Watershed Management Plan

Prepared for the Province Lake Association by FB Environmental Associates in cooperation with the Acton Wakefield Watersheds Alliance, UNH Stormwater Center, the New Hampshire Department of Environmental Services, and the Maine Department of Environmental Protection.

Final Draft ~ October 2014

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Cover photos: Pete Dinger, Province Lake Association

FOREWORD

We met at the state line on a warm, fall day. There were about fifteen of us -- supervisors and crew from the New Hampshire and Maine Departments of Transportation who take care of Route 153, the main road through the Province Lake watershed, accompanied by members of the Acton Wakefield Watersheds Alliance, Province Lake Association, watershed managers from the New Hampshire and Maine state water quality agencies, the University of New Hampshire Stormwater Center, and FB Environmental Associates . Our purpose was to open a dialogue about the relationship between ongoing erosion adjacent to Route 153 and the water quality of Province Lake.

Monumental occasion at the State Line- Maine DOT and NHDOT meet to discuss solutions to the eroding roadway they share along Route 153. (Photo: NH DES)

At first, we gathered awkwardly, with representatives of each state standing on their respective side of the State Line and the others seemingly trying to stand in a neutral place, not favoring one state over the other.

Forrest Bell spoke eloquently about the challenges that lay ahead, about a "lake on fire" where too much of a good thing, phosphorus, turns the lake ugly with toxic algae. But on this day, the lake was serene, its blue-black waters framed by the distant hills and mountains, the very picture of the kind of Province Lake we all want to keep, this day and every day.

By the end of the meeting, members of the highway crews from the two states had blended together as one, a single tribe who, without knowing each other beforehand, found much in common and kept on sharing stories together long after the meeting ended. That State Line highway sign was largely ignored by then.

I left the meeting reflecting on the power of watershed planning. It's about the lake, of course. But it really is about people, the connections they make, their collective aspirations, and their limitless capacity to make a better future.

~ Eric Williams, Supervisor, NH DES Watershed Assistance Section

ACKNOWLEDGEMENTS

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**Con Com – Conservation Commission*
**FBE – FB Environmental*
**GMCG – Green Mountain Conservation Group*
**ME DEP – Maine Department of Environmental Protection*
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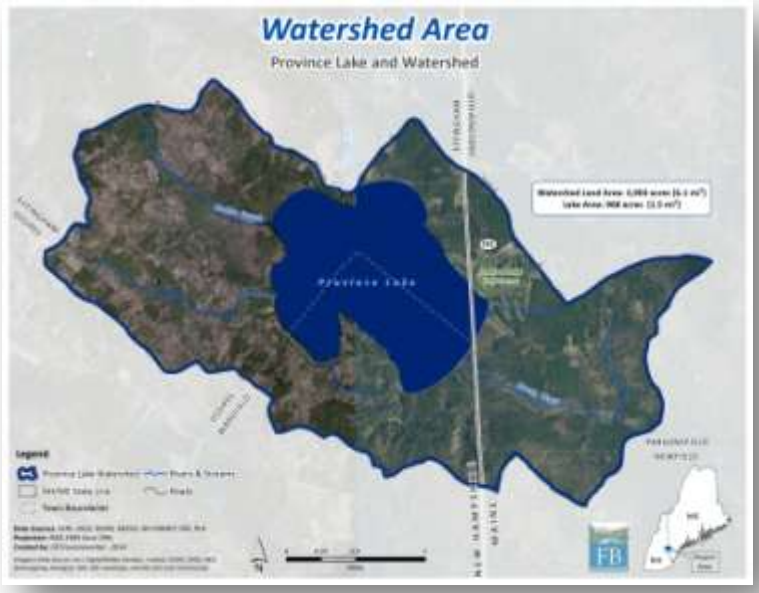
EXECUTIVE SUMMARY

PURPOSE OF THE PLAN

The Province Lake Watershed Management Plan describes the water quality conditions, watershed characteristics, and steps that can be taken to improve and restore the lake's water quality. The Plan establishes water quality goals and objectives, and outlines the actions needed to reach them. Long-term management and funding options for water quality improvements are also discussed. The Plan is the culmination of a major effort led by the Province Lake Association in cooperation with many local and state partners. The Plan is intended to serve as a roadmap for collaborative water quality restoration.

THE PROVINCE LAKE WATERSHED

Within the White Mountain Region of north-central New Hampshire, and southwestern Maine, the Province Lake watershed is located in the towns of Effingham (45%), Wakefield (17%), and Ossipee (4%) in Carroll County, New Hampshire, and Parsonsfield (30%) and Newfield (4%) in York County, Maine. Province Lake flows north into the South River, which flows north to the Ossipee River, a tributary of the Saco River.



The Province Lake watershed covers 6.1 square miles on the New Hampshire/Maine border (Map 1, Appendix A).

Province Lake's watershed (3,903 acres) is small relative to the size of the lake (968 acres). The watershed contains a large percentage of forestland (84%), as well as developed land (12%) (including shoreline development, a golf course, and several private campgrounds), wetlands (3%), and agriculture (1%).

THE PROBLEM

Province Lake is listed on the New Hampshire Department of Environmental Services (NH DES) 2010 and 2012 303(d) list as impaired for Aquatic Life Use due to low pH, high levels of chlorophyll-a and total phosphorus, and is impaired for fish consumption due to mercury. It is also on the 2012 303(d) list as impaired for Primary Contact Recreation (swimming) due to reoccurring cyanobacteria blooms.

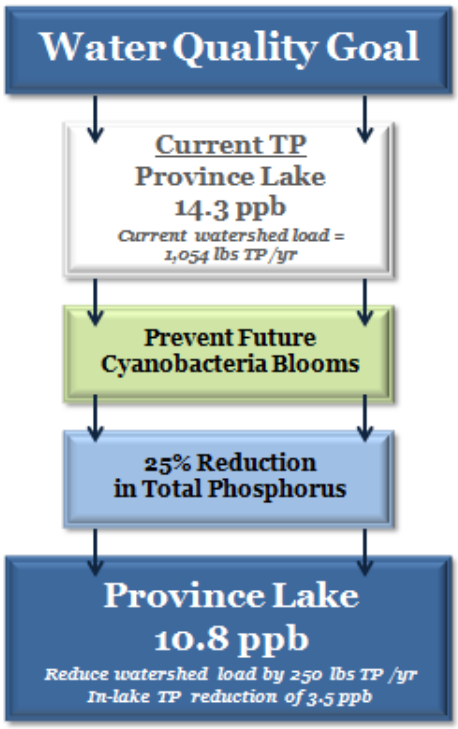
Since the fall of 2010, there has been an increasing prevalence of documented cyanobacteria blooms in localized areas within Province Lake. An abundance of cyanobacteria may indicate excessive phosphorus inputs in the lake, or that the lake ecology is out of balance.

Since 2010, documented cyanobacteria blooms are becoming more frequent on Province Lake- posing a threat to public health. (Photo: AWWA)

Cyanobacteria are a concern in Province Lake for many reasons, including lake aesthetics, concern about declining water clarity and the associated economic effects to the area, and most importantly, the potential affects to wildlife, domestic animals and human health. Cyanotoxins are released into the water when cells die or are consumed by organisms higher in the food chain. Ingesting lake water and/or recreating on a lake with high levels of cyanobacteria can result in both acute and chronic illnesses (NH DES, 2014) that target the liver, kidney, the central nervous system and skin. Since some forms of cyanobacteria are toxic to people as well as other animals, these blooms have resulted in public beach advisories at targeted areas along the shore to protect public health.

While cyanobacteria are naturally occurring in all lakes, their abundance can increase as lake nutrients increase. Increases in phosphorus, (the limiting nutrient in freshwater systems) provide food for algae and cyanobacteria. Other factors that result in bloom conditions include increased water temperature, sunlight, and wind and motorboat activity which can resuspend sediments and nutrients back into the water column. Province Lake is susceptible to all of the above conditions due to its shallow depth, long pitch, and large photic zone (a lighted and well-mixed portion of the lake that extends from the lake surface down to where the light levels decrease to 1% of that at the surface).

The documented cyanobacteria blooms in Province Lake are a signal that current land-use practices on developed land throughout the watershed may be contributing excess sediment and nutrients from soil erosion, aging septic systems, and roads (among other factors), and affecting the health and function of the lake system. Immediate action is needed to prevent future occurrences of potentially toxic cyanobacteria blooms in Province Lake.



THE GOAL

The Province Lake Project Management Team, with technical support from FB Environmental Associates, set a water quality goal to prevent the future occurrence of toxic cyanobacteria blooms on Province Lake. This goal is to reduce the amount of phosphorus entering the lake by 25% (equivalent to 250 pounds of phosphorus) over the next 10-15 years.

A 25% reduction is no easy task, and because there are diffuse sources of phosphorus getting into 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.

ACTIONS NEEDED TO ACHIEVE THE GOAL

The Province Lake Watershed Management Plan provides the means to make the water quality goal a reality. An action plan was developed for Province Lake based on feedback from approximately sixty community members that attended the community forum on January 18, 2014. These stakeholders discussed what they perceived to be the greatest threats to Province Lake's water quality, and developed solutions to address them. The Province Lake Project Management Committee helped further refine these inputs into action items with associated time frames and estimated costs as presented in the action plan (Section 5.2).

The action plan is divided into six major categories which are expected to result in the following load reductions:

Category	**Estimated Load Reduction** *(lbs TP/yr)*
Septic Systems	44 - 55
Shoreline BMPs	66 - 99
Roads	110 - 165
Ordinances & Land Conservation	187 - 209
Boating	TBD
Water Quality Monitoring	N/A
TOTAL EST. LOAD REDUCTION	***407 - 528 lbs/yr***

THE 25% TARGET REDUCTION IN PHOSPHORUS CAN BE ACHIEVEDTHROUGH THE FOLLOWING OBJECTIVES:

1) *Utilize the BMP matrix to identify, prioritize, and implement BMPs throughout the watershed to reduce sediment and phosphorus runoff from existing shoreline development and roads;*
2) *Educate landowners through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a water resource, rarely pumped out, or inadequate);*
3) *Institute greater controls on new development and conversion of seasonal to year-round homes by requiring low-impact development (LID) in site plans, and encourage regular septic system maintenance;*
4) *Protect high value plant and animal habitat, wetlands, and riparian areas through permanent conservation options such as conservation easements;*
5) *Continue and/or enhance water quality monitoring and aquatic invasive plant control programs.*

The action plan is not only designed to reduce phosphorus loading to Province Lake, but also to promote communication between citizens, municipalities, and state agencies. The action plan outlines pollution reduction targets, responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each of the six categories.

FUNDING THE PLAN

The cost of successfully implementing this watershed plan, and to improve water quality in Province Lake is estimated at close to $70,000 per year over the next 10 - 15 years (approximately $18/watershed acre/year). However, many costs are estimated, and many have not yet been factored in. Any changes to the plan should be incorporated into the watershed action plan as information becomes available- through research and after factoring in site-specific design considerations including structural BMPs, such as fixing eroding roads and planting shoreline buffers, and non-structural BMPs such as improving ordinances.

Estimated costs by category are presented below:

Category	**Estimated Annual Cost**	**10-year Total**
Education & Outreach	22,000	$220,000
Municipal Ordinances	$9,600	$96,000
Shoreline, Septic & Road BMPs	$34,000	$340,000
Monitoring	$3,700	$37,000
TOTAL EST. COST	***$69,300***	***$693,000***

A diverse source of funding and a funding strategy will be needed to fully fund planned implementation activities. Funding for **education and outreach** might come from the Province Lake Association (PLA) and Acton Wakefield Watersheds Alliance (AWWA), or state and federal grants. Funding to cover **municipal ordinances** could be supported by municipalities through tax collection, permit fees, or violation fees. Funding to improve **septic systems, public and private roads, and shoreland buffers** could be matched by the states, road associations, private property owners and commercial campgrounds most affected by the improvements. **Monitoring and assessment** funding could come from a variety of sources, including state and federal grants (Section 319, ARM, Moose Plate, etc.) and PLA. The funding strategy should be incorporated into this plan within the first year, and be revisited on an annual basis.

MEASURING SUCCESS

Environmental, Social and Programmatic Indicators and numeric targets (benchmarks) were established to quantitatively measure the progress of the Watershed Plan (Section 5.3). The indicators were developed to reflect how well watershed implementation activities are working, and provides a means by which to track progress toward the established goals and objectives. The benchmarks represent short-term (1-2 years), mid-term (2-5 years) and long-term (5-10 years) targets for improving water quality.

Indicators	**Benchmarks*** *(1-2 years)*	**Benchmarks*** *(2-5 years)*	**Benchmarks*** *(5-10 years)*
Improvement in average annual water clarity ***Goal: 3.0 meters***	+ 0.1 m	+ 0.25 m	+ 0.4 m
Reduction in the in-lake phosphorus concentration ***Goal: 10.8 ppb***	10% of goal= 14.0 ppb	30% of goal= 13.3 ppb	75% of goal= 11.7 ppb
Percent reduction in the number of reported algal blooms ***Goal: No reported blooms***	10%	50%	90 - 100%
Decreasing trend in apparent color ***Goal: Non-colored, decreasing trend***	< 30 PCU	< 25 PCU	<20 PCU

** Benchmarks are cumulative starting at year 1.*

Much of this progress weighs heavily on the cooperation of local municipalities and key stakeholders to support the plan, and the ability of the Province Lake Watershed Steering Committee to develop a sustainable funding strategy. Setting benchmarks allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The steering committee will review the benchmarks for each indicator on an annual basis to determine if progress is being made, and then determine if the watershed plan needs to be revised if the targets are not being met.

ADMINISTERING THE PLAN

The Province Lake Watershed Management Plan provides a framework for restoring the Province Lake watershed in order to improve water quality conditions so that the lake no longer supports cyanobacteria blooms. The plan includes a series of goals and objectives, or planning actions including: a list of high-priority sites for restoration, phosphorus loading reductions, cost estimates, preliminary funding mechanisms, benchmarks for measuring success, and a timeframe for accomplishing each of the action items.

Rainbow over Province Lake (Photo: Barber, PLA)

The plan will be led by the combined efforts of the PLA and AWWA, in coordination with a watershed steering committee. Because local participation is an integral part of the success of this plan, the committee should include the leadership of NH Department of Environmental Services (NH DES), Maine Department of Environmental Protection (Maine DEP), local municipalities (including Wakefield, Effingham, New Hampshire and Parsonsfield, Maine) schools, community groups, local businesses, road associations, and individual landowners. The formation of smaller action committees that focus on the six main watershed action categories would result in more efficient implementation of the plan.

The steering committee will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce nonpoint source pollution in the watershed, thereby eliminating the occurrence of toxic cyanobacteria blooms in Province Lake.

CHAPTER OVERVIEW

The Province Lake Watershed Management Plan features five main sections. Below is a summary of information presented by section:

SECTION 1- INTRODUCTION

Section 1 introduces the plan by describing the problem, the goals and objectives, the community-based planning process, and applicable federal regulations. Section 1 also provides background information, including watershed survey results and current watershed efforts in phosphorus reduction and awareness.

SECTION 2- WATERSHED CHARCTERIZATION

Section 2 describes the watershed, providing detailed information about climate, population and demographics, land use, topography, soils and geology, wetlands and riparian habitat, lake morphology and morphometry and drainage areas or tributaries.

SECTION 3- ASSESSMENT OF WATER QUALITY

Section 3 describes water quality standards, highlights the estimated sources of phosphorus in Province Lake, and provides a summary of the current water quality classification based on the water chemistry assessment and water quality goals. Estimates of future phosphorus loading, municipal ordinance recommendations, septic survey results, and identification of nonpoint source (NPS) pollution are also included in this section.

SECTION 4- MANAGEMENT STRATEGIES

Section 4 outlines the necessary management strategies (structural and non-structural best management practices (BMPs) as well as alternative treatments) to reduce phosphorus in Province Lake. Current and future sources of phosphorus are discussed and an adaptive management strategy is presented.

SECTION 5- PLAN IMPLEMENTATION

Section 5 describes who will be carrying out this plan and how the action items will be tracked to ensure that necessary steps are being taken to improve the water quality of Province Lake over the next 10-15 years. This section also provides estimated costs and technical assistance needed to successfully implement the plan, a description of the education/outreach and monitoring activities that are needed, and a description of the evaluation plan to assess the effectiveness of restoration and monitoring activities.

INCORPORATING EPA'S 9 ELEMENTS

The Province Lake Watershed Management Plan includes nine key planning elements to restore waters impaired by nonpoint source (NPS) pollution. These guidelines, set forth by the U.S. Environmental Protection Agency (EPA), highlight important steps in protecting water quality for waterbodies impacted by human activities, including specific recommendations for guiding future development, and strategies for the reducing the cumulative impacts of NPS pollution on lake water quality. The following locates the section write-up and describes the nine required elements found within this plan:

A. **Identify Causes and Sources: Sections 1.5, 3.4, 3.7, 3.8, and 4.3** highlight known sources of NPS pollution in the Province Lake watershed and describe the results of the watershed and septic system survey conducted in 2013. 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 Planned Management Measures** described under (C) below: **Section 4** describes how reductions in annual phosphorus loading to Province Lake may be realized over a ten to fifteen year period, and describes the methods used to estimate phosphorus reductions. These reductions apply primarily to structural best management practices (BMPs) for existing development (e.g. installing vegetated buffers, improving and maintaining roads, and upgrading septic systems), but they will not be possible without the use of non-structural BMPs. Examples of non-structural practices include, but are not limited to reviewing and improving zoning ordinances, promoting the use of low impact development (LID) designs for future development, and educating watershed residents and visitors about activities to reduce phosphorus.

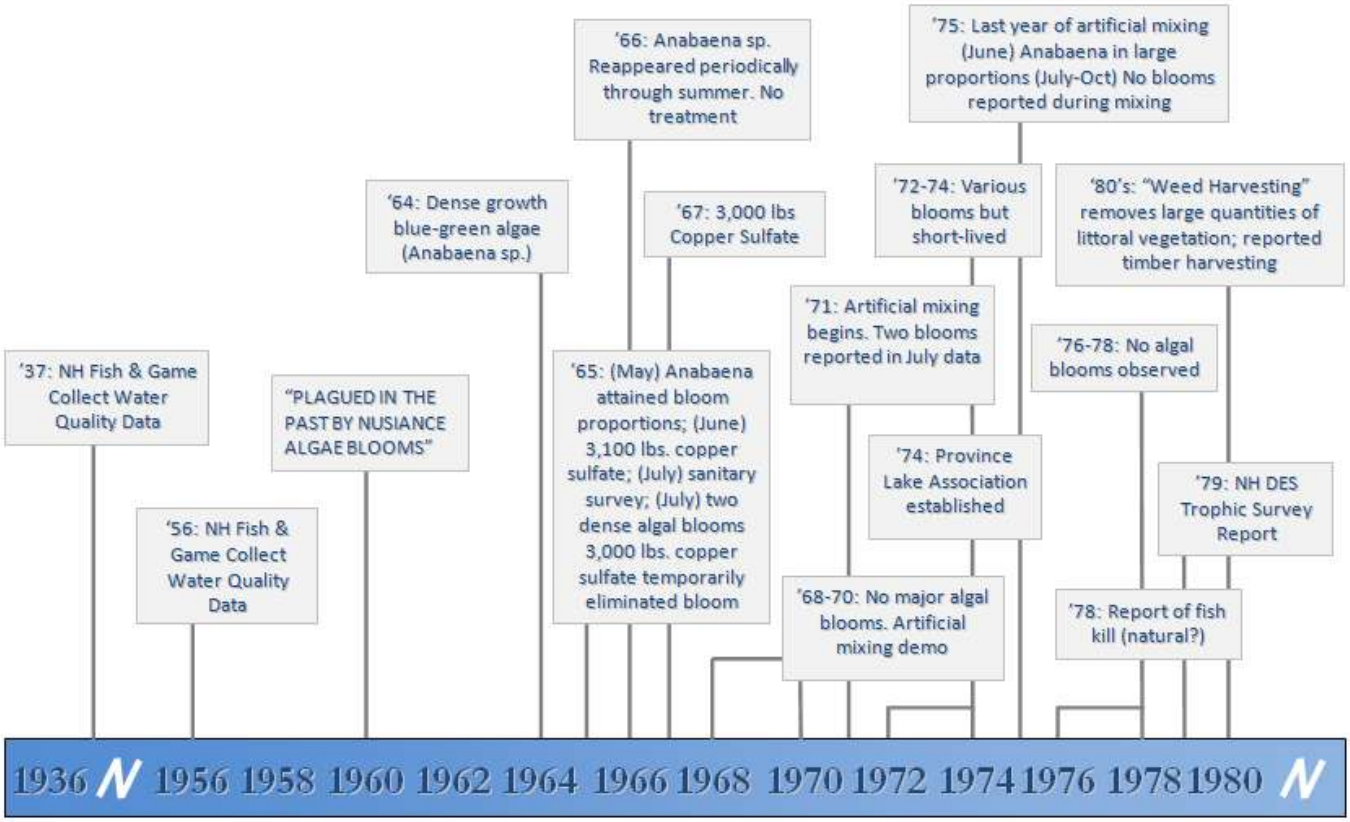
C. **Description of Management Measures: Section 5** identifies ways to achieve the estimated phosphorus load reduction and reach water quality targets described in (B) above. The action plan focuses on six major topic areas that address NPS pollution, including: Septic Systems, Shoreline BMPs, Roadway BMPs, Municipal Ordinances and Land Conservation, Recreation/Boating, and Water Quality Monitoring. 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 5.2 and 5.4** includes a description of the associated costs, sources of funding, and primary authorities responsible for implementation. The estimated cost to address NPS pollution and reduce phosphorus loading to Province Lake is estimated at $70,000 per year over the next ten years (or $700,000). A diverse source of funding, a detailed funding strategy, and collaborative partnerships (states, towns, lake and watershed associations, private landowners, road associations and businesses) will be needed to fully fund planned implementation activities. Site specific BMP costs are presented in Appendix C.

E. **Information & Education & Outreach: Section 5.5** describes how the Education and Outreach component of the plan should be implemented to enhance public understanding of the project. This includes leadership from the PLA and AWWA to promote lake/watershed stewardship. BMP demonstration sites, annual beach clean-ups and discovery cruises, and targeted septic education are among a few of the proposed actions within the plan.

F. **Schedule for Addressing Phosphorus Reductions: Section 5.2** provides a list of strategies to reduce stormwater and phosphorus runoff to Province Lake. Each strategy, or "Action Item," has a set schedule that defines when the action should begin. The schedule should be adjusted by the steering committee on an annual basis (see **Section 4.4** on Adaptive Management).

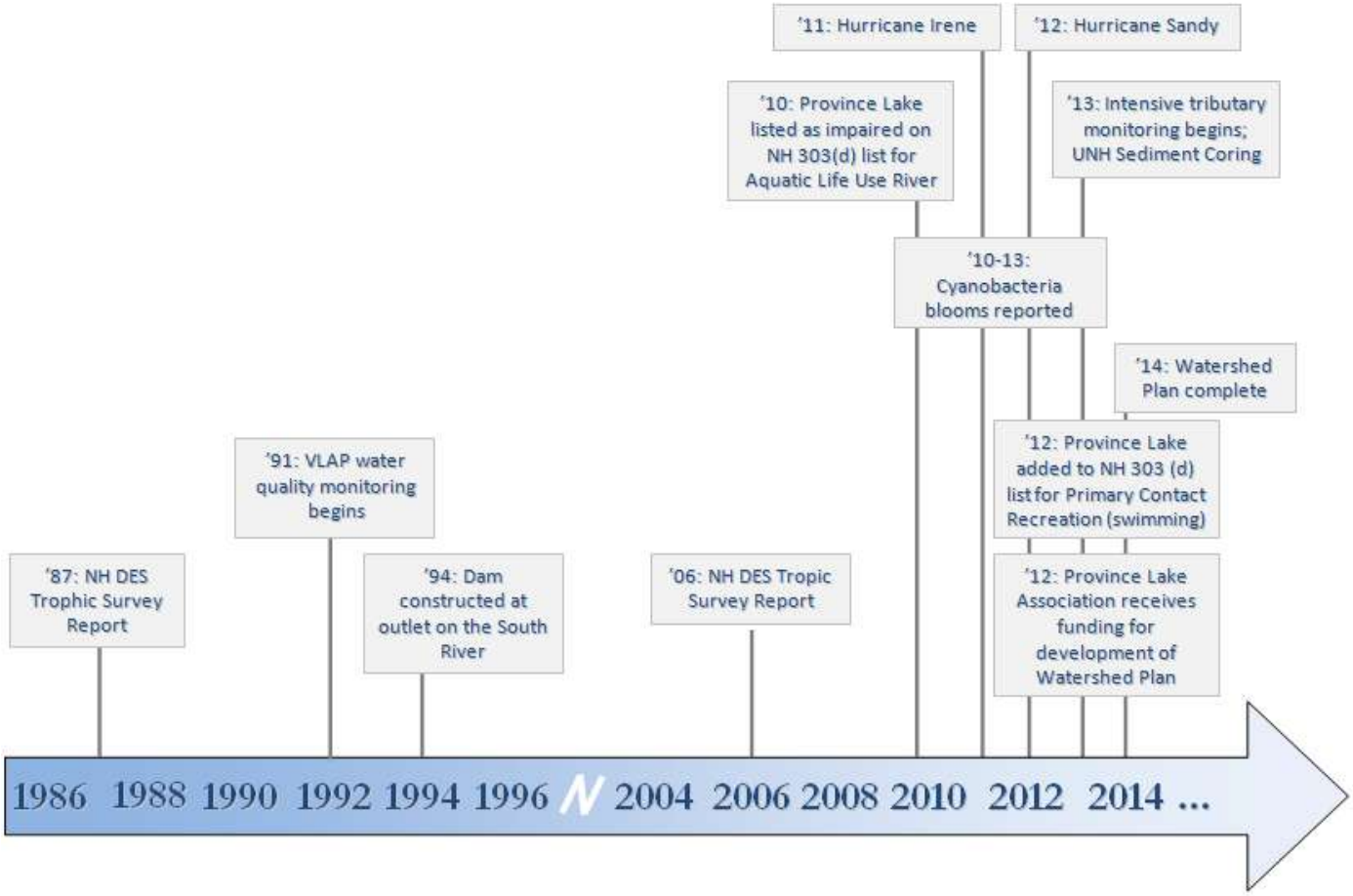
G. **Description of Interim, Measureable Milestones: Sections 5.3 and 5.7** outline indicators of implementation success that should be tracked annually. Using indicators and benchmarks to measure progress makes the plan relevant and helps sustain the action items. The indicators are broken down into three different categories: Environmental, Programmatic, and Social Indicators. Environmental indicators are a direct measure of environmental conditions, such as reduced in-lake phosphorus concentration and decreased prevalence of cyanobacteria blooms. 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 stakeholders on the steering committee or the number of new lake monitoring volunteers. Indicators are broken out into projected benchmarks (milestones) at 1-2 years, 2-5 years and 5-10 years into the planning process.



Province Lake Timeline (1936 to 2014)

H. **Set of criteria: Section 5.3** can be used to determine whether loading reductions are being achieved over time, if substantial progress is being made towards water quality objectives, and if not, criteria for determining whether this plan needs to be revised.

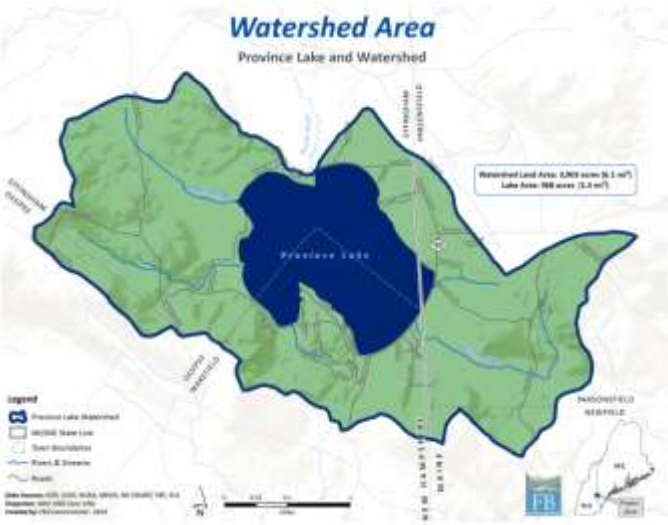
I. **Monitoring component: Section 5.6** describes the long-term water quality monitoring plan for Province Lake, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The ultimate objective of this plan is to prevent cyanobacteria blooms. This means taking immediate actions to reduce the amount of phosphorus delivered to the lake from developed land within the watershed. 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. INTRODUCTION

1.1 Background & Purpose

Province Lake is located on the New Hampshire/Maine border in the towns of Effingham and Wakefield, in Carroll County, New Hampshire, and Parsonsfield in York County, Maine. Province Lake serves as an attractive summer getaway for tourists and seasonal residents who come to enjoy the scenic beauty and recreational opportunities provided by the lake.



Province Lake is located on the Maine/New Hampshire border in the towns of Parsonsfield, ME and Effingham and Wakefield, NH.

Reoccurring cyanobacteria blooms pose a serious threat to human health and the quality of life that residents and visitors alike come to expect during the summer months at Province Lake. The cause of blooms is multi-faceted, and is largely driven by increasing levels of nutrients, specifically phosphorus in the lake. Phosphorus can be delivered to the lake in sediment via soil erosion from developed areas including houses, campgrounds, and roads throughout the watershed. Other factors that may be contributing to the blooms include aging septic systems, and resuspension of phosphorus in the water column from motor boats and wind. Additional, factors such as the increase in large storm events such as Hurricane Irene (2011) and Hurricane Sandy (2012) may be influencing the changes in lake chemistry enough to contribute to documented blooms.

In 2012, the Province Lake Association (PLA) applied for and received a New Hampshire Department of Environmental Services (NH DES) Watershed Assistance Grant to develop a watershed-based plan, which was partially funded by NH DES, with additional financial and in-kind services provided by the PLA. The purpose of the plan is to develop a series of actions that will reduce pollution and improve the lake's water quality.

Two years after initial discussions began to address the lake's impairments, this comprehensive watershed plan has been created which will provide guidance for the next phase of actions to improve the water quality of Province Lake.

The plan is the culmination of a major effort by many individuals who really care about improving the long-term water quality of the lake. Throughout the process, many individuals enthusiastically participated including members of the PLA, the Acton Wakefield Watersheds Alliance (AWWA), staff from NH DES, faculty and students from the University of New Hampshire (UNH), and watershed residents and stakeholders.

As part of this plan, a municipal ordinance review, buildout analysis, water quality analysis, and septic system and watershed surveys were conducted. Results of these efforts were used to run a land-use loading model to estimate the current and projected amount of phosphorus being delivered to the lake from the watershed. Since phosphorus is the limiting nutrient in freshwater systems (driving growth of algae and cyanobacteria) total phosphorus was used for setting a water quality improvement goal for the lake.

1.2 Statement of Goal

This plan provides short and long-term goals for improving the water quality of Province Lake over the next 10 - 15 years (2014-2029). The long-term goal is to improve the water quality and prevent the future occurrence of toxic cyanobacteria blooms on Province Lake. **Success would mean reducing the amount of phosphorus entering the lake by 25%.** This goal can be achieved through the following structural treatment options and non-structural objectives:

1) **Utilize the BMP matrix** to identify, prioritize, and implement BMPs throughout the watershed to reduce sediment and phosphorus runoff from existing shoreline development and roads (Sections 3.8, 4.2 and 5.2).
2) **Educate landowners** through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a water resource, or rarely pumped out) (Section 5.5).
3) **Institute greater controls on new development** and conversions from seasonal to year-round residential by requiring low-impact development (LID) in site plans, and encouraging regular septic system maintenance (Sections 3.6, 4.1 and 4.2).
4) **Protect high value plant and animal habitat,** wetlands, and riparian areas through permanent conservation options such as conservation easements (Section 2.3.2 and Section 2.3.3).
5) **Continue and/or enhance water quality monitoring** and aquatic invasive plant control programs (Section 2.4 and Section 5.6).

These objectives are discussed in greater detail in the action plan (Section 5.2).

1.3 Plan Development and Community Participation Process

This plan was developed through the collaborative efforts of numerous project management team meetings and conference calls between FB Environmental Associates (FBE) and outside technical staff, including PLA, AWWA, UNH Stormwater Center, UNH Center for Freshwater Biology, NH DES and Maine DEP (see Acknowledgments). A description of the main steering committees follows.

- The Province Lake Project Management Team served to review data and help prioritize sites for BMP implementation.

- The Province Lake Watershed Plan Steering Committee met once at the Province Lake Golf Club for a project kick-off meeting at the Province Lake Golf Club on April 12, 2013 to discuss the project goals and objectives and schedule. Members of the committee include representatives from the towns of Wakefield and Effingham, NH, PLA, AWWA, the Golf Course, and FBE;

- The Province Lake Water Quality Steering Committee was formed to review the water quality data and help set the water quality goal. This group met twice. The first meeting was held at NH DES on July 10, 2013 to review the results of the water quality analysis and set an interim water quality goal. The second meeting was held at UNH on November 6, 2013 to present the results of the watershed loading model and buildout analysis, set the final water quality goal, and to learn more about the cyanobacteria monitoring efforts underway at UNH.

Information about the watershed management plan was presented to the public on three occasions:

- FB Environmental presented background information about the plan development process and water quality analysis at 2013 PLA annual meeting at the Province Lake Golf Course on July 20, 2013, with AWWA staff presenting information on the watershed survey;

Approximately sixty community members attended the community forum in January 2014. (Photo: AWWA)

- FB Environmental provided an update on the results of the watershed planning process to date at a public forum at the Greater Wakefield Resource Center in Union, NH on January 18, 2014. Project partners organized facilitated break-out groups to gather input on perceived threats and solutions to improving water quality for the watershed action plan, and additional input was solicited for those unable to attend the public forum by posting a draft of the action plan on the PLA website in February 2014;

- FB Environmental presented the results of the final management plan (including the water quality goal) at the 2014 Province Lake annual meeting at the Province Lake Golf Club on July 19, 2014. Approximately eighty-two community members attended the community forum and provided valuable input for this plan. Attendees represented a diverse subset of the community, including the PLA, AWWA, officials from Wakefield and Effingham, commercial business owners, agency and academic representatives, local press and watershed citizens. The forum was designed to provide local stakeholders with background information about the watershed and water quality of Province Lake, to solicit stakeholder concerns, and to discuss the timing and elements of the watershed management plan. The Province Lake Project Management Team helped further refine these inputs into action items with associated time frames and estimated costs as presented in the action plan

(Section 5.2). The biggest threats to water quality identified were old septic systems and outhouses, shoreline erosion, poorly maintained roads, power boating in shallow coves, and lack of zoning to protect water quality.

1.4 Current Watershed Efforts

1.4.1 Watershed Organizations

The Province Lake Association (PLA) was originally established in 1974. It is an organization of area property owners, friends and visitors who love this lake and share the mutual interest of maintaining the quality of the lake. The association was established to educate, communicate and coordinate with its members and the community what is and can be done to protect, preserve and improve the quality of Province Lake. Currently, with over 130 members, the association is coordinated by a ten member Board of Directors which includes four officers (President, Vice President, Secretary and Treasurer).

The Province Lake Association (PLA) hosts several annual events including the PLA breakfast. (Photo: PLA)

The PLA currently oversees many annual events and programs including the Weed Watch program, Lake Host program, water quality monitoring through the NH DES Volunteer Lake Assessment Program (VLAP), beaver monitoring and lake-level monitoring through our dam management program. Other annual events and fund raising programs include a golf tournament, lake breakfast, and various raffles.

In 2006, the PLA began working with the Acton Wakefield Watersheds Alliance (AWWA), a regional non-profit organization established in 2005. AWWA is dedicated to protecting and restoring the water quality of the lakes, ponds, rivers and streams of Wakefield, New Hampshire and the border region of Acton, Maine. AWWA staff members and volunteers work within the communities to strengthen the understanding that what happens on land determines the health of the local waters. Healthy waterbodies provide essential benefits to our communities as a natural resource, wildlife habitat, recreational opportunity and economic engine.

AWWA employs a Youth Conservation Corps (YCC) annually to implement erosion control techniques in order to protect local waterbodies. AWWA staff oversees the YCC and pollution control projects while actively promoting water resource awareness in the communities that they serve. AWWA offers workshops, teaches in the local schools, works with the town boards, presents at local lake association meetings, and staffs informational

AWWA's Youth Conservation Corps has installed eleven projects on Province Lake to date (Photo: AWWA)

displays and activities at community events. AWWA has presented at several PLA meetings, and maintained an active role in the Province Lake community, having completed eleven YCC projects on Province Lake and preventing an estimated total of 41 tons of sediment and over 35 lbs. of phosphorus from reaching the lake. AWWA prepared the watershed and septic survey reports for the watershed plan. AWWA will continue its role in helping implement the Province Lake Watershed Management Plan by completing more YCC projects, implementing road fixes, assisting conservation efforts, and increasing public education and awareness alongside the PLA.

1.4.2 Septic Survey

There are a variety of different types of wastewater systems designed to deal with human waste. Septic systems, outhouses, and even portable toilets help us to manage our wastewater to prevent undue harm to human health, aquatic life, or water resources. However, outdated or improperly maintained systems can release disease-causing bacteria into waterbodies, causing gastrointestinal illness and ecosystem dysfunction. While soils serve as an efficient filter of phosphorus in subsurface wastewater systems, failing systems have the potential to contribute excessive phosphorus into lakes and stream through groundwater. Because septic effluent contains about one thousand times the concentration of phosphorus than what is in lake waters (Gilliom and Patmont, 1983), a small amount of effluent can have a major impact on a lake as small as Province Lake.

The Province Lake Door-to-Door Septic Survey provides a "snap-shot" of the state of wastewaters systems in the watershed. (Source: beachwaterchers.net)

A door-to-door septic survey was conducted for all properties located within 250 feet of Province Lake and adjacent to tributaries. Results of the septic survey indicate that septic waste is a major concern for Province Lake due to the high percentage of old systems (>20 years old), cesspools and outhouses. Results of the septic survey are described in detail in Section 3.7.

1.4.3 Watershed Surveys

A watershed survey is designed to locate potential sources of NPS pollution in a geographical area that drains into a waterbody. Watershed surveys are an excellent education and outreach tool, as they raise public awareness by documenting types of problems, engaging volunteers, and providing specific information to landowners about how to reduce NPS pollution on their property. 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

Bare, exposed soil, and runoff from the roadway on Rt. 153, results in delivery of nutrients and sediments into Province Lake. (Photo: AWWA)

watershed. Results of the watershed survey are presented in more detail in Section 3.8.

1.4.4 Land Conservation

Land conservation in the undeveloped headwater areas, steep slopes, critical wildlife habitat and other environmentally sensitive land and water resources including riparian corridors adjacent to the lake and streams can provide significant benefits for the long-term protection of the water quality of Province Lake. In addition, land conservation provides low-impact public recreational opportunities such as hiking, hunting, and fishing to these natural resources. Several local land trusts are active in the towns within the watershed, yet land protection efforts have been limited. More information on current and proposed the land conservation efforts are described in Section 2.3 and Appendix B.

1.4.5 Public Outreach

Outreach efforts by the Province Lake Association (PLA) are aimed at local and seasonal residents, summer visitors, and community decision-makers. Through the lake host program, golf tournament, and lake breakfast, the mission of the PLA to educate, communicate and coordinate with its members and the community about what can be done to protect, preserve and improve the quality of Province Lake has been widely distributed across the watershed. The 2013 watershed and septic survey was an effort to educate lakefront residents on the use of non-phosphorus based products, such as detergents and fertilizers, preventing erosion, and awareness of septic system issues. Educational materials distributed during the watershed and septic surveys are available to all interested residents through the Association's frequently-updated website (http://provincelake.org).

The Province Lake Associations (PLA) hosts an annual breakfast to raise awareness among watershed residents about water quality issues, and raise funds to support watershed programs. (Photo: Donna Davis)

"We hope for an ever growing number of spirited, involved community members who will continually support the future of our lake."

-Donna Davis, PLA

In addition, AWWA actively promotes water resource awareness in the communities. AWWA offers workshops, teaches in the local schools, works with the town boards, presents at local lake association meetings, and provides educational information at local community events. AWWA and PLA will continue to collaborate to increase public education and awareness in the Province Lake watershed.

2. WATERSHED CHARACTERIZATION

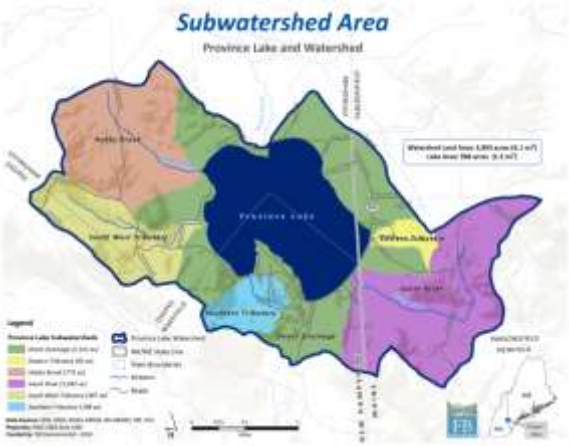
Many seasonal residents in the Province Lake watershed enjoy the natural beauty of the landscape from Memorial Day through Labor Day each year. These seasonal residents and visitors utilize various types of properties around the lake shore, including private camps, private rental camps, group rental cottages, commercial campgrounds, and overnight cabins. There is a lakeside golf course as well as privately-owned land adjacent to Route 153 used by the public for swimming, and a boat launch owned by the Towle Farm Community Corporation off Bonnyman Road.

Understanding population growth, demographics, and watershed development patterns provides critical insight into watershed management, particularly as it pertains to lake water quality. The Province Lake watershed is characterized by 87% undeveloped land. The 13% of the watershed considered developed consists largely of low to mid-density residential development along the lake shore and major roadways within the watershed.

2.1 Location & Climate

Province Lake remains a hub for recreation in the summer and winter months, with vacationers and year round residents owning property around the lake. The lake and surrounding watershed offers fishing, boating, camping, swimming, and golf in the summer, and ice fishing, cross country skiing and snowmobiling in the winter. Province Lake has a small watershed (3,903 acres/6.1 square miles) relative to the lake's surface area (968 acres/1.5 square miles). The watershed is located within the White Mountain Region of north-central New Hampshire, in the towns of Effingham (45%), Wakefield (17%), and Ossipee (4%) in Carroll County, New Hampshire, and Parsonsfield (30%) and Newfield (4%) in York County, Maine. While only 1.8% of the lake area is located in Maine, a larger part of the watershed is located in Maine (34%), approximately half of the total land area in New Hampshire.

The watershed can be divided into six distinct subwatersheds. Five of the subwatersheds (Hobbs Brook, Southwest tributary, Southern tributary, South River, Eastern tributary) contain tributaries that collect runoff from the surrounding land area and deliver it directly to Province Lake. The largest subwatershed is the Province Lake Direct Drainage (green area in map to right), which includes the area that flows over land directly to the lake. This subwatershed contains the greatest density of development and roads. The second largest subwatershed is the South River (pink area in map to right), which drains the eastern portion of the watershed in Parsonsfield, Newfield and a small portion of Wakefield. The Eastern tributary drains the Province Lake Golf Club, and is the smallest of the six subwatersheds.



The Province Lake watershed consists of six smaller subwatersheds (Map 2, Appendix A).

Province Lake is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions of the New Hampshire Lakes Region. The area experiences moderate rainfall and snowfall, averaging 51.7 inches of precipitation annually over the past decade. The average winter temperature over the past decade is 21.5°F, while the average summer temperature is 65.1°F (NOAA, 2010). Winter extends from December to March, with normal ice out in mid to late April.

2.2 Population, Growth Trends & Land Use

2.2.1. Population and Growth Trends

According to the US Census Bureau, the towns within the Province Lake watershed have experienced steady population growth since the middle part of the last century. The combined population of the three towns that make up the majority of the watershed has grown from 2,421 people in 1960 to 8,441 people in 2010- a 249% increase. The average annual growth rate of the three towns during this period is 2.49% (Table 1).

Table 1. *Population and growth trends for Province Lake watershed communities.*

Town	1960	1970	1980	1990	2000	2010	Numeric Change 1960-2010	Percent Change 1960 - 2010	Avg. Annual Growth Rate
Effingham, NH	329	360	599	941	1,273	1,465	1,136	345%	3.45%
Wakefield, NH	1,223	1,420	2,237	3,057	4,252	5,078	3,855	315%	3.15%
Parsonsfield, ME	869	971	1,089	1,472	1,584	1,898	1,029	118%	1.18%
Combined	***2,421***	***2,751***	***3,925***	***5,470***	***7,109***	***8,441***	***6,020***	***249%***	***2.49%***

(Source: FBE, 2014b. Does not include estimates for Newfield or Ossipee)

Demographics within the watershed towns indicate that the majority of the population is between the ages of 20-64 years old, and the number of people less than 20 years old exceeds the number of retirement age people (65+) in these towns. Ossipee has the greatest percentage of people over age 65 (Table 2).

Table 2. *2010 population demographics for Province Lake watershed communities.*

Town	Total Population	Population Aged 0-19	Population Aged 20-64	Population Aged 65+
Effingham, NH	1,465	317	925	223
Ossipee, NH	4,345	924	2,578	843
Wakefield, NH	5,078	1,126	3,071	881
Newfield, ME	1,522	357	959	206
Parsonsfield, ME	1,898	561	1,148	280

(Source: US Census American Fact Finder, 2014)

The total number of seasonal vs. year-round residents in the Province Lake watershed is based on results from the 2013 Septic Survey, in which respondents within the 250 foot shoreland zone were asked whether they used their house year round, seasonally, or for more than one season. These statistics illustrate the well-known fact that lakes are an attractive destination for second homeowners and tourists seeking a tranquil summer retreat, and Province Lake is no exception.

Table 3. *Occupancy status of landowners in the Province Lake watershed.*

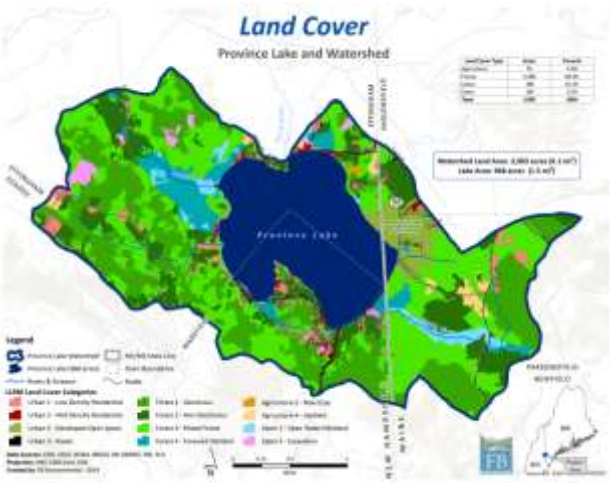
Occupancy Status	**% of Population**
Year round	13%
Seasonal (< 50 days/yr)	46%
More than one season (50-150 days/yr)	38%
No response/Other	3%

(Source: Province Lake Septic Survey - AWWA, 2013b)

The desirability of Province Lake as a recreational destination will likely stimulate continued population growth in the future, including an increase in the number of year-round residents. Growth figures and estimates suggest that communities within the watershed 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.

2.2.2 Land Use

Characterizing land use within a watershed on a spatial scale can highlight potential sources of nonpoint source (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 from NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams.



Land use is the Province Lake watershed is dominated by mixed forestland (Map 3, Appendix A).

Comparing land use within a watershed over time can also highlight significant changes. Over the past 50 years, the Province Lake watershed has experienced changes in land use, largely as a result of new development, upgrades to seasonal camps, conversion of agricultural land, and ongoing forestry activities. Land use is an essential element in watershed

<u>Vision:</u> "That there will be a time when people have a heightened respect for our environment and better understand the lake and the actions required to continue to move the water closer to what it can be." *-Pete Dinger, PLA*

modeling because it can help estimate the contribution of phosphorus from the watershed to the lake via stormwater runoff. Unmanaged forested land, for example, tends to deliver very little phosphorus downstream when it rains, while row crops and high density urban land export significantly more phosphorus due to fertilizer use, soil erosion, car and factory exhaust, pet waste, and many other sources.

Impervious Cover (IC) *refers to developed and landscaped areas covered by roads, driveways, parking lots and rooftops that no longer absorb rain, and may direct large volumes of polluted stormwater runoff into nearby lakes and streams.*

As part of the watershed planning process, digital land use data was updated by FB Environmental. This included carefully reviewing the assigned land use types, and making changes where necessary based on local knowledge or field observations. Today, developed land (including agriculture at ~ 1.4%) accounts for approximately 12% of the watershed, while forested area (dominated by mixed hardwood/softwood forests) makes up the majority of the watershed (~ 84%). Wetlands and open water (not including the surface areas of Province Lake) make up approximately 3% of the watershed.

Developed areas within the Province Lake watershed are characterized by ***impervious cover*** such as roads, driveways, rooftops, and patios. Unlike naturally vegetated areas such as forests, impervious cover does not allow water to infiltrate into the ground, and therefore results in stormwater runoff. This stormwater flowing to nearby streams and the lake carries pollutants such as sediment, nutrients, pathogens, pesticides, hydrocarbons, and metals that are harmful to aquatic life and/or result in increased probability of algae and cyanobacteria. Studies have shown a link between the amount of impervious cover in a watershed and water quality conditions (CWP, 2003).

While development in the Province Lake watershed is primarily restricted to the direct drainage area and roadways, it makes up 12% of the overall land use, but accounts for 53% of the total phosphorus load to the lake, more than any other land use type (Figure 1). In addition, due to its expansive area and intensity of development, the direct drainage area yields the greatest load of phosphorus among the six subwatersheds.

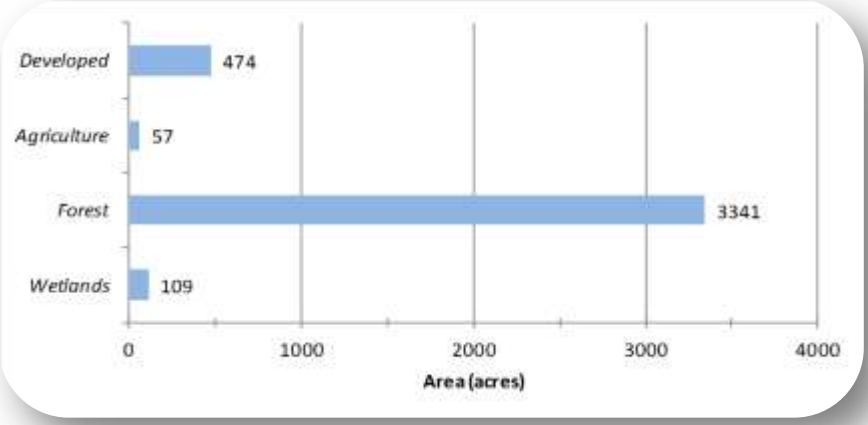


Figure 1. *Land use in the Province Lake watershed.*

Projected population growth trends and future development patterns in the watershed will dictate the extent of impervious cover. Therefore, it is imperative that watershed communities incorporate low-impact development (LID) techniques into new development projects to minimize the effects of impervious cover, allowing water to soak into the ground rather than flow into the lake.

2.2.3 Commercial and Residential Development

There are several fairly large commercial and residential developments within the Province Lake watershed including the golf course, five campgrounds and two road associations.

Aerial view of the Province Lake Golf Club. (Photo: Province Lake Golf)

Province Lake Golf Club: The Province Lake Golf Club is a prominent watershed feature located on the north-east side of the watershed. The course includes 300 acres of land including housing, wooded areas as well as streams and ponds. It was originally built in 1918 as a 9-hole course that provided at least a glimpse of the lake from every hole. It remained a 9-hole course until the second nine was added in 1988. The second nine was added to the wooded area to the east of the original nine. One of the more interesting features of the course is that the majority of the holes are in Parsonsfield, ME, however on #4, you tee off in Maine and can hit your drive into Effingham, NH. The 5th hole is a par 3 all in Effingham and on #6, you tee off in NH and hit your drive back into Maine. Local wildlife can be seen all around the course.

The Province Lake Golf course began using strictly phosphorus-free fertilizer in 2001. FB Environmental and PLA met with the course Managing Director in September 2013 and conducted a site inspection that documented potential sites for enhancement, and made recommendations on how the course could address them. Recommendations included continued use of phosphorus-free fertilizer, reducing erosion on the course and to add vegetative buffers to drainage areas, and consideration of enrolling in the Audubon Cooperative Sanctuary Program.

Province Shores Campground: Consisting of approximately eight acres of land off Remick Road in Effingham, Province Shores Campground has a total of 80 sites available for trailers, 77 of which are used for the entire season. The majority of these trailers remain on the property year-round. A tributary to Province Lake flows through the property.

Jolly Roger Campground, Butler Field, MacDougal Field, The Grove and Happy Hollow Campground: These four "non-traditional" campgrounds include built structures as opposed to mobile units, and are located in different areas around the lake. The structures are typically small, with no running water, no heat/insulation and no foundations, but have small crawl spaces. Camp owners pay rent to the landowner. Jolly Roger has its office in Parsonsfield, ME, but all of the approximately 45 camps are located in Effingham, NH. Butler Field, MacDougal Field, The Grove and Happy Hollow are located in East Wakefield, NH.

Roads and Road Associations: The lake has three primary roads around it that are public. Route 153 (a.k.a. Province Lake Road) is State owned and maintained by both New Hampshire Department of Transportation (DOT) on the western section and Maine DOT on the eastern section. Bonnyman Road in East Wakefield and Effingham, NH is on the southeastern side of the lake, and is maintained by the Towns of Wakefield and Effingham. Bailey Road in Effingham, NH is on the northern side of the lake, and is maintained by the Town of Effingham, NH. Off of these primary roads, there are several small, primarily gravel, private roads maintained by the homeowners on those roads. There are two legally established road associations, one is the Towle Farm Community Corporation which includes approximately 65 houses and the primary boat launch off Bonnyman Road. The other legal road association is on Point Road and includes about 30 houses. Many of the other private roads have "informal" associations to maintain the road.

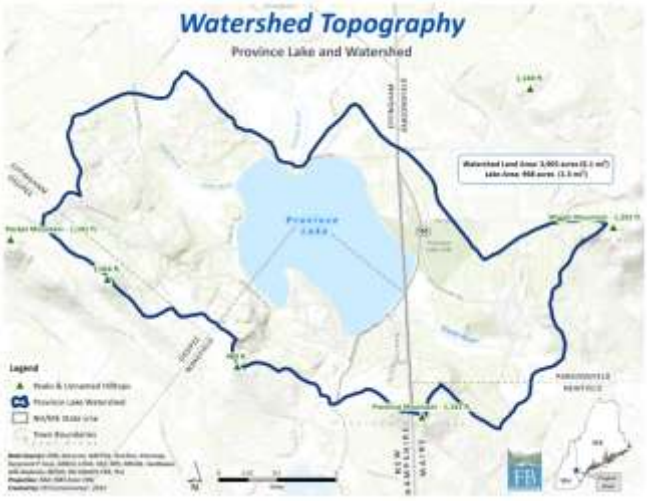
There are 6.3 miles of roads within riparian buffers in the Province Lake watershed (Map 4, Appendix A).

An assessment of roads within riparian areas in the watershed indicates that there are 6.3 miles of roads in the watershed that are located within riparian areas (within 250 feet of the lakes and wetlands, and within 75 feet of streams). This is the equivalent of the length of all rivers and streams in the watershed. Road runoff and road erosion can be a major source of pollutants (road salt, petroleum products, heavy metals, sediment and nutrients, etc.) in lake watersheds, and have a major effect on water quality.

2.3 Physical Features

2.3.1 Topography

At 480 feet above sea level, Province Lake is ringed by mountains, topped at 1,292 feet above sea level by Wiggin Mountain to the east, Province Mountain to the south at 1,141feet above sea level. Mountain peaks within or near the Province Lake watershed include Page Mountain (994 feet) to the east; Colcord Hill (781 feet), and Rumney Hill (695 feet) to the north; and Pocket Mountain (1,216 feet) to the west.



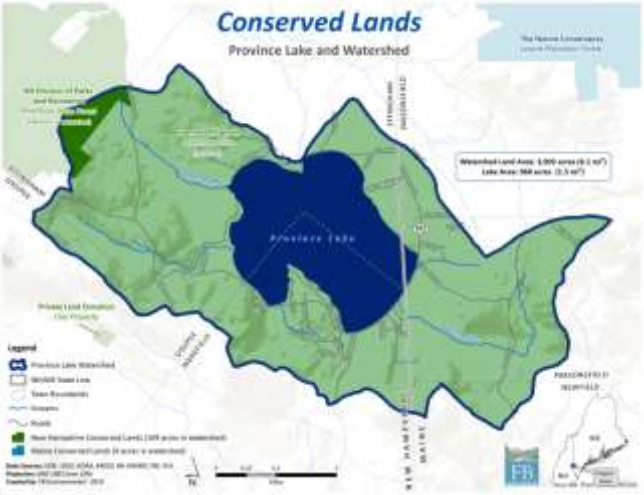
Province Lake is located in the White Mountain region of New Hampshire (Map 5, Appendix A).

2.3.2 Land Conservation

Land conservation in the undeveloped headwater areas can provide significant benefits for the long-

term protection of the water quality of Province Lake Target areas are steep slopes, critical wildlife habitat and other environmentally sensitive land and water resources including riparian corridors adjacent to the lake and streams.. In addition, land conservation provides low-impact public recreational opportunities such as hiking, hunting, and fishing to these natural resources.

There are three land trust organizations working within the Province Lake watershed. Moose Mountains Regional Greenways covers Wakefield, NH; Green Mountain Conservation Group covers Effingham, NH and Francis Small Heritage Trust covers Parsonsfield, ME (see Appendix B for more information about the local land trusts). Yet, the amount of conservation land in the watershed is limited.



There are 109 acres of conserved lands in the Province Lake watershed including a portion of the Pine River State Park in Effingham, NH (Map 6, Appendix A).

At the time of this study there are four small parcels on the northwest shore of the lake deeded to the Town of Effingham, three to the Effingham Conservation Commission and one to the Town of Effingham. The only other conserved parcel within the watershed is 109 acres of the Pine River State Park in Effingham, located in the northwest corner of the watershed. In addition, there are 72 parcels in the watershed that are greater than ten acres in size that should be considered for conservation (see Map 11, Appendix A).

2.3.2 Soils and Geology

The composition of soils surrounding Province Lake reflects the dynamic geological processes that have shaped the landscape over millions of years. Over 380 million years ago, the region was under a shallow sea from a sinking continent; layers of mineral deposition compressed to form sedimentary layers of shale, sandstone, and limestone known as the Littleton Formation (Goldthwait, 1968). The Earth's crust folded under high heat and pressure to form metamorphic rock comprising the parent material – schist, quartzite, and gneiss. This parent material has since been modified by bursts of igneous rock intrusions known as the New Hampshire Plutonic Series (300 million years ago) and the White Mountain Plutonic Series (120 million years ago) (Goldthwait, 1968).

The current landscape was 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 bed rock and depositing glacial till to create the deeply scoured basins of lakes. The retreating action also eroded nearby mountains composed of granite, quartz, gneiss, and schist, leaving behind remnants of drumlins and eskers from ancient stream deposits. The glacier deposited more than three feet of glacial till (mix of coarse sand, silt, and clay), laying the foundation for vegetation and meandering streams as the depression basins throughout the

region began to fill with water (Goldthwait, 1968).The region continues to be modified by tributary streams, wave action, lake ice formation, frost, and wetting/drying till (Goldthwait, 1968).

"Province Lake is a haven offering abundant summer and winter recreating, diverse wildlife and as an added benefit, amazing views and stunning sunsets."

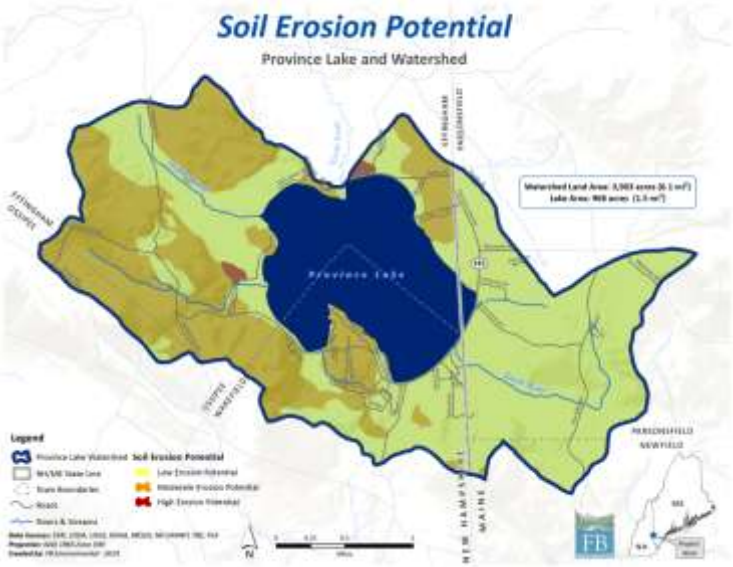
-Jon Samuelson, PLA

The Province Lake watershed is characterized by multiple soil series. Over 1,000 acres of the watershed is maintained by Henniker soil series which consists of well drained soils that formed in a loamy mantle overlying sandy or loamy dense till characterized by a sandy component on drumlins and glaciated uplands. Over 500 acres of the watershed is characterized by Hermon series soil. This soil series was formed in glacial till and consists of very deep, somewhat excessively drained soils on upland till plains, hills and ridges. Metacomet, Chocorua, and Gloucester soil series each comprise approximately 300 acres of the Province Lake watershed. Similar to Henniker soil series, Metacomet soil series are moderately well drained soils that formed in a loamy mantle overlying sandy/loamy dense till and are also found on drumlins and glaciated uplands. Chocorua series consists of very poorly drained soils formed in organic deposits overlaying sand or gravel. These soils are located in broad drainageway depressions or in bogs bordering lakes. Runoff and internal drainage are often very slow with this soil series and will lead to ponding during wet periods. The Gloucester soils series is somewhat excessively drained soils that formed in deposits of stony sand glacial till. These soils are often found on hilly uplands and permeability is moderately rapid, meaning available water capacity is often low. The Skerry soil series are moderately well drained soils formed in the deposits of glacial till and cover approximately 200 acres of the watershed. These soils are most often found in upland depressions at the head of drainageways or concave foot slopes (USDA, 1977, 1982).

Soil series that characterize smaller portions of the watershed include Brayton (~130 acres), Naumburg (~100 acres), and Champlain (~120 acres). Brayton soils are deep, somewhat poorly drained soils, and due to the slow drainage are often found lower on the landscape. Similarly, Naumburg soil series consist of deep, poorly drained soils and are found on low-lying areas of outwash plains and deltas. Champlain soil series is also found in deltas and outwash plains but are excessively drained soils. Other soil series of smallest size (generally 100 acres or less) within the watershed include: Boscawen, Croghan, Pillsbury, Woodstock, Becket, Lyman, Buckspot, Colton, Acton, Adams, Westbury, Salmon, Nicholville, Rumney, and Ossipee series (USDA, 1977, 1982).

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. Soils with negligible soil erosion potential are primarily low lying wetland areas near abutting streams. The soil erosion potential for the Province Lake watershed was determined from each

soil class hydrologic group (or runoff potential) as classified by the Natural Resources Conservation Service (NRCS) in the Hydrology National Engineering Handbook, May 2007, Part 630 (210-VI-NEH) (Appendix C). High erosion potential areas in the Province Lake watershed are limited to two small areas. Moderate erosion potential is more prevalent on the west side of the watershed in New Hampshire, and low erosion potential is most common on the Maine side of the watershed and in low lying wetland areas near Hobbs Brook and the South River, and areas of intact forest.



Soil erosion potential in the Province Lake watershed should be carefully considered for all future development (Map 7, Appendix A).

Development should be restricted in areas with steep slopes and 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 is required to maintain its stability and function within the landscape, particularly from Best Management Practices (BMPs) that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources.

2.3.3 Wetlands, Streams, Open Water, and Riparian Habitat

Wetlands provide many values to the local community including flood protection because they trap and slowly release rainwater; shoreline protection along lakes, rivers and streams because plant roots hold sand and soil in place and absorb the energy of waves; groundwater recharge/quality because wetlands help maintain baseline conditions; water quality because wetlands act as natural filters to remove, retain or transform pollutants and sediments from nonpoint sources; habitat, because wetlands provide habitat for a variety of species that depend on them for breeding, nesting and raising their young, and act as wildlife corridors (USEPA, 2013). In addition, wetlands provide scenic beauty, recreational opportunities, and educational opportunities for the local community. Wetlands and ***riparian habitat*** in the Province Lake watershed are home to a diverse community of fish, birds, mammals, and plants that are dependent on clean water to survive and flourish. The Province Lake watershed drains 3,903 acres of land, and is host to abundant water resources including 360 acres of wetlands, 6.3 miles of rivers and streams, and 686 acres of associated riparian habitat. An assessment of riparian habitat in the watershed indicates that there are 477 parcels of land located within riparian habitat, as well as 6.3 miles of roadway. The most

"I am more in tune with nature here than I have ever been- the beauty of an ever changing water, woods and sky spectacle, and an ongoing wildlife parade encompassed in tranquil silence...."

-Pete Dinger, PLA

prominent wetlands in the watershed include a large wetland complex associated with Hobbs Brook on the west side of the watershed, the South River flowing into Province Lake on the east side of the watershed, and wetlands associated with the South River at the outlet of Province Lake on the north end of the lake adjacent to Bailey Road.

Riparian Habitat *refers to the type of wildlife habitat found along the banks of a lake, river or stream and associated water-bodies. Not only are these areas ecologically diverse, they also help protect water quality by protecting the shoreline from erosion and filtering polluted stormwater runoff by trapping nutrients and sediments.*

At least five named and unnamed mapped streams drain directly into the lake. The most prominent include: Hobbs Brook flowing in from the northwest in Effingham, and the South River flowing in from the southeast at Route 153 in Wakefield (a.k.a."Rt. 153 inlet"). Additional tributaries include the southern tributary (a.k.a. "Island Inlet") on the south side of the lake off Bonnyman Road in Wakefield, the southwest tributary (a.k.a. "Campground Inlet") off Remick Road, and the eastern tributary (a.k.a. "Golf Course") on Route 153 in Parsonsfield. Because 77% of the total water load and 66% of the total phosphorus load to Province Lake is from watershed runoff, the tributaries that drain the watershed and their associated direct land uses are critical to the water quality of Province Lake.

New Hampshire Fish & Game ranks habitat based on its value to the state, biological region, and supporting landscape. According to this schema, Province Lake, its wetlands and major tributaries – have been ranked in the highest possible category for habitat value to New Hampshire by the State Fish and Game Department (NHF&G, 2010).

The Province Lake watershed is characterized primarily by mixed forest that includes both conifers (white pine, hemlock, larch, spruce, and juniper), and deciduous tree species (maple, birch, beech, ash, red oak, alder, and poplar). Fauna that enjoy these rich forested resources include land mammals (moose, deer, black bear, coyote, fisher, fox, raccoon, skunk, weasel, porcupine, muskrat, mink, chipmunks, squirrels, and bats), water mammals (muskrat, otter and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, and birds (herons, loons, gulls, multiple species of ducks, and bald eagles, as well as a wide variety of song birds).

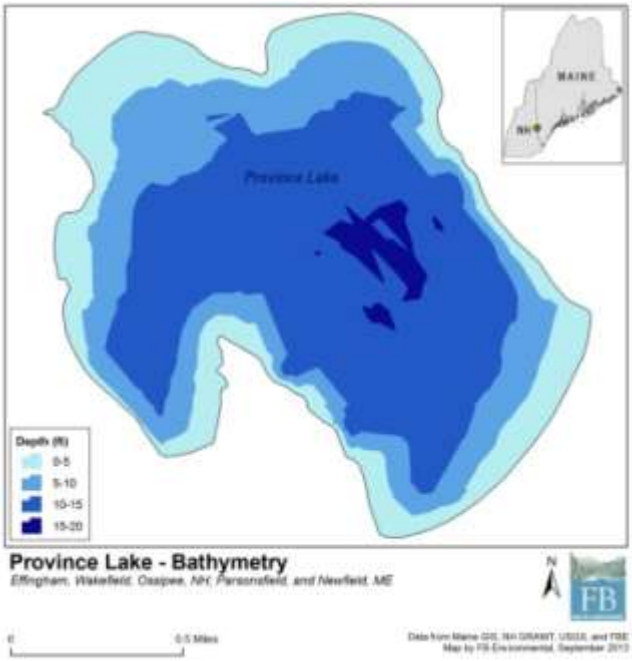
Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. The shallow nature of Province Lake ensures that the lake temperature is warmer than other deep lakes in the area, and therefore, does not provide habitat for any coldwater fish species. Fish species present in Province Lake include smallmouth and largemouth bass, chain pickerel, sunfish, perch and horned pout, also known as brown bullhead (NHF&G, 2014).

2.3.4 Lake Morphology and Morphometry

The morphology (shape) and morphometry (measurement of shape) 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.

Province Lake is a shallow, well-mixed lake that does not stratify like other larger, deeper lakes in the region. This means that the lake has a large littoral zone, meaning that sunlight penetrates the water to the bottom of the lake, providing habitat for the growth of aquatic plants. This also means that the lake is susceptible to resuspension of sediment and phosphorus from the lake bottom as a result of wind and motor boat activity, especially in the shallowest areas near the shoreline.



Province Lake is a shallow, well-mixed lake with an average depth of 9 feet (2.7 m) (FBE, 2014c).

The lake is 1.4 miles long and 1.7 miles wide at its maximum. There are 11.2 miles of shoreline and 10,701,066 m^3 of water in the lake, and the lake water volume flushes completely every year (1.1 flushes/year).[1] Average depth is 9 feet (2.7 m), and maximum depth is 17 feet (5.1 m). The majority of the lake area is between 12-15 feet deep, with the deepest area (deep spot) limited to a small area just north of the center of the lake. A large area near the shoreline near the Hobbs Brook inlet is shallow, ranging from 0-10 feet deep. The surface area of Province Lake is approximately 1.5 mi^2 (968 acres).

2.4 Invasive Plants

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 control costs. Once established, invasive species are difficult and costly to remove.

Variable milfoil is an aquatic invasive plant known to have detrimental effects on lake function, habitat, recreational opportunities and property values. (Photo: NH DES)

Province Lake is fortunate to be free of invasive aquatic plants, yet the Province Lake Association (PLA) is very concerned with the potential for the lake to easily become overrun with invasive plants, especially given the large

[1] Watershed area, lake surface area, lake volume, mean depth and flushing rate were recalculated using the most recent bathymetric data from NH DES, and calculated in the Lake Loading Response Model (LLRM) by FB Environmental in 2013.

area of shallow, littoral habitat. If an aquatic invasive plant were to be introduced to Province Lake, it will be very difficult to manage due to the large percentage of the lake that is shallow and corresponding large area of littoral habitat that provides perfect conditions for aquatic plant growth. PLA currently has two programs in place to guard against an infestation. As of 2012 during the summer months the PLA coordinates a Lake Host program which staffs a person at the boat ramp on Friday through Sunday each week. In addition, the week of the fourth of July is staffed all week long as it is a traditional holiday week for many. Other high volume days such as holidays or fishing tournaments are also staffed. Inspections of boats and trailers are done to assure weeds are not being transported into the lake.

"I can't separate the lake from the rest of the area. It is the most beautiful, peaceful refuge from a hectic world I have ever known.

-Pete Dinger, PLA

PLA also maintains a Weed Watcher program. The entire shoreline and shallow water areas of the lake are inspected monthly by trained volunteers. The lakeshore is divided into 8-10 sections, and volunteers inspect a section monthly, noting any new weed development, and reporting their findings to PLA. To date no invasive species have been detected. Continued monitoring and assessment is needed to protect Province Lake from the threat of invasive species.

2.5 Phytoplankton and Cyanobacteria

Phytoplankton and cyanobacteria present in a lake can be used as an indicator of general lake water quality. There are many different types of phytoplankton including golden-brown algae and diatoms that are typically found in New Hampshire lakes. However, an abundance of cyanobacteria may indicate excessive phosphorus inputs in the lake, or that the lake ecology is out of balance. Cyanobacteria are bacterial microorganisms that photosynthesize and may accumulate to form surface water scums on lakes. While many species are found naturally occurring in all lakes across the world, there are eight known genera common to New Hampshire lakes. These include: *Gloeotrichia, Merismopedia, Anabaena, Aphanizomenon, Oscillatoria, Coelospharium, Lyngba, and Microcystis* (NH DES, 2014b).

Certain cyanobacteria species produce toxins known as "cyanotoxins" that can adversely affect livestock, domestic animals and humans. *Microcystis and Oscillatoria* are best known for producing hepatotoxins known as microcystins, which affect liver function. *Anabaena* can produce a nerve toxin that is often responsible for the rapid death of dogs and cattle drinking from contaminated water. *Oscillatoria and Lyngbya* produce dermatotoxins which cause skin rashes. Both *Anabaena* and *Microcystis* have been documented in Province Lake.

Cyanobacteria blooms on Province Lake have documented with increased annual frequency since 2010. (Photo: Linda Schier)

While cyanobacteria are naturally occurring in all lakes, their abundance can increase as lake nutrients increase. Other factors that result in bloom conditions include increased water temperature and sunlight. Cyanobacteria may overwinter on the lake bottom, moving up to the surface of the water and forming blooms in mid to late summer, or into fall (NH DES, 2009), as is the case for Province Lake over the past three years.

Cyanobacteria are a concern in Province Lake for many reasons, including lake aesthetics, concern about declining water clarity and the associated economic effects to the area, and most importantly, the potential affects to wildlife, domestic animals and human health. Cyanotoxins are released into the water when cells die or are consumed by organisms higher in the food chain. Ingesting lake water and/or recreating on a lake with high levels of cyanobacteria can result in both acute and chronic illnesses (NH DES, 2013b) that target the liver, kidney, the central nervous system and skin.

NH DES will post a beach advisory if potential toxin-producing cyanobacterial scum is present at the beach and cell dominance is greater than 50% of the total cell count (NH DES, 2014b). In 2009, the standard was revised to be based on a total cell count of all phytoplankton species (70,000 cells/mL or greater). The total phytoplankton cell count guideline is not intended as a direct measure of cyanobacteria abundance, but is intended to indicate conditions in which excessive cyanobacteria levels could either exist or rapidly develop.

Table 4. *Reported blooms on Province Lake between 2010 to 2013.*

Reported Bloom	**Sample Collected?**	**Genera**	**Cell Count**	**DES Warning Issued?**
September 1-15, 2010	No	Unknown	Unknown	Yes
September 2, 2010	Yes	*Anabaena*	243,772 cells/mL	Yes
September 14, 2010	Yes	Unknown	< 100 counts/100	In effect until 9/15/10
September 23- October 15, 2011	No	-	-	No
September 6, 2012	Yes	*Anabaena & Microcystis*	1,267,614 cells/mL, microcystin < detectable limit.	No
September 7, 2012	Yes	*Anabaena* (13%)	6,704 cells/mL	No
November 11, 2012	Yes	*Not tested*	No detectable microcystins or BMAA. No testing for anatoxins.	No
June 21, 2013	Yes	*Anabaena*	< 70,000 cells/mL	In effect until 6/28/13
July 11, 2013	Yes	-	-	Yes
August 27, October 9, October 31, November 4, 2013	Yes	-	-	No

Blooms of cyanobacteria were reported to NH DES over a four year period (2010 - 2013). Samples were tested for toxic cyanobacteria in 2010, twice in 2012 (September & November), and again in June and July 2013. A summary of these findings is provided in Table 4.

Levels of in-lake phosphorus above 9 - 10 ppb have been shown to dramatically increase the toxicity of phytoplankton.

-Dr. Jim Haney, UNH

The increased frequency of blooms in Province Lake is alarming, from just one report in the fall of 2010 and 2011, three reports in the late summer and fall of 2012, and six reports beginning in early summer through late fall of 2013. Historical information from the 1960's and 1970's indicate that the cyanobacteria blooms are not new to Province Lake, despite the fact that they have not been reported in thirty years. Documentation of reoccurring blooms between 2010-2013 indicates a recent shift in lake condition that favors cyanobacteria. Because cyanobacteria are indicative of excess nutrients, immediate action is needed to reduce the amount of nutrients, especially phosphorus that is entering the lake.

Recent research at the University of New Hampshire (UNH) indicates that reducing total phosphorus levels in lakes can significantly reduce the risks associated with cyanobacteria blooms. Based on a survey of cyanotoxins in New Hampshire Lakes, levels of in-lake phosphorus above 9-10 ppb have been shown to dramatically increase the toxicity of phytoplankton (personal communication, Jim Haney).

Total phosphorus is measured in parts per billion (ppb). One ppb represents one microgram, or 1/1000th of a gram of phosphorus in one liter of water. Because lakes are phosphorus limited, a very small amount of phosphorus added to a lake can have significant consequences to water quality.

3. ASSESSMENT OF WATER QUALITY

This section provides an overview of the water quality standards that apply to Province Lake, the methodology used to assess water quality, and recommendations for managing the lake to prevent further decline in water quality, and prevent cyanobacteria blooms on the lake. Province Lake is listed on the New Hampshire Department of Environmental Services (NH DES) 2010 and 2012 303(d) list as impaired for Aquatic Life Use due to low pH, high levels of chlorophyll-a and total phosphorus, and is impaired for fish consumption due to mercury. It is also on the 2012 list as impaired for Primary Contact Recreation (swimming) due to reoccurring cyanobacteria blooms (NH DES, 2014a). This plan focuses on total phosphorus as a driver of lake health. Lakes with excess nutrients are over productive and may experience symptoms of water quality decline, including algal (and cyanobacteria) blooms, fish kills, decreased water clarity, loss of aesthetic values, and beach advisory's.

3.1 Applicable Water Quality Standards and Criteria

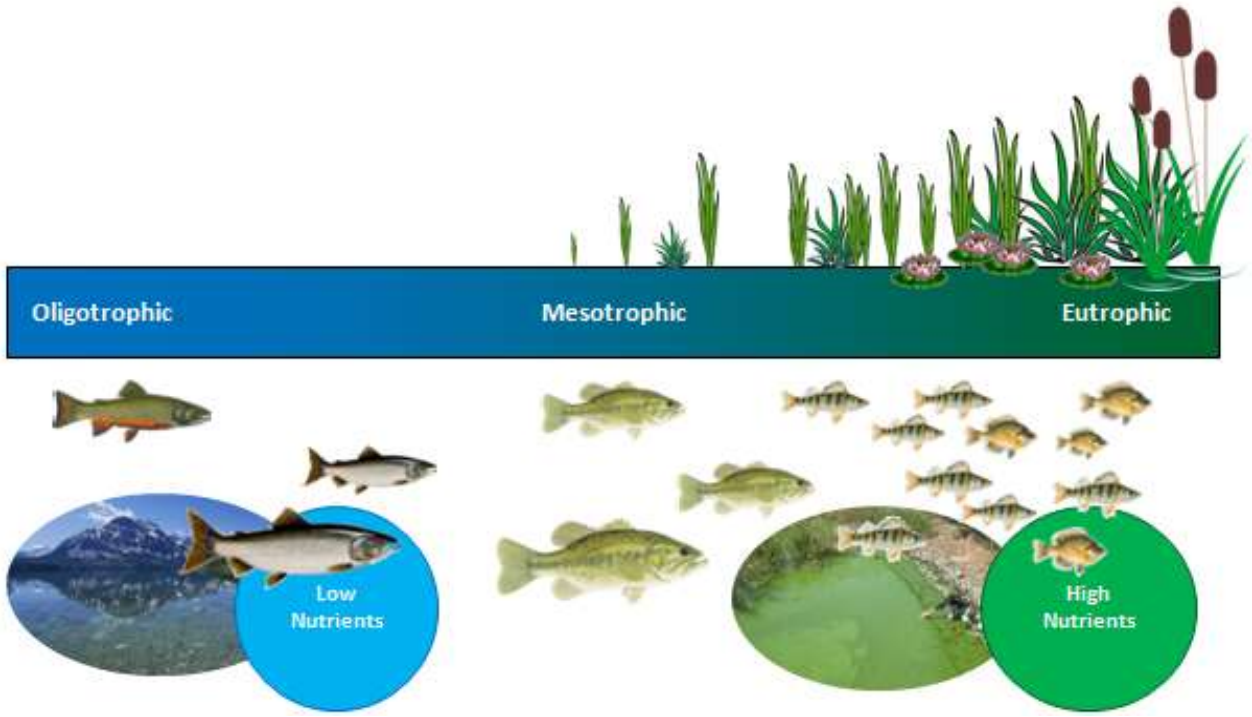
3.1.1 General Standards

New Hampshire's water quality standards are used to protect the state's surface waters. They provide a baseline measure of water quality that surface waters must meet to support designated uses. Water quality thresholds 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 the 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.

Trophic Class/Trophic State *is a determination of the degree of eutrophication of a lake as assessed by the transparency, Chl-a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion.*

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 standards and criteria, and antidegradation provisions. These regulations provide the regulatory bases for governing water quality protection in New Hampshire. 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 Env-Wq 1700 (NH DES, 2008).

New Hampshire recently developed thresholds for the narrative criteria based on ***trophic classes.*** The draft water quality threshold for Aquatic Life Use was set by analyzing 233 New Hampshire lakes (or about one-fourth of all lakes in New Hampshire), for phosphorus and chlorophyll-a, and trophic class. The results of that analysis indicated that statistically significant values for phosphorus could be determined for each trophic class (as shown in Table 3.3).



Example of lake trophic classes. While eutrophication is a natural process which can occur over 10,000 years or more, cultural eutrophication (increased nutrients due to human sources) can speed up the lake aging process, causing lakes to shift trophic classes in just decades to hundreds of years.

These thresholds, based on summer median TP were incorporated into the *Consolidated Assessment and Listing Methodology (CALM)* for determining impairment status for the 2010 water quality report to Congress. The data indicate that a lake will exhibit characteristics of a lower trophic class when chlorophyll-a levels exceed the identified thresholds.

3.1.2 Lake Nutrient Criteria

New Hampshire incorporates criteria in its water quality regulations to help determine whether nutrients are affecting lake water quality. For Aquatic Life Uses (ALU), the state has a narrative nutrient criteria with a numeric translator or threshold, consisting of a "nutrient indicator" (for example, phosphorus) and a "response indicator" (in this case, chlorophyll-a). Sampling results from both the nutrient indicator and the response indicator are used to assess Aquatic Life Uses (ALU) in New Hampshire Lakes (Table 5). For primary contact recreation (PCR), New Hampshire has a narrative criteria with a numeric translator or threshold for chlorophyll-a. The nutrient indicator and response indicator are intricately linked since increased phosphorus loading frequently results in increased phytoplankton levels, which can be estimated by measuring chlorophyll-a levels in the lake. Increased phytoplankton may lead to decreased oxygen at the bottom of the lake, decreased water clarity, and possibly changes in aquatic species composition.

Table 5. *Aquatic life nutrient criteria ranges by trophic class in New Hampshire.*

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

Primary Contact Recreation

The definition of Primary Contact Recreation (PCR) is, "*Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.*" This use applies to all surface waters in the state. The narrative criteria for PCR can be found in Env-Wq 1703.03, 'General Water Quality Criteria' and reads, "*All surface waters shall be free from substances in kind or quantity which float as foam, debris, scum or other visible substances, produce odor, color, taste or turbidity which is not naturally occurring and would render it unsuitable for its designated uses or would interfere with recreation activities*". Nutrient response indicators chlorophyll-a (Chl-a) and cyanobacteria scums (cyano) are used as secondary indicators for PCR assessments. These indicators can provide reasonable evidence to classify the designated use as "not supporting," but cannot result in a "fully supporting" designation. In order to make a full support designation, *E. coli* concentrations must be below the state water quality criteria. Elevated Chl-a levels or the presence of cyanobacterial scums interfere with the aesthetic enjoyment of swimming or may pose a health hazard. Chl-a levels greater than or equal to 15 ppb or cyanobacteria scums are considered "not supporting" for this designated use.

Aquatic Life Use

Measurements for Aquatic Life Use (ALU) ensures that waters provide suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms. For ALU assessment, the combination of TP and Chl-a nutrient indicators is used to make support determinations. The ALU nutrient criteria vary by lake trophic class, since each ***trophic state*** has a certain phytoplankton biomass (Chl-a) that represents a balanced, integrated, and adaptive community. Exceedances of the Chl-a criterion suggests that the phytoplankton community is out of balance. Since phosphorus is the primary limiting growth nutrient for Chl-a, it is included in this evaluation process.

For ALU assessment determinations, Chl-a and TP results are combined according to the decision matrix presented in Table 6. The Chl-a concentration will dictate the assessment if both Chl-a and TP data are available and the assessments differ. While dissolved oxygen and pH are also core indicators for aquatic life for lakes, this analysis, and forthcoming watershed plan focuses on the stressor phosphorus and its response indicator, chlorophyll-a.

Table 6. *Decision matrix for Aquatic Life Use assessment determinations in New Hampshire.*

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	Potential Non-support	Insufficient Info	Insufficient Info

From 1974 through 2010, NH DES conducted trophic surveys on lakes to determine trophic state. The trophic surveys evaluate physical lake features and chemical and biological indicators. Trophic state may be designated as: oligotrophic, mesotrophic, or eutrophic. These are broad categories used to describe how productive a lake is. Generally, oligotrophic lakes are less productive or have less nutrients, while very 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 and often have a higher quantity of submerged aquatic plants than oligotrophic lakes.

As described in Section 3.1.1, an assessment of 233 New Hampshire Lakes indicated that significant values could be derived for each trophic class. Oligotrophic lakes have high dissolved oxygen levels in the epiliminion (> 5 mg/L), high transparency (> 12 ft.), low chlorophyll-a concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen in the epilimnion (< 2 mg/L), low transparency (< 6 ft.), high chlorophyll-a concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of oligotrophic and eutrophic lakes for the parameters listed (NH DES, 2012).

For Province Lake, the trophic status was determined to be oligotrophic in 1979 and 1987. However, the status was changed to mesotrophic during the most recent 2006 trophic survey conducted by NH DES (Table 7).

Table 7. *Trophic state determination for Province Lake.*

Year	**Trophic State**
1979	Oligotrophic
1987	Oligotrophic
2006	Mesotrophic

Water quality assessments in New Hampshire are based on the highest trophic status reported for a lake; therefore, when NH DES conducts assessments, Province Lake is considered an oligotrophic lake. This means that in-lake water quality concentrations such as total phosphorus, chlorophyll-a and dissolved oxygen should be consistent with the thresholds set for oligotrophic lakes. However, the Province Lake Project Management Team reviewed the information, collected additional historical information about the state of the lake at the time of the surveys, compared the surveys to the results of the water quality

analysis, and factored in water quality trends before deciding which trophic state is most practical for the watershed management plan.

3.2 Study Design & Data Acquisition

A water quality analysis is a key component to assessing the health of a lake and determining impacts from watershed activities. The goal of the analysis was to summarize water quality data, apply and compare this data to state water quality standards, present historical water quality trends, and provide recommendations for improving the water quality of Province Lake.

The purpose of the analysis, which was completed by FB Environmental (FBE) for the Province Lake Watershed Management Plan, was to provide information and recommendations to help guide the Province Lake Water Quality Subcommittee in setting a water quality goal for Province Lake. This water quality goal is used to measure the success of future watershed management actions.

The water quality analysis for Province Lake utilized data for several key water quality parameters, including water clarity, chlorophyll-a (Chl-a), color, total phosphorus (TP), turbidity, dissolved oxygen (DO), and temperature. A full analysis of water quality parameters can be found in the Province Lake Water Quality Analysis report (FBE, 2014a), which is available on the PLA website: http://ProvinceLake.org

3.2.1 Historical Water Quality Monitoring Data

Historical water quality monitoring data was analyzed by FBE to determine historical water quality trends across multiple parameters, and to determine the median phosphorus concentration and the assimilative capacity for Province Lake. Data from the NH DES OneStop Environmental Monitoring Database was used to assess the water quality of Province Lake. With the exception of three years of trophic surveys conducted by NH DES, the remainder of the data were collected by volunteer monitors through the NH DES Volunteer Lake Assessment Program (VLAP). Despite a small portion of the lake, and a significant percentage of the watershed being located in Maine, no data are available from the Maine Department of Environmental Protection (Maine DEP) or volunteer monitors.

UNH Professor Dr. Jim Haney demonstrates techniques for collecting lake sediments at the bottom of Province Lake. (Photo: Donna Davis)

On July 10, 2013, the Province Lake Project Management Team met to discuss the water quality analysis and to set an interim water quality goal for Province Lake. At that meeting, several committee members discussed other historical data that might be linked to annual and long-term trends presented by FBE. The first is an artificial mixing study that was completed by the New Hampshire Water Supply and Pollution

Control Commission (NHWSPCC, 1979), and the second is data from the New Hampshire Fish and Game Department which includes data from 1937 and 1956 (In: NHWSPCC, 1979).

3.2.2 Methods

Data acquisition and analysis for Province Lake followed protocols set forth in the Site Specific Project Plan (SSPP) (FBE, 2013a). Water quality monitoring data was analyzed in order to: 1) determine trends in several key water quality parameters such as water clarity, chlorophyll-a, color, dissolved oxygen and temperature, 2) determine the median phosphorus concentration of the lake and the assimilative capacity, and 3) provide recommendations that will help guide the Province Lake water quality subcommittee to set a water quality goal for the lake. The analysis includes a comparison of historical (2002 and earlier) and recent (2003-2012) total phosphorus monitoring results, and a seasonal analysis (samples collected between May 15 and October 15), as well as a summary of available data and sources of this data.

Water quality data from multiple sources were combined into a common spreadsheet, and then sorted by date and station for Quality Assurance/Quality Control (QA/QC) in order to avoid duplicate data sets. All duplicates were removed, and multiple samples collected on the same day were averaged. The analysis for total phosphorus (TP) included an initial analysis to determine median total phosphorus (TP) based on all samples regardless of their location in the water column. Secondly, minimum, maximum, mean, and median TP concentrations were determined for the deepest spot on the lake, and were sorted by depth of sample (labeled as either epilimnetic/upper samples or hypolimnion/lower). Data were further refined using only samples collected in the epilimnion/upper to calculate the median epilimnetic TP concentration. The seasonal (May 15 - October 15), TP concentration represents the 'Existing Median Water Quality' applied to the NH DES Assimilative Capacity Analysis for determining if a waterbody is Impaired, Tier 1 or Tier 2. Similar methodology was used to calculate average Chlorophyll-a, Secchi disk transparency (SDT), and color. In addition, TP, turbidity and color were analyzed for two primary tributary locations including the Island Inlet (PROEFFI) and Rt. 153 Inlet (PROEFFR). A full description of results is presented in the Province Lake Water Quality Analysis (FBE, 2014a).

3.2.3 Summary of Existing Water Quality Data

The water quality of Province Lake was first monitored by NH DES in 1979 at the deepest spot on the lake (PROEFFD). Subsequent trophic surveys were conducted by NH DES in 1987/88 and 2006/07, with more consistent data collected through the VLAP program between 1991-2012 (Table 8).

Table 8. *Sources of water quality data for Province Lake.*

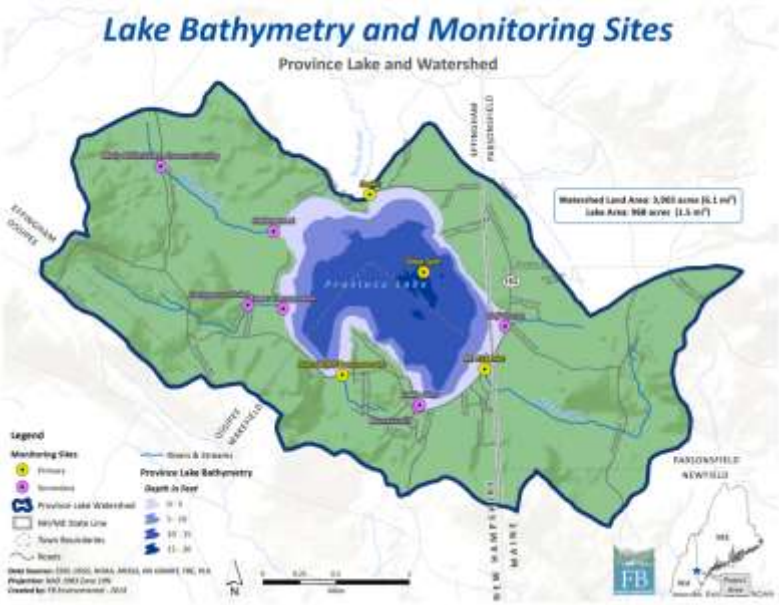
Water Quality Data Available for Province Lake			
Data Source	***Agency/Organization***	***Years Sampled***	***# of Years Sampled***
NH VLAP	NH DES	*1991-2012*	22
NH Trophic Survey	NH DES	*1979, 1987, 1988, 2006, 2007*	5

During this period, basic chemical information, including total phosphorus, chlorophyll-a, dissolved oxygen, pH, and specific conductivity was collected, in addition to Secchi disk transparency (SDT)

readings. Additional water quality parameters, including chloride, turbidity, color, bacteria, and alkalinity, were measured during this historical sampling period, but not for all years. With the exception of late winter sampling by NH DES for the trophic surveys, the majority of sampling was performed primarily on a monthly basis during ice-free conditions (May 15 – Oct 15) at the deepest spot on the lake (PROEFFD). In addition to monitoring at the deep spot, there are four primary (Table 9), and seven secondary monitoring locations in the watershed.

Table 9. *Primary monitoring stations at Province Lake.*

Site Name	***Site ID***	***Description/Notes***
Primary Sampling Stations		
Deep Spot	PROEFFD	North of mid-lake
Island Inlet	PROEFFI	Inlet to culvert above Bonnyman Rd.
Rt. 153 inlet	PROEFFR	Inlet to culvert above Rt. 153
Outlet	PROEFFO	Province Lake Association dam



Monitoring stations on Province Lake include four primary monitoring stations (yellow) and seven secondary stations (Map 8, Appendix A).

Two of these sampling stations, Island Inlet (PROEFFI) and the Route 153 Inlet (PROEFFR), have been monitored consistently since 1991. The primary parameters collected at these stations include: total phosphorus, specific conductance and pH, color, turbidity, and chloride have also been collected at these stations, but not as consistently over the historic sampling period. Ten other stations are believed to have been monitored historically in the Province Lake watershed; however, the exact location of a few of these sites is currently unknown.

In 2013, PLA began intensive monitoring of tributaries in coordination with NH DES and VLAP. The monitoring included four sampling events at six tributary sites (Outlet, Golf Course tributary, Rte 153 inlet, Bonnyman Rd., Campground inlet and Molly Philbrick Rd. tributary. A "wet weather" sample to collect TP at the golf course tributary, and two sampling events to collect *E.coli* and TP at the mouth of Hobbs Brook. In addition to E.coli and TP, dissolved oxygen, conductivity, turbidity, pH, specific conductance and temperature were measured. High TP readings were documented at the golf course tributary in July and August, and E.coli was elevated at the golf course outlet and Bonnyman Rd. in July, and again at the golf course in August. Follow-up monitoring will be conducted in 2014 as well as source tracking studies to examine the source of the high levels of *E.coli* and TP.

3.3 Water Chemistry Assessment

The water quality analysis for Province Lake examined trends over time (increasing, decreasing, or unchanged) for several key parameters, including total phosphorus (TP), *Secchi disk transparency* (water clarity), dissolved oxygen, chlorophyll-a, and *color*. Trend analysis can be useful at understanding how, and when the conditions in the lake changed to favor increased phytoplankton productivity. For example, if total phosphorus, which drives primary productivity in lakes, increased dramatically in recent years, then the water quality data provides a clear explanation for what triggered the change, and what can be done to prevent the changes from happening the future. A brief summary of water quality at the primary monitoring location at the deep spot in Province Lake is provided here.

3.3.1 Secchi Disk Transparency (SDT)

Secchi disk transparency (SDT) is a vertical measure of water transparency (the ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring SDT is one of the most useful ways to determine whether a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Since algae are usually the most common factor, transparency is an indirect measure of algal populations.

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).*

SDT in Province Lake ranged from 1.3 m to 4.3 m with an average of 2.56 m. Shallow lakes, like Province Lake often have transparency readings lower than the state or regional average compared to deeper lakes. This is true of Province Lake, where the recent (2003-2012), average, seasonal transparency is 2.56 meters (historical average = 2.59), more than half a meter lower than the state average, and close to one and a half meters less than the regional

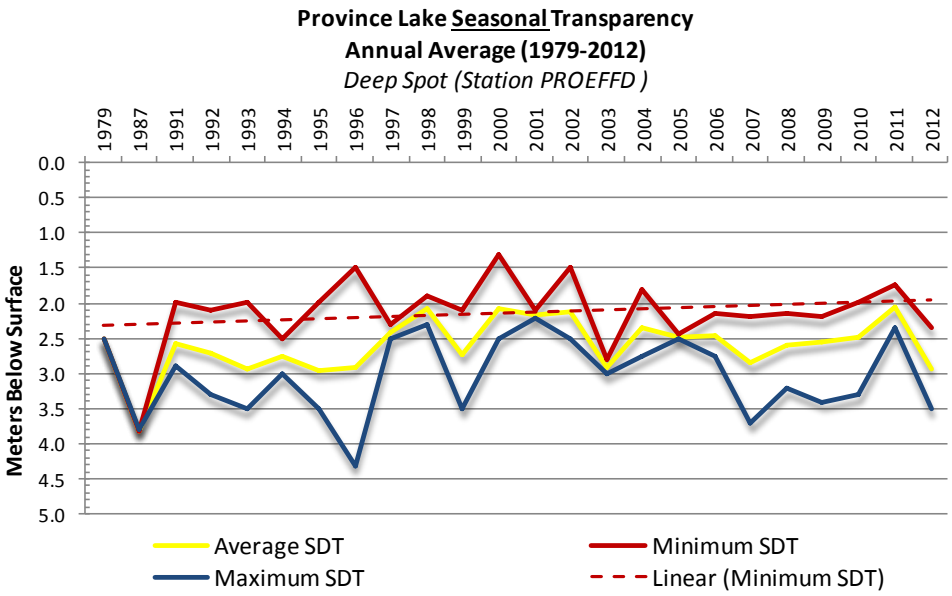


Figure 2. *Historical water transparency for Province Lake.*

average. Therefore, an important factor of the water quality analysis is to examine how transparency has changed over time.

A trend analysis indicates that minimum water clarity readings in Province Lake have been relatively stable over time. In fact historic (1979-2002) annual average of 2.62 m, is only slightly, but not significantly better than the recent (2003-2012) annual average. Major fluctuations in SDT (extreme high and low values) as seen in 1993, 1995, 1996 and 2010, are likely driven by changes in weather between dry (high SDT) and very wet (low SDT) conditions that either limit or increase the amount of sediment delivered to the lake (Figure 3).

3.3.2 Total Phosphorus

Total phosphorus (TP) refers to the total concentration of phosphorus found in the water, including organic and inorganic forms, and is one of the major nutrients needed for plant growth. It is generally present in small amounts, and therefore limits plant growth (both vascular plants and algae) in freshwater ecosystems. Anoxia (low dissolved oxygen) can release phosphorus bound to sediments into the water column, thereby increasing the amount of available phosphorus. Humans can also add phosphorus to lakes through stormwater runoff, lawn or garden fertilizers, and poorly maintained septic tanks. In shallow lakes like Province Lake, motorboat activity has been shown to increase the potential for phytoplankton growth as a result of resuspension of sediments and attached phosphorus on the lake bottom (Wagner, 1990). As TP increases within a system, the amount of algae also increases, and may lead to nuisance algal and/or cyanobacteria blooms and decreased water clarity.

In New Hampshire lakes, the median summer epilimnetic (upper layer) TP is 12 parts per billion (ppb), while the TP concentration for the White Mountain Region is 8 ppb (NH DES, 2013). As described in Section 3.1, NH DES uses a narrative nutrient criteria with a numeric translator, consisting of a "nutrient indicator" (phosphorus) and a "response indicator" (chlorophyll-a). The results from both the nutrient indicator and the response indicator are used to assess Aquatic Life Uses (ALU) in New Hampshire lakes.

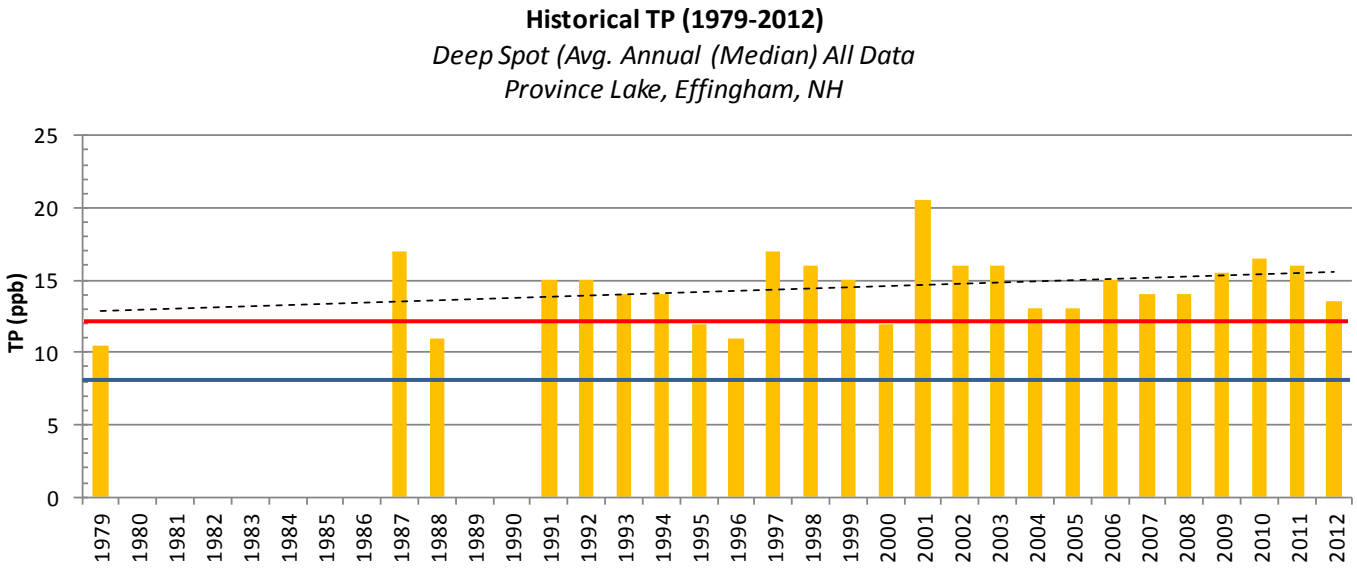


Figure 3. *Historical total phosphorus levels in Province Lake. (Dotted line= Province Lake TP trend, red line= mesotrophic threshold of 12 ppb, blue line= oligotrophic threshold of 8 ppb.)*

Total phosphorus concentrations in Province Lake over the historical sampling period ranged from 5 ppb to 46 ppb with an average (median) concentration of 14.3 ppb (Figure 4). This value exceeds the threshold set by NH DES for the aquatic life nutrient criteria pertaining to phosphorus for both oligotrophic (< 8 ppb) and mesotrophic (<12 ppb) lakes.

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

The lack of data between 1979 and 1987, make it impossible to conclude that the lowest reading on record in 1979 (5 ppb in the epilimnion) is representative of in-lake TP concentrations in the 70's and early 80's, or if it is merely an outlier in the data. A comparison of recent (2003-2012) vs. historic (1979-2002) data for only seasonal epilimnetic samples indicates a decrease of 1.4 ppb (15.6 ppb historic vs. 14.3 recent) for TP in Province Lake, though the difference is not statistically significant.

3.3.2 Chlorophyll-a

Chlorophyll-a (Chl-a) is a measurement of the green pigment used for photosynthesis, and is found in all plants (including microscopic plants such as algae and cyanobacteria). Chl-a is used as an estimate of algal abundance or lake productivity- higher Chl-a equates to a greater amount of algae in a lake. Chl-a concentrations are believed to be related to phosphorus concentrations, where increased concentrations of phosphorus result in increased algal growth.

The median summer Chl-a concentration in New Hampshire lakes and ponds is 4.58 ppb, and slightly lower in the White Mountain Region at 3.11 ppb. For Province Lake, recent (2003-2012) and historical (1979-2002) median annual Chl-a concentrations of 3.6 ppb, are lower than the state average, but higher than the regional average by 0.5 ppb.

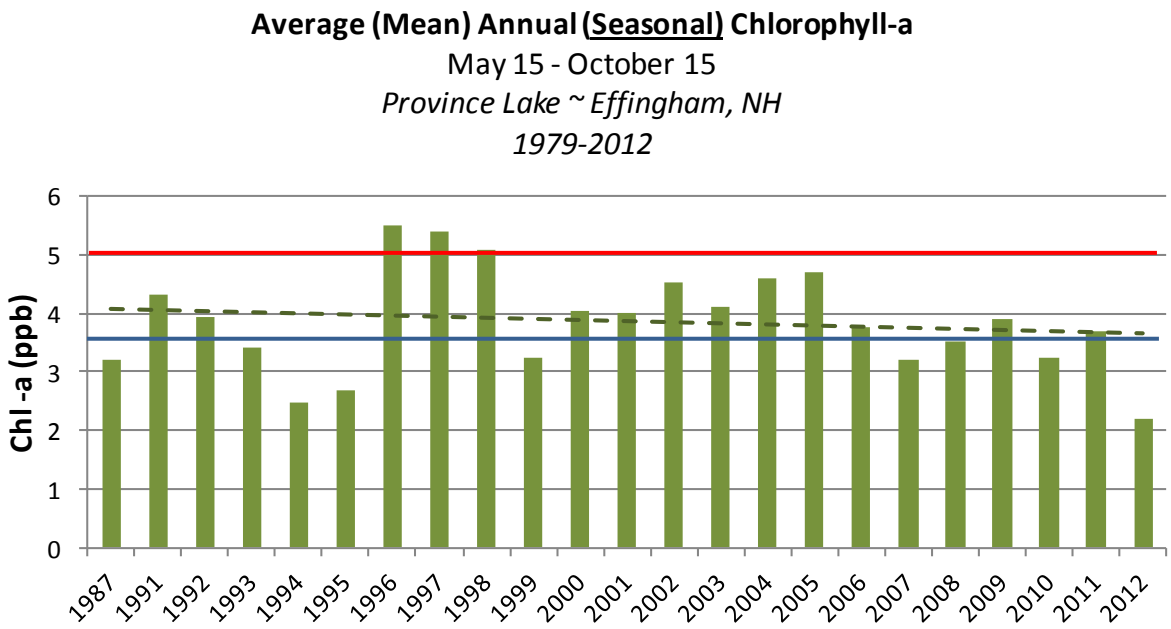


Figure 4. *Historical chlorophyll-a results for Province Lake. (Dotted line= Province Lake TP trend, red line= mesotrophic threshold of 5 ppb, blue line= oligotrophic threshold of 3.3 ppb).*

Chl-a ranged from 1.6 ppb to 10.8 ppb over the historical sampling period (1987-2012), with an average of 3.8 ppb, within the acceptable range for mesotrophic lakes under the aquatic life criteria, but above the acceptable range for oligotrophic lakes (< 3.3 ppb). Chl-a reached a high point between 1996-1998 with concentrations greater than 5 ppb (Figure 5). Since 2006, average annual Chl-a concentrations have been below 4 ppb, with the lowest annual average in 2012 (2.2 ppb). A comparison of historical averages (2002 and earlier) vs. recent (2003-2012) averages shows a decrease of 0.36 ppb, but is not statistically significant.

As described previously, New Hampshire has a narrative nutrient criteria with a numeric translator, consisting of a "nutrient indicator" (phosphorus) and a "response indicator" (chlorophyll-a). The results from both the nutrient indicator and the response indicator are used to assess Aquatic Life Uses (ALU) in New Hampshire lakes. If the ALU assessment for Province Lake was based on the thresholds set for mesotrophic lakes, then it would be considered within the acceptable range for Chl-a (≤ 5 ppb). Similarly, though the phosphorus concentrations in Province Lake exceed the mesotrophic threshold, since the Chl-a concentration is within the range for mesotrophic lakes, the lake would be considered fully supporting for aquatic life.

In addition to being used as a response indicator under the narrative nutrient criteria for Aquatic Life Uses in New Hampshire, Chl-a is also used as a secondary nutrient response indicator for Primary Contact Recreation assessments along with cyanobacteria scums (cyano). Chl-a can cause a "not support" assessment, but, by itself, cannot result in a "full support" designation (the primary indicator *E. coli* is needed for a "full support" assessment). The logic is that elevated Chl-a levels or the presence of cyano blooms interfere with the aesthetic enjoyment of swimming and, in the case of cyano, may also pose a health hazard. Non-support for Chl-a is defined as concentrations greater than or equal to 15 ppb, far greater than Chl-a concentrations in Province Lake.

3.3.3 Color

Color is the influence of suspended and dissolved particles in the water as measured as apparent color in Platinum Cobalt Units (PCU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land use activity.

Color *measures the influence that soils and geology, plants and trees, and land cover types in the watershed have on a lake, and are reported in Platinum Cobalt Units (PCU). Naturally colored lakes with > 25 PCU may exhibit reduced transparency.*

Color data is limited for Province Lake, with only nine years of monitoring data between 1979 and 2007 (Figure 5). The single sample collected in 2007 was from February, and was not included in the seasonal analysis. Color in Province Lake ranged from 12 - 48 PCU with an average of 24 PCU. In Maine, lakes with greater than 25 PCU are considered colored. Results of the analysis indicate that color increased in the lake over the historic sampling period (though weakly correlated, $R^2 = 0.4$). When lakes are highly colored, the best indication of algal growth is Chl-a. Current data is needed to determine if this trend has continued to the

present. An increase in color affects light penetration and transparency, and may result in increased levels of phosphorus and favor cyanobacteria growth.

Increased color in lakes can also affect water temperature. Lakes with high color can warm up more quickly in the spring since sunlight warms water at shallower depths. This also can affect what type and when plankton are present in the water. If nutrients such as phosphorus remain constant, warmer lake temperature (driven by increased color) can benefit blue-green algae and increasing their levels of productivity. Climate change can also affect color.

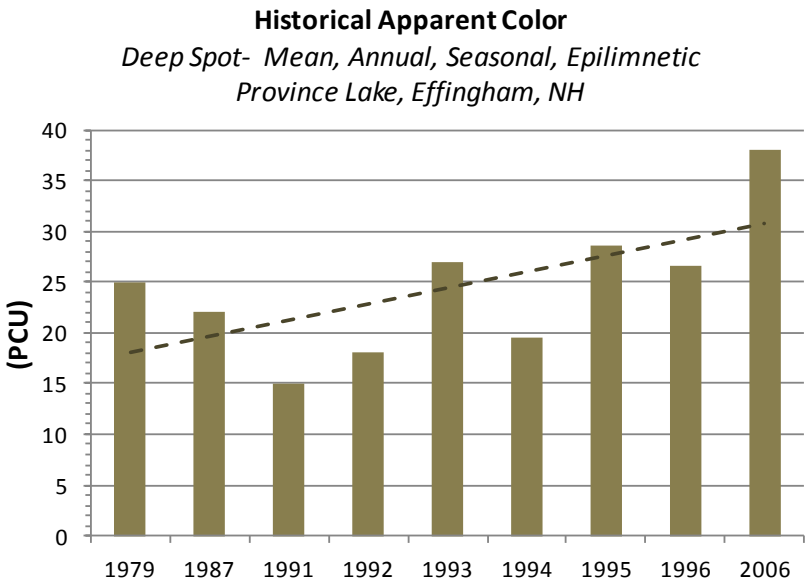


Figure 5. *Apparent color in Province Lake.*

Large storm events/storm surges like Hurricane Irene in August 2011, and Hurricane Sandy in October 2012, may result in irregular pulses of color and nutrients from wetlands as a result of flushing. Province Lake has several large wetlands that flow into the lake, and therefore may be contributing to this color change.

3.3.4 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is the concentration of oxygen dissolved in the water, and is vital to fish, aquatic insects, and chemical reactions that support lake functioning. Too little oxygen (known as anoxia) severely reduces the diversity and abundance of aquatic life. DO levels in lake water are influenced by a number of factors, including water temperature, concentration of algae and other plants in the water, and the amount of nutrients and organic matter flowing into the lake as runoff from the watershed.

DO 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). In deep, stratified lakes, changes in DO and temperature are more dramatic with high oxygen near the surface and virtually no oxygen near the bottom, compared with non-stratified lakes like Province Lake where water is continually mixed through the water column. DO levels below 5 ppm can stress fish and other bottom-dwelling organisms including amphibians, and over time reduce habitat for sensitive cold water fish species.

Dissolved oxygen and temperature profiles for Province Lake have been collected over the course of twenty-one years between 1987 and 2011. Results are consistent with a non-stratified lake, showing little change in temperature or oxygen from the surface to the bottom of the lake. Only a few instances of low

dissolved oxygen (< 5 ppm) occurred in 1998, 2003 and 2005. A single reading of 3.2 ppm was recorded on 8/8/79 at 4.5 m. In general, temperature in Province Lake ranges from 18-26 degrees Celsius, and dissolved oxygen levels range from approximately 7 ppm to 9.5 ppm. The high levels of dissolved oxygen throughout the profile, coupled with the TP results indicate that the lake is well oxygenated, well mixed, and not highly susceptible to internal loading as a result of low levels of dissolved oxygen.

3.3.5 Internal Loading

Internal phosphorus loading is a process in which phosphorus is released from bottom sediments as a result of low levels of dissolved oxygen at the bottom of the lake. The consistently high levels of dissolved oxygen throughout the water column in Province Lake is not cause for internal loading, however, because Province Lake is a large, shallow lake with moderate boat traffic during the summer months, resuspension of phosphorus and sediment can lead to internal loading.

Heavy boat traffic, *especially in shallow areas of Province Lake can result in significant re-suspension of sediment and phosphorus into the water column, providing food for algae and cyanobacteria.*

Local stakeholders have voiced concern about resuspension of phosphorus-laden sediment as a result of boat propellers, especially in shallow coves. No data exists to estimate/quantify internal loading caused by sediment disturbance from boat traffic. Further study of this possibility is recommended, and could be accomplished by monitoring the lake water column both before (Thursday afternoon), during, and after (Monday afternoon) heavy boat traffic weekends, or on holiday weekends. Phosphorus concentrations, turbidity, and Secchi disk transparency would provide valuable data to help answer the question of man-made mixing/internal loading as a result of boat traffic in the lake. While the increase in nutrients is especially important to Province Lake in order to reduce the potential for ongoing cyanobacteria blooms, there are many other negative effects of boating on the lake including increased turbidity, decreased water clarity, metal and gasoline inputs, shoreline erosion, effects on rooted aquatic plants, invertebrates, fish, waterfowl and other aquatic wildlife.

3.3.6 Summary of Water Chemistry

The water quality analysis for Province Lake focused on three major parameters: transparency, chlorophyll-a, and total phosphorus, as well as dissolved oxygen, temperature and color (Table 10). The analysis indicates that Province Lake is considered "not supporting" based on the Aquatic Life Uses indicator threshold for total phosphorus, and that overall, water quality has declined over time. However, a closer look at the historic (1979 - 2002) and recent (2003-2012) water quality monitoring data indicates that this trend has been gradual, and in some cases, the historical water quality was less desirable than the recent water quality.

With the exception of one data point from 1979, there is no record of any seasonal total phosphorus data below 8 ppb, the NH DES oligotrophic phosphorus threshold. However, there are many instances in which the seasonal epilimnetic TP concentration met the mesotrophic TP threshold.

Table 10. *Summary of water quality parameters for Province Lake.*

WQ Parameter	**PROEFFD-Deep Spot**
Mean Secchi (m)	2.59
Mean Color (PCU)	24
Mean Chl-a (ppb)	3.7
Mean TP (ppb)	14.3
DO Trends	Good

Based on the decision matrix for Aquatic Life Use assessment determinations in New Hampshire, Province Lake is considered potentially non-supporting for Aquatic Life Use under the mesotrophic classification, and impaired for Aquatic Life Use under the oligotrophic classification. This is due to elevated levels of chlorophyll-a that exceed the threshold for oligotrophic lakes (<3.3 ppb), in conjunction with a large phosphorus stressor that exceeds both the oligotrophic threshold (8.0 ppb) and the mesotrophic threshold (12 ppb).

The water quality analysis indicates that declining water quality trends have been gradual over time, and based on the highest trophic class for Province Lake (oligotrophic), reductions are needed for both phosphorus and chlorophyll-a. Since chlorophyll-a is an indirect measure of the algal biomass, and algae (and cyanobacteria) are limited by phosphorus, the water quality goal for Province Lake is based on reducing the amount of total phosphorus delivered to the lake. **If phosphorus inputs continue at the present rate, or continue to increase, then toxic cyanobacteria blooms are expected to continue, and may even become more frequent, longer and duration, and more toxic then they are today.** A water quality goal of 25% reduction in total phosphorus was set to improve the conditions in the lake so that it no longer experiences toxic cyanobacteria blooms.

3.4. 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 Lakes Loading Response Model (LLRM) used to model Province Lake, can make predictions about chlorophyll-a concentrations and Secchi disk transparency under different pollutant loading scenarios. The model can trace water and phosphorus loads (in the form of mass and concentration) from various sources in the watershed, through tributary basins, and into the lake.

Since the model is spreadsheet-based, it uses numbers rather than maps as inputs and outputs. However, it requires detailed information about land uses in the watershed for several inputs, which in essence requires mapping as part of the modeling process. Models such as the LLRM play a key role in the watershed planning process. The US Environmental Protection Agency (EPA) requires that a Watershed-Based Management Plan be created for communities to be eligible for watershed assistance

implementation grants. EPA guidelines for Watershed Based Plans require that both pollutant loads from the watershed, and the assimilative capacity of the waterbody be estimated.

3.4.1 Assimilative Capacity Analysis

There is a natural balance between the amount of phosphorus flowing in and out of a lake system, also known as the ability of the lake to ***"assimilate"*** *phosphorus.*

The assimilative capacity of a lake is its ability to resist the effects of landscape disturbance without water quality impairment. For purposes of this plan, phosphorus was determined to have the greatest direct impact on the water quality in Province Lake. A lake receives natural inputs of phosphorus in the form of runoff from its watershed. This phosphorus will be taken up by aquatic life within the lake, settle out in the bottom sediments, or flow out of the lake into 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, and precipitation runoff coefficient. **If a lake is receiving more phosphorus from the watershed than it can assimilate, then water quality will decline over time, and algal or cyanobacteria blooms will become more frequent.**

The epilimnetic median total phosphorus concentration of Province Lake, at the deepest sampling location, was used to calculate the total, reserve, and remaining assimilative capacity using procedures described in the Standard Operating Procedures for Assimilative Capacity Analysis for New Hampshire Waters (NH DES, 2008). Tier 2 waters, or high quality waterbodies, have one or more water quality parameters that exceed the water quality threshold and that also exhibit a reserve capacity of at least 10% of the water body's total assimilative capacity. Tier 2 waters have some assimilative capacity remaining, whereas Tier 1 and Impaired (or potentially non-supporting) waters do not. An impaired water is one in which the water quality of one or more parameters is worse than the threshold; they have a negative assimilative capacity and require reductions in pollutant loading in order to restore the waterbody to meet the standard. The assimilative capacity analysis uses the highest designated trophic class for the waterbody.

Based on the NH DES assimilative capacity analysis, Province Lake exceeds the water quality threshold for both oligotrophic and mesotrophic lakes (Table 11). This is because there is no remaining reserve assimilative capacity. A reduction of at least 3.5 ppb (~25% reduction from current TP) of phosphorus is needed in Province Lake to meet the mesotrophic water quality threshold for total phosphorus. However, the response indicator, Chl-a will ultimately determine if the lake will be listed as impaired for Aquatic Life Use. If Chl-a is not supporting in Province Lake, then the lake would be considered impaired for Aquatic Life Use (ALU). Based on the results of the Chl-a analysis, and direct comparison to the decision matrix for Aquatic Life Use assessment determinations, Province Lake is considered "impaired" under the oligotrophic classification, and "Potentially Non-Supporting" under the mesotrophic classification.

Table 11. *Assimilative capacity analysis results for Province Lake by trophic class.*

Lake/Station	Existing Median TP (ppb)	TP WQ Threshold (ppb)	AC Threshold (ppb)	Remaining AC (ppb)	Chl-a Concentration (ppb)	Analysis Results
Province Lake- *Deep Spot (PROVEFFD)*	14.3	8.0 (olig.)	7.2	-7.1	3.7	Impaired
	14.3	12.0 (meso.)	10.8	-3.5	3.7	Potentially Non-Supporting

3.4.2 Watershed Loading Model

A second analysis was used to link watershed loading conditions with in-lake total phosphorus concentrations to predict the effect of existing watershed development on future water quality in Province Lake. An Excel-based model, known as the Lake Loading Response Model (LLRM), was used to develop a water and phosphorus loading budget for lakes and their tributaries. The loading model makes predictions about chlorophyll-a concentrations and Secchi disk transparency. 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.

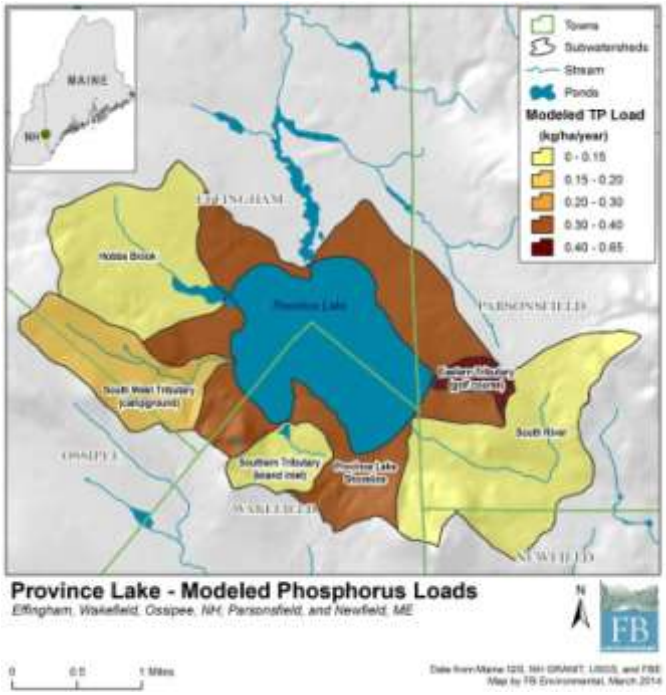
The model incorporates data about land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and an estimate of internal lake loading, combined with many coefficients and equations from scientific literature on lakes and nutrient cycles. This information can be used to determine how much phosphorus it takes to increase or decrease total phosphorus concentrations in the lake by 1 ppb- and therefore can be extrapolated to estimate the number of kilograms (or pounds) of phosphorus that needs to be prevented from entering the lake in order to improve water quality.

The results of this model indicate that the greatest phosphorus load comes from watershed runoff, which accounts for 66% of the total loading for Province Lake (Table 12). Atmospheric deposition to the lakes account for 16% of the P loading, septic systems account for 17%, and waterfowl are assigned less than 1% of the P entering the lake. Internal loading has not been quantified for Province Lake, but is likely a factor due to the shallow nature of the lake, long pitch (stirred up by wind), and resuspension of sediment and phosphorus by motorboats.

Table 12. *Total phosphorus and water loading summary for Province Lake.*

Loads to Province Lake	TP *(kg/year)*	TP *(%)*	Water *(m^3/year)*	Water *(%)*
Atmospheric Deposition	78	16%	2,826,216	22%
Internal Loading	0	0%	NA	NA
Waterfowl	3.5	<1%	NA	NA
Septic Systems	81	17%	54,394	<1%
Watershed Runoff	315	66%	9,806,021	77%
Total Load To Province Lake	**478**	**100%**	**12,686,632**	**100%**

The model estimates which tributary subwatersheds are the largest sources of phosphorus, and therefore are most in need of phosphorus reduction efforts. The tributary basins are sorted by phosphorus loading per hectare. The largest per hectare land use loading, based on the model, comes from the unnamed eastern tributary, where the golf course is located. Based on the very limited water quality data available, the golf course seems to have a somewhat lower phosphorus loading rate than typical golf courses, which is good news. Nonetheless, this small catchment area still contributes the most phosphorus per unit area, and should be a high priority for lake protection efforts.



While the Eastern Tributary (dark brown) delivers the greatest phosphorus load per unit area, the direct drainage area around the shoreline (light brown) has the largest overall phosphorus load, largely due to shoreline development (FBE, 2014c).

Direct shoreline drainages are typically among the highest load areas for most lakes given their close proximity to the lake, and because in rural lake watersheds, contain the highest density of development. The model indicates that the shoreline drainage area provides the second highest phosphorus load per unit area to Province Lake, and is first in terms of total phosphorus delivery to the lake due to the large area that drains the shoreline compared to the other subwatersheds. The direct shoreline to the lake deserves special attention in any lake protection plan, and Province Lake is no exception.

Both the model and the limited data from the unnamed southwest tributary (campground) suggest that phosphorus concentrations are relatively high. The development pattern leaves very little natural vegetated buffer around the tributary and lake. Therefore, this basin should be included among the high priority areas. Continued monitoring is an essential part of ensuring that wastewater systems and other lake protection practices in this densely populated area are working as designed.

The next two tributaries in order of phosphorus loading per area are unnamed southern tributary (Island Inlet) and the South River. Both the southern tributary and the South River have a long history of empirical data, which suggest a relatively high phosphorus concentration despite the model results. Flow in these streams could be lower than the model predicts, and flow monitoring could determine if that were the case. Alternately, phosphorus loading could be unusually high in those areas. Inspections by qualified personnel of wastewater treatment systems in those areas could determine whether onsite wastewater systems are inundated by spring high groundwater, a condition which compromises the system and may increase the transport of nutrients and bacteria to the lake. Hobbs Brook also has very little empirical data, but both the model and the two data points indicate that this catchment sends the least amount of

phosphorus per unit area to the lake. Hobbs Brook is a large catchment area, and deserves continued monitoring to confirm its low loading rate.

"We now know how close the lake is to becoming spoiled, and how imperative it is to reverse the downward trends immediately."

-Carl & Donna Davis

Wastewater systems, including septic systems, outhouses and cesspools are the second largest source of phosphorus to Province Lake. The combined categories of old septic systems (>20 years), cesspools, and outhouses were estimated to provide over 81% (66.2 kg) of the phosphorus load from the wastewater category. More information on the septic survey and recommendations for addressing input from wastewater is described in Section 3.7. A more detailed discussion of watershed modeling results can be found in the Province Lake Nutrient Loading Model Report (FBE, 2014c).

3.5 Establishment of Water Quality Goals

The process of establishing water quality goals was guided by the water quality and assimilative capacity analysis and watershed modeling conducted by FB Environmental (FBE). It was first determined whether the current median water quality for Province Lake is greater than the reserve assimilative capacity. Comparisons were made between the current median TP value and the historic water quality data, and trophic state. This analysis determined that phosphorus concentration exceeds the threshold for both mesotrophic and oligotrophic lakes.

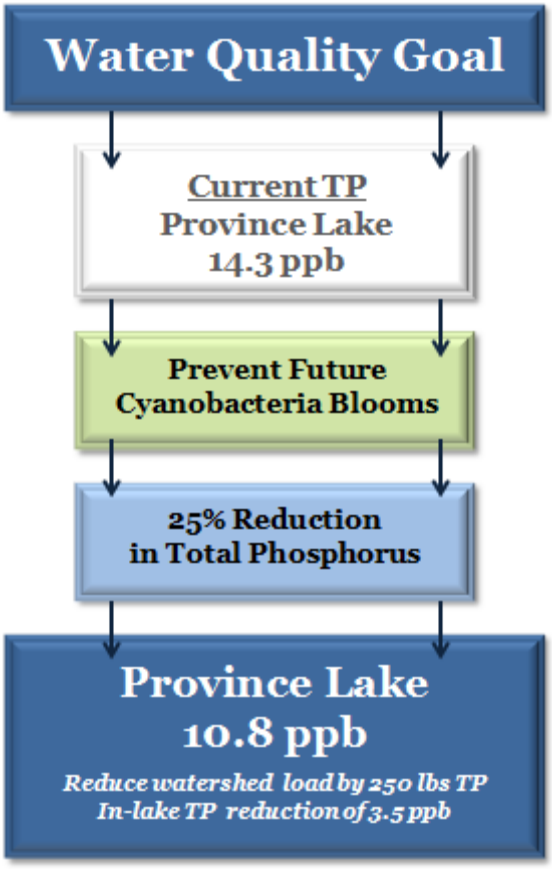


Figure 6. *Water quality goal for Province Lake.*

The over-arching goal for the watershed is to improve water quality conditions so that the frequency of reoccurring toxic cyanobacteria blooms in Province Lake are reduced, or eliminated. This can be accomplished by reducing the amount of phosphorus delivered to the lake, and by protecting the lake from future, unaccounted-for inputs of phosphorus from new development in the watershed over the next 10-15 years.

In July 2013, the Province Lake Project Management Committee, comprised of representatives from the PLA, AWWA, NH DES, and Maine DEP, and with technical support from FB Environmental (FBE) and UNH set an interim water quality goal based on the results of the water quality analysis and assimilative capacity analysis. The interim goal was designed to meet the mesotrophic Aquatic Life Use standards, which would reduce phosphorus concentrations to a level that

would diminish favorable conditions for cyanobacteria growth. The interim goal was revisited in November 2013 following FBE's presentation of the nutrient modeling results, and analysis of loading reduction estimates for planned management measures to ensure that the goal would be achievable. The Project Management Committee unanimously stood by the interim goal, and formalized the water quality goal at the November 2013 meeting.

Within the next 20 years, in-lake concentrations of phosphorus could be as high as 18.4 ppb, an increase of 29% based on 2013 zoning standards.

Success means reducing the amount of phosphorus getting into the lake by 25% over the next 10-15 years. Average total phosphorus concentrations will need to be reduced from the current average of 14.3 ppb to 10.8 ppb, by preventing 250 lbs (113 kg) of phosphorus from entering the lake annually. A 25% reduction is no easy task, and because there are many diffuse sources of phosphorus getting into 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. These goals will be discussed further in Sections 4 and 5.

3.6 Municipal Ordinance Review & Buildout Analysis

3.6.1 Municipal Ordinance Review

Numerous studies have shown that the extent and type of development can degrade water quality of lakes and streams, causing significant risks to aquatic life and cyanobacteria blooms. Municipal land-use regulations are a guiding force for where and what type of development can occur in a watershed, and therefore, how much phosphorus can be discharged to local waterbodies via stormwater. In fact, land-use and zoning ordinances are among the most powerful tools municipalities can use to protect their natural resources.

FB Environmental (FBE) conducted a Municipal Ordinance review as a supplement to this plan, reviewing Effingham’s and Parsonfield’s existing and proposed land use and zoning regulations (FBE, 2014d). A previous review of the Town of Wakefield's Site Plan and Subdivision regulations was conducted by FBE in 2012 (FBE, 2013b). The 2014 ordinance review provided a summary of New Hampshire and Maine Shoreland Zoning Standards (Table 13), and analyzed the standards within each towns’ ordinances pertaining to percent lot coverage, building setbacks, wetland buffers, conservation subdivisions, and low-impact development (Table 14). The review provides the towns with information about how they can improve standards pertaining specifically to these topic areas.

Table 13. *Summary of New Hampshire and Maine Shoreland Zoning Standards.*

Standard	New Hampshire	Maine
Area Encompassed Under Shoreland Zoning	250' from shoreline of rivers, lakes, and ponds >10 ac. Fourth order and higher rivers and streams and designated river segments.	250' from high-water line of any pond >10 ac., any river draining ≥25 sq. miles, all tidal waters and saltwater marshes. 250' from freshwater non-forested wetlands >10 ac. 75' from outlets of great ponds, and streams below the confluence of two perennial streams depicted on USGS topo maps.
Impervious surface area limits	>20% impervious cover requires a stormwater management plan. >30% cover requires a stormwater management system designed and certified by a professional engineer.	20% limit in shoreland areas
Septic system setbacks	75 feet for rivers and areas where there is no restrictive layer within 18 inches and where the soil down gradient is not porous sand and gravel. 100 feet for soils with a restrictive layer within 18 inches of the natural soil surface. 125 feet where the soil down gradient of the leach field is porous sand and gravel.	At least 100' from the high-water mark of a perennial water body.
Natural Woodland Buffer	Within 50 feet of reference line a limited amount of tree and saplings may be removed (grid and point system) but vegetation <3 feet in height must remain intact. At least 25% of the area between 50-150 feet must be maintained in an unaltered state.	Within 75 feet of the reference line (100 feet for great ponds and rivers), 40% of the volume of trees ≥4 in. dbh may be removed in a ten-year period. Beyond the 75 or 100 feet, clearings may not exceed 25% of lot area or 10,000 sq. feet. No more than 40% of volume of trees can be removed in any ten-year period.
Primary Building Setback	50 feet from the reference line for primary structures.	100 feet for most districts on a great pond or river flowing into a great pond. A 75 foot setback applies to all other waterbodies, streams, and wetlands.

Table 14. *Summary of town ordinances/development techniques.*

Standard	Effingham	Wakefield	Parsonsfield
Percent lot coverage (Shoreland)	Follows state standard - can exceed 30% but requires stormwater management system.	Follows state standard - can exceed 30% but requires stormwater management system.	Follows state standard - no more than 20%.
Building Setback (Shoreland)	50 feet (State standard)	50 feet (State standard)	100 feet (State standard)
Wetland Buffers	25-150 feet (see Table 1)	30 feet (20-foot no disturbance area)	100 feet
Conservation Subdivisions	Allowed if property is >10 ac. and contains certain features (e.g., prime agricultural land, endangered species). Requires ≥50% of land to be conserved.	Encouraged if parcel contains certain features (e.g., Agricultural land, steep slopes, lake frontage). Minimum 50% *buildable* area must be designated as open space.	No less than 30% of reserved open space shall be useable open space.
Low Impact Development (LID)	Not mentioned in ordinances.	Not mentioned in ordinances.	Not mentioned in ordinances.

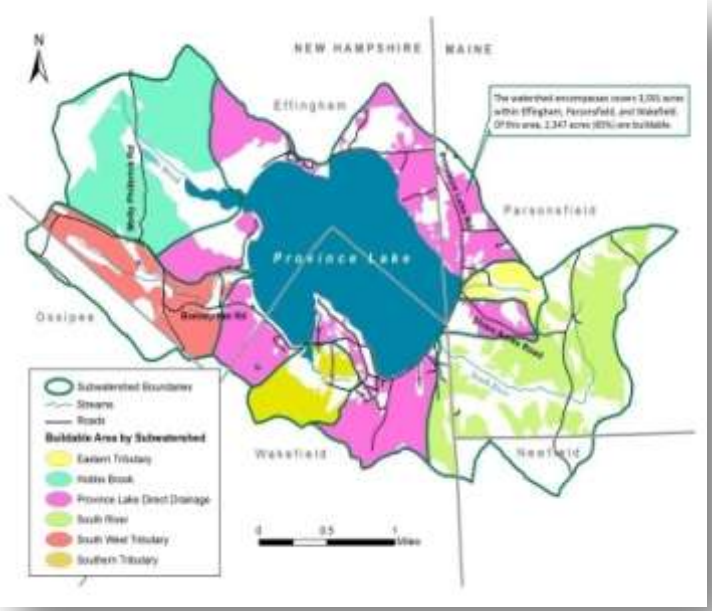
The review suggests that the watershed communities of Province Lake have room for improvement in order to protect water quality of the lakes and streams in the watershed now and in the future. The primary areas where changes to ordinances should be considered are: septic systems, buffer setbacks, conservation subdivisions, and low impact development. Specific suggestions for new or revised ordinances include:

- **Septic System Ordinance** – Develop non-regulatory approaches to address aging wastewater systems. Improve ordinances to consider more than just the number of bedrooms when doing expansions.
- **Buffer Setbacks** – Require all watershed towns to adopt setback guidelines based on proximity to Province Lake, the lake tributaries and hydrologic soil classification (similar to Parsonsfield's ordinance).
- **Conservation Subdivisions** – Increase incentives for conservation subdivisions in town ordinances.
- **Low Impact Development (LID)** – Require more stringent drainage standards and long-term erosion control using LID techniques, especially for private roads and subdivisions. Standards should require no net increase in stormwater from all new development and expansions.

Additionally, municipal ordinances was a topic at the Province Lake Community Forum in January 2014, and several action items were developed as part of that process. In addition to the recommendations below, more specific details relating to recommended municipal ordinances, are outlined in the action plan (Section 5.2.4).

3.6.2 Buildout Analysis

A buildout analysis was conducted by FB Environmental for the Province Lake watershed. The analysis combined 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) in order to determine the extent of buildable areas in the watershed. The analysis determined that 65% of the watershed (2,347 acres) is developable, and that more than half of the total land area in all six subwatersheds is buildable (range 59 - 77%).



The buildout analysis for Province Lake predicts full buildout in the year 2060 based on current growth rates, zoning and total available land. Graphic indicates total buildable land by subwatershed (FBE, 2014b).

The buildout analysis provides estimates about the potential for new residential development,

including the number of new buildings and the amount of land area that could be developed in the watershed based on current zoning standards. The build-out also presents information about where in the watershed the development is expected to occur, and how total phosphorus exported from the watershed is expected to increase in Province Lake as a result of this development. While the build-out analysis provides a full build-out scenario based on current zoning standards, it should be viewed as an estimate only, to be used as a useful planning tool that can be utilized to guide future development activities in the watershed as well as to target high priority areas for conservation.

The area adjacent to the shoreline of Province Lake contains the greatest amount of existing development. The build-out analysis estimates that the land area encompassing the Province Lake Direct Drainage, South River, and Hobbs Brook subwatersheds have the greatest potential for new development, and that 886 new buildings could be added to the watershed by the year 2060.

The subwatersheds with the highest percentage of developable land is the southwest tributary, located in Effingham, followed by the eastern tributary. Note that the build-out projections show buildings on the Province Lake Golf Course. These buildings were not removed from the build-out projections as land uses may change over time, and open spaces (such as golf courses) may be desirable locations for developers to build due to the already cleared land and picturesque lake views. The buildout also predicts where the most development will occur by zoning district (FBE, 2014b). In Effingham, the Rural/Agricultural zone is expected to have the largest increase in new development as well as the Forest and Farm zone for Parsonsfield, and the Agricultural zone in Wakefield

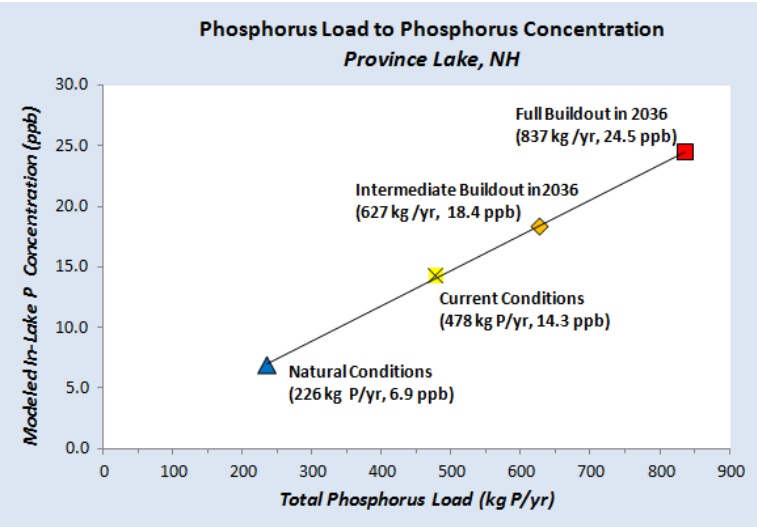


Figure 7. *Phosphorus load and concentration under various development scenarios.*

Future development will increase the amount of runoff that drains to Province Lake and its tributaries, and result in greater amounts of phosphorus entering the lake. In the intermediate term (year 2036), the in-lake TP concentration is expected to rise to 18.4 ppb, an increase of 29%. In 2060, at full buildout, without any action to reduce nutrients, the TP concentration in the lake could rise to 24.5 ppb, an increase of 72% over current conditions (Figure 8).

"...with the analysis and modeling complete, I learned just how much of an impact humans have on the water quality of these delicate gems (our lakes)"

- Jon Samuelson, PLA

Significant increases in phosphorus loading, as predicted in the build-out, can result in dire consequences for sensitive lake systems that by nature are phosphorus-limited. Since Province Lake will need phosphorus reductions on the order of 25% to meet water quality goals, any new phosphorus added to the lake will make conditions worse, and make it increasingly difficult to reach the goal.

Development standards that result in no net increase of phosphorus (and/or stormwater) should be considered for all new development, including low impact development (LID), which utilizes smart site design principles to capture and treat polluted runoff from rooftops, driveways and other impervious cover so that they don't end up in nearby streams and lakes. Other tools such as conservation or cluster subdivisions (such as Effingham's Open Space Conservation Subdivisions) should also be encouraged in order to protect open space, wildlife habitat, water quality, and to discourage sprawl. All towns should consider improving shoreland zoning standards for future development within the shoreland zone of Province Lake due to the fact that the direct shoreline area contains the greatest estimated phosphorus load under both current and future development conditions.

3.7 Septic System Survey

Septic systems, outhouses, and even portable toilets help us to manage our wastewater to prevent undo harm to human health, aquatic life, and water resources. However, old and poorly maintained systems, and systems that interact with groundwater pose a serious threat to the health of Province Lake.

Because septic effluent contains about one thousand times the concentration of phosphorus in lake waters, a small amount of effluent can have a major impact on a lake as small as Province Lake.

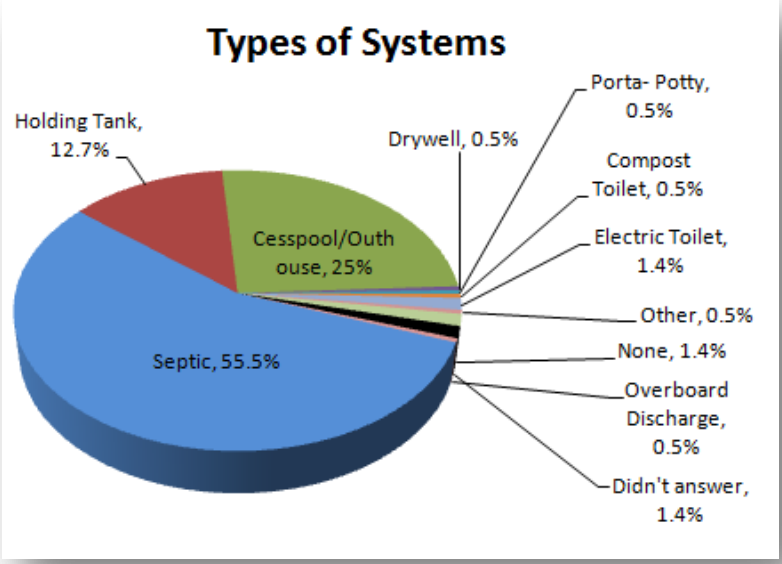
Generally, the scientific literature shows phosphorus reduction of approximately 20% can occur in the septic tank via settling of solids, and between 23-99% in the leach field and immediately surrounding soils (Lombardo 2006, Lusk *et al.* 2011). Factors affecting the ability of septic systems to prevent phosphorus from entering surface waters include soil and groundwater pH, redox conditions (oxidation-reduction potential of the soil), and mineral composition. In some cases, septic systems which had been operating for many decades were found to still retain 85% of the phosphorus within the first 30 cm of soil (Harman *et al.* 1996, and Zanini *et al*. 1998). Several studies have found that phosphorus migrates through the soil much slower than other dissolved contaminants in wastewater, and that over a distance of between 10 to 100 meters, phosphorus was reduced to background levels (Robertson *et al.* 1998, and Weiskel *et al.* 1992). Weiskel *et al.* in particular found that the degree of phosphorus reduction was related to unsaturated infiltration distance, suggesting it is important to have septic systems well above the seasonal high groundwater table.

On August 24, 2013, 14 resident volunteers and seven technical leaders from PLA, AWWA, FBE and NH DES conducted door-to-door surveys for all properties located within 250 feet of Province Lake or a tributary draining to Province Lake. Out of the 320 surveys mailed out, 220 property owners responded by mail, online or by interview for a 68.75% response rate. Eighty-eight (88) responses were completed in

person on the day of the survey, 49 responses were completed online, and 83 respondents sent their survey in via mail. The remaining residents were not home on the day of the survey, had no building on the property, or declined participating in the survey.

The septic survey included questions relating to the owner's current wastewater system use, along with several other questions to gauge their perception of the lake and knowledge of conservation practices. Questions included the respondent's perception of Province Lake's water quality, the age of the system, age of the house, occupancy, how often the system is pumped, the last time it was pumped, and about other types of water using machines. Results of the survey were incorporated into the watershed loading model conducted by FB Environmental (FBE, 2014c) to estimate the total phosphorus loading into the lake from wastewater systems.

Surprisingly, results of the septic survey indicate that just over half of the survey respondents have a septic system. A quarter (25%) use either a cesspool or outhouse, and 12.7% use holding tanks. 5% of respondents use alternative systems such as electronic toilets and porta-potties. The age of the wastewater systems was well distributed, yet the largest percentage of systems were older than 25 years old (AWWA, 2013).



More than 40% of survey respondents claim to use an alternative type of wastewater system than a septic system (Source: AWWA, 2013)

Results of the septic survey indicate that septic waste is a major concern for Province Lake due to the high percentage of old systems (>25 years old), cesspools and outhouses. Wastewater treatment systems contribute approximately 17% (179 lbs/year) of the total amount of phosphorus load entering Province Lake; the second largest source of phosphorus to the lake. **The combined categories of old septic systems, cesspools, and outhouses were estimated to provide over 81% (~ 145 lbs/year) of the phosphorus load from the wastewater category** (FBE, 2014c).

Information gathered from the Province Lake Septic Survey provides a snapshot of the state of wastewater systems in the Province Lake watershed. Reducing phosphorus loading from wastewater systems in the watershed should be considered a high priority to help reduce the overall phosphorus load which will ultimately help decrease the potential for future cyanobacteria blooms in the lake.

If just half of the 540 estimated old septic systems, cesspools and outhouses in the watershed were upgraded, it is expected that 50 lbs of phosphorus could be prevented from entering Province Lake each year.

RECOMMENDATIONS
FROM THE 2013 SEPTIC SURVEY:

The Province Lake Association

- Prioritize outreach to target landowners with older systems (>25 years), landowners with systems that are within fifty feet of a stream or the lake, and residents who rarely or have never had their systems pumped.
- Distribute copies of the septic survey report to residential property owners within the target groups and encourage property owners to make improvements to their properties.
- Apply for funding to fix potential septic system problems identified in the survey; especially at heavy usage sites such as the several campgrounds along the lakeshore.
- Continue to educate landowners on the importance of maintaining septic systems and the effects of the phosphorus-based products on the lake quality.
- Educate municipal officials about lake water quality issues and work cooperatively to find solutions.

Individual Landowners

- Properly maintain wastewater treatment systems. Pump tanks regularly (every 2 to 3 years for a year round residence; 4-5 years for seasonal occupancy) and upgrade marginal systems.
- Call or email the Province Lake Association for advice on how to fix septic issues. You can also call the NH DES for free advice on how to get started.
- Join the Province Lake Association to get involved with their activities to improve the water quality in Province Lake. Reach them through the PLA website www.provincelake.org or call them at (207) 200-3234

Towns

- Enforce septic system ordinances to continue to support restoration efforts at Province Lake.
- Participate and support the long-term watershed management plan.

It is critical to ensure not only adequate setbacks (horizontal distance) from the lake, but also good vertical separation from the seasonally high groundwater table.

A strong wastewater inspection and maintenance program can reduce phosphorus and bacteria loading to Province Lake. Survey results can be used to prioritize watershed upgrades to where they are most needed. The Province Lake Association (PLA) intends to work with its partners including federal, state, and local organizations to assist property owners that require assistance upgrading wastewater systems through grant funding or other options (AWWA, 2013b).

3.8 Watershed Survey

In conjunction with the septic survey described above, a Watershed Survey was also conducted to document sources of pollution on residential sites within the 250-feet of the lake and streams. The survey documented sources of pollution from roadside runoff into tributaries, direct runoff to lakes, runoff from development, use of fertilizers, erosion from poorly buffered properties, and artificially created beaches. More specifically, it identified the type of land use activity, the nature of the stormwater problem, the size of exposed or eroded area, on-site recommendations, impact on water quality, and cost of implementation.

Example of a nonpoint source pollution site identified during the Watershed Survey. (Photo: AWWA)

In May 2013, a team of 23 volunteers and technical leaders fanned out around the Province Lake watershed in seven teams to identify areas of erosion that contribute pollution to the lakes. Technical leaders for the survey teams were from AWWA, NH DES, and Maine DEP. The volunteers took careful notes when they identified a source of erosion using standardized data sheets. They also photographed the site for future reference. On each site where erosion was evident volunteers characterized the impact that the site was having on the lake, estimated the cost to remediate the problem and made BMP recommendations. Volunteers and technical staff identified 61 sites that are impacting or have the potential to impact water quality (AWWA, 2013a).

Of the 625 properties within the shoreland zone, 481 parcels were surveyed, with 61 documented stormwater issues. Of the 61 sites with potential to impact water quality, thirteen contained artificially created beaches. This indicates that artificial beach enhancement may be a lake-wide issue that requires more attention in the future. The most problematic land-use types observed were residential (roofs, paths, buffers, etc.), beach access, and driveways. Eleven percent of identified sites were documented high impact sites. Commonly observed stormwater problems stemmed from surface erosion, bare soil, and lack of shoreline vegetation (Figure 3.8).

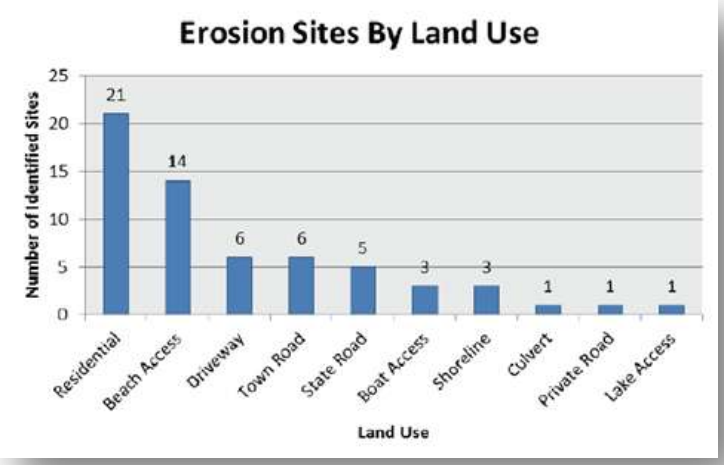


Figure 8. *Frequency and number of polluted runoff problems by type.*

Residential properties accounted for 21 of the identified sites (34%). The majority of these have a low to moderate impact on water quality and will be inexpensive to fix (less than $500), by applying simple best management practices, often easily fixed by the landowner or the YCC. Private, town and state roads accounted for 12 of the sites identified (20%). These sites have the potential to have a severe impact on the

lake with higher associated costs (greater than $2,500) and often require technical experience to properly solve the erosion problems. Beach access sites accounted for 14 of the sites identified (23%). Due to their proximity to the lake and how easily water can move beach sand, these sites tend to have a high impact on the lake.

Erosion sites were identified all around the watershed across ten different land-use types. Therefore, everyone has a role to play in protecting Province Lake. The towns of Wakefield, Effingham and Parsonsfield, waterfront property owners, road associations, and even people living far from the lake can all help reduce pollution entering the lake to protect this treasured resource. Suggested next steps include implementation of prioritized watershed survey sites, developing strategies to address high, medium and low impact sites, applying for grants to help landowners, road associations, the towns and states fix the sites, and offering homeowners incentives such as working with AWWA's YCC program to develop site specific remediation designs.

ADDRESSING EROSION AND SEDIMENTATION ISSUES ON ROUTE 153

Route 153 is a scenic road that runs directly along the southeast shore of Province Lake for approximately one mile. Part of this road is located in New Hampshire and part is located in Maine. The Province Lake Project Management Team recognized early on in the watershed management planning process that there were serious concerns with stormwater runoff causing erosion of the road shoulder and beach (see photo below left). The problems are exacerbated by parking along the road which further destabilizes the road shoulder and eroding banks. The watershed survey and resulting pollutant load analysis estimated that there are approximately **106 tons of sediment per year** washing into Province Lake from multiple sites along this roadway. This is equal to approximately 10 dump truck loads of sediment entering the lake each year. The phosphorus content in this amount of sediment is approximately 85 pounds per year which is a concern for the sensitive waters of Province Lake.

To address the concerns along the lake and to help reduce these sediment and phosphorus loads, the Province Lake Project Management Team met on-site with Maine and New Hampshire Department of Transportation officials (see photo below right) to discuss methods for addressing the erosion and excess sedimentation stemming from the road. This opened communication lines between the local groups and state agencies to begin to develop an implementation plan for the roadway. A full site plan will be developed in future years, and the public will be invited to participate in the planning process. Current recommendations include replacing and stabilizing culverts, adding vegetation to treat runoff, and potentially adding a guardrail which would include openings to allow for passage to the popular beach area. For more information on proposed “fixes” to this area please refer to Appendix G.

4. MANAGEMENT STRATEGIES

4.1 Goals for Long-Term Protection

The goal of the Province Lake Watershed Management Plan is to improve the water quality of the lake for current and future generations to enjoy. Reducing pollutant loads to the lake will prevent the future occurrence of toxic cyanobacteria blooms. This goal states the need to reduce the amount of phosphorus entering the lake by 25%, from 14.3 ppb to 10.8 ppb (equivalent to 250 pounds of phosphorus) over the next 10-15 years.

A 25% reduction is no easy task, and because there are diffuse sources of phosphorus getting into the lake from 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 using many different tools to be successful.

This target reduction in TP can be achieved through the following ***structural and non-structural*** objectives:

1) Utilize the BMP matrix to identify, prioritize, and implement ***best management practices (BMPs)*** throughout the watershed to reduce sediment and phosphorus runoff from existing shoreland development and roads.
2) Educate landowners through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a water resources, inadequate systems, or rarely pumped out).
3) Institute greater controls on new residential development and upgrades of seasonal to year-round homes; require ***low-impact development (LID)*** in site plans, and incentivize regular septic system maintenance.
4) Protect high value plant and animal habitat, wetlands, and riparian areas through permanent conservation options such as conservation easements.
5) Continue and/or expand the water quality monitoring and aquatic invasive plant control programs.

Structural BMPs, *or engineered Best Management Practices are often on the forefront of most watershed restoration projects. However,* ***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 such as street sweeping and road sand/salt management, and targeted education and training.*

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/permanent) BMPs for existing and new development to ensure long-term restoration success.*

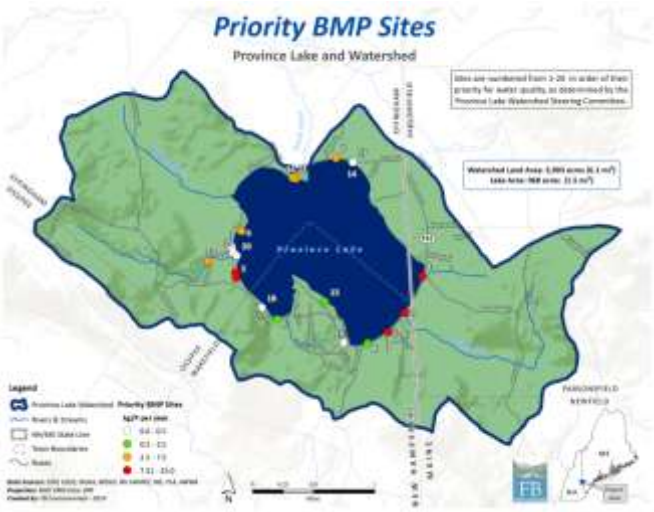
Low Impact Development (LID) *is an alternative approach to conventional site planning, design, and development that reduces the impacts of stormwater by working with natural hydrology and minimizing land disturbance by treating stormwater close to the source, and preserving natural drainage systems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

These objectives and more are discussed in greater detail in the action plan (Section 5.2). Achieving the goals and objectives for implementation work in the Province Lake watershed will require a comprehensive and integrated set of activities as identified below.

4.2 Addressing Nonpoint Source Pollution (NPS)

4.2.1 Structural NPS Restoration

The Province Lake Watershed Survey identified 61 sites that impact water quality directly through the delivery of sediment and attached phosphorus. Consequently, structural BMPs are a necessary and important component for the improvement of water quality in Province Lake. The best methods for treating these sites are to:



Twenty BMP sites were prioritized from the list of 61 documented sites in the 2013 Watershed Survey (Map 9, Appendix A)

- Address the top 20 priority BMP sites with an emphasis on low-cost fixes for roadways, shorelines and residential dwellings (Table C.1, Appendix C and Map 11, Appendix A).
- Utilize the BMP matrix (Table C.2., Appendix C) to address sites with the greatest phosphorus reduction to cost ratio.
- Work with engineers to develop conceptual designs (such as Towle Farm, Appendix D) for high impact sites, and work with willing homeowners to host demonstration workshops to encourage landowners to install BMPs on their own property.

Measure and track load reductions achieved through BMP implementation. These basic criteria will help guide the proper installation of BMPs in the watershed. Refer to the action plan in Section 5.2, the Septic and Watershed Survey Report (AWWA, 2013a and b), and Section 3.8 for continued discussion of BMP implementation strategies.

The 20 high priority BMP sites were determined based on consensus from the Province Lake Project Management Team with assistance from FB Environmental. Several of these sites are located on Rt. 153 on the east side of the lake, and will address direct road runoff and road shoulder erosion into Province Lake. These sites are described in greater detail in Appendix C, but a brief summary is provided below.

In total, these twenty sites will reduce the watershed phosphorus load by an estimated 187 lbs/year, or 76% of total needed to reach the goal of 250 lbs/year. Approximately $208,000 would need to be raised in order to successfully implement these BMPs (see Table C.1, Appendix C).

A breakdown of shoreline BMPs (including beach access, residential, lake access and golf course) indicates that shoreline BMPs will cost $145,000 over ten years with a relatively even split between high

priority shoreline sites and medium/low impact sites. Road sites are estimated to cost $220,000 over ten years, with the highest costs for town roads ($104,000), followed by state roads ($75,000) and driveways ($15,000). See Table C.3 BMP Cost List in Appendix C for a list of different BMPs and their estimated costs. Note that estimates are based on labor and materials, and do not include engineering fees.

Descriptions of the top five priority BMPs are provided below.

Site 1: 5-4

Site Summary: Culverts are present and have been recognized as high priority management locations at the east end of Province Lake. Specifically, the culverts are located along Route 153 near where it meets Shore Acres Road in Parsonsfield, Maine. Severe surface and road shoulder erosion are evident.

Proposed Improvement:

- Installing an armor culvert for the inlet/outlet
- Reshaping/installing a ditch
- Vegetating the shoulder of the road.

Estimated Cost: ~ $2,800.00

Estimated Pollutant Load Reduction: 55 lbs TP/yr

Site 2: 5-2

Site Summary: Approximately 135 feet of Route 153 in New Hampshire on the east end of Province Lake is showing evidence of severe erosion and requires attention. Stabilization efforts should be focused on the culvert inlet just north of Donville Road in Wakefield, NH at the mouth of the South River.

Proposed Improvement:

- Installing an armored culvert inlet
- Lengthening the inlet
- Installing a plunge pool.

Estimated Cost: ~ $3,200

Estimated Pollutant Load Reduction: 19 lbs TP/yr

Site 5: 2-2

Site Summary: To the west of Province Lake is Bonnyman Road, located in Effingham, NH. Approximately 63 feet from the entrance to the Province Shore Campground this site requires best management practices for surface erosion, lack of vegetation and runoff.

Proposed Improvement:

- Replace retaining wall
- Plant behind wall to take up water
- Install a trench
- Establish a buffer

Estimated Cost: $6,500

Estimated Pollutant Load Reduction: 17 lbs TP/yr

Site 3: 5-1

Site Summary: Severe erosion is occurring along the southeast side of Province Lake. In particular, a section of Route 153, from approximately Emery Lane in East Wakefield, NH to the Maine state line, is a high priority site for best management practices.

Proposed Improvement:

- Remove grader/plow berm
- Armor shoulder of the road
- Install water retention berms
- Establish a buffer
- Extend guard rail to Maine state line

Estimated Cost: ~ $13,000

Estimated Pollutant Load Reduction: 11 lbs TP/yr

Site 4: 2-1

Site Summary: Approximately 1000 feet of Bonnyman Road, located in Effingham, NH requires management attention. This area is located to the west of Province Lake between the entrance to the Province Shore Campground and Silver Hill Drive. Problems of concern include surface erosion, lack of vegetation and stormwater runoff.

Proposed Improvement:

- Install a retaining wall
- Install an infiltration trench
- Water retention swale
- Establish a buffer

Estimated Cost: ~ $26,500

Estimated Pollutant Load Reduction: 40 lbs TP/yr

4.2.2 Non-Structural NPS Restoration

Non-structural watershed restoration practices prevent or reduce stormwater related runoff problems by reducing the exposure and generation of pollutants and providing a regulatory framework that minimizes impervious cover. Non-structural approaches to watershed restoration can be the most cost-effective and holistic practices within a watershed management framework. The non-structural approaches recommended in this plan will help improve water quality by streamlining the permitting process (e.g. removing conflicting design or stormwater codes), and reducing development costs (e.g. minimizing impervious area development).

There are two primary components of non-structural Best Management Practices (BMPs):

1) Planning and design that minimizes or eliminates adverse stormwater impacts;
2) Good housekeeping measures and education/training to promote awareness regarding the first component.

In watersheds with future development potential, such as Province Lake with buildable land extending across 65% of the watershed, it is critical for municipal staff and planning boards to develop and enforce stormwater management criteria to prevent any increase in pollutant loadings that may offset reduced loads as a result of implementing watershed management plans. Zoning in the Province Lake watershed presents considerable opportunity for continued development (see Buildout Analysis or Section 3.6) and, by extension, increased threats to aquatic habitat and recreational use of the lake, and lost opportunity for improving lake health and preventing future cyanobacteria blooms. As described in Section 3.6, at the current growth rate, phosphorus levels in Province Lake could increase by 29% in the next 20 years to

18.4 ppb, being well on its way to being a eutrophic lake where bloom conditions are the norm, rather than infrequent.

In conjunction with the recommendations provided in Section 3.6 that focus on LID and improving septic systems, the Center for Watershed Protection identifies BMP/LID implementation requirements for development projects in watersheds with significant development potential, as the best mechanism for enhanced stormwater management over the long term. Additionally, a recent publication by American Rivers identifies local land use planning and zoning ordinances as the most critical components of watershed protection despite federal Clean Water Act requirements (American Rivers, 2007). The guidelines for local water policy innovation outlined in the American Rivers document are as follows:

- Review current zoning ordinances for regulatory barriers and improvements (see Municipal Ordinance Review or Section 3.6).
- Set performance based standards.
- Take additional measures to reduce impervious cover.
- Promote the use of specific LID designs.
- Use overlay districts to add new requirements to existing zoning districts.
- Establish standards or incentives to improve stormwater management in developed areas.
- Address storage/use of pollutants that contact stormwater.

4.2.3 Alternative BMPs

There are several in-lake treatment options that have been used in lakes to reduce the probability of cyanobacteria blooms. For this plan, eight different treatment options were examined:

1. Aluminum Sulfate Treatment (Alum)
2. Artificial Circulation (Aeration)- *tried in Province Lake in 1975 and 1776*
3. Biomanipulation of Fish Populations
4. Floating Wetland Islands
5. Barley Straw
6. Dilution or Flushing
7. Sonication
8. Aquatic Dyes and Shades

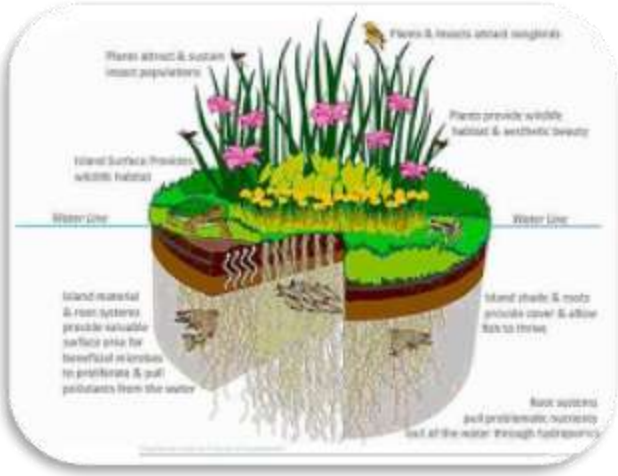


Diagram of a floating wetland island.

A description of each alternative BMP, examples of its use, and an assessment of its efficacy and cost are presented in Appendix E. High costs, or lack of long-term success, and limited research on ecosystem

effects make many of the alternative BMPs a last resort should more practical on-the-ground options have been depleted and water quality problems persist. Several of these alternatives (e.g. wetland island) could be considered in combination with traditional BMPs. More consideration is needed by the steering committee to determine the applicability/feasibility of these options for Province Lake.

4.3 Current and Future Pollutant Sources

Improper waste management, beach erosion, inadequate shoreline buffers, poorly maintained roads, boat traffic all contribute to the current state of the water quality in Province Lake. The watershed survey documented more than 60 issues persisting today within the watershed (refer to Section 3.8). The PLA and the AWWA have begun the task of educating residents about the potential adverse effects of soil erosion and phosphorus as part of the watershed planning process and through recent YCC projects.

Example of erosion on a residential lot adjacent to Province Lake. The landowner has since received assistance from the local YCC to install a rain garden to treat the runoff. (Photo: AWWA)

By combining the land-use modeling results with estimated future loading increases from the Buildout Analysis, we can estimate the total P load at the 20-year and full buildout mark. Currently, 1,053 lbs of P enters Province Lake annually. According to the Buildout Analysis, Province Lake could experience a 29% and 72% increase in P loading at the 20-year and full buildout marks (year 2060), respectively. If future development is not addressed, in 20 years, 1,382 lbs of P could enter Province Lake annually. At full buildout, 1,845 lbs of P will enter Province Lake annually. This is dramatic compared to natural conditions (pre-development estimated at 520 lbs/yr), and current conditions (1,053 lbs/yr).

Ideally, if all 61 problem sites identified in the 2013 watershed survey were treated with BMPs, and all new development contained proper phosphorus controls, these annual P loadings would be significantly reduced. The top twenty BMP sites would remove approximately 187 lbs of phosphorus per year from entering Province Lake. This would account for 76% of the total estimated removal needed to reach the water quality goal. On average, the top 20 BMPs will cost an estimated $2,000 per pound of phosphorus removed (refer to Appendix C).

It is important to note that, while the focus of this plan is on phosphorus, the treatment of stormwater will result in the reduction of many other kinds of harmful pollutants that could have a negative impact on these waters. These pollutants would likely include:

- Nutrients (e.g. nitrogen)
- Bacteria and viruses
- Heavy metals (cadmium, nickel, zinc)
- Petroleum products

- Road sand/salt

Without a monitoring program in place to determine these pollutant levels, it will be difficult to track successful reduction efforts. 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 input to the LLRM model developed for this project to estimate the response of the lakes to the reductions.

4.4 Adaptive Management Approach

The Adaptive Management Approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame.

An adaptive management approach is highly recommended for protecting lake watersheds, because it enables stakeholders to conduct restoration activities in an iterative manner. For example, the steering committee should review and update the BMP matrix annually to re-establish priorities as the plan progresses. This provides opportunities for utilizing available resources efficiently through BMP performance testing and watershed monitoring activities. Stakeholders can 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 activities. The adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short-time frame. Instead, adaptive management features establishing an ongoing program that provides adequate funding, stakeholder guidance, and an efficient coordination of restoration activities. Implementation of this approach would ensure that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time period. The adaptive management components for future implementation efforts should include:

- ***Creating an Organizational Structure for Implementation.*** Since the watershed spans multiple municipalities and two states, a cooperating group representing the five towns, two states, the lake association and local watershed group should be established for the implementation of future efforts in the watershed. This will help coordinate the implementation of restoration activities. In addition to state and municipal officials and watershed groups, this collaborative approach should involve the various commercial business interests (i.e. campgrounds, golf course) in the watershed to allow for a full consideration of all issues relevant to an effective, efficient, and cost-effective restoration program.
- ***Establishing a Funding Mechanism.*** A long-term funding mechanism should be established to provide financial resources for restoration actions. In addition to construction and organizational management costs, consideration should also be given to the type and extent of technical assistance needed to design, inspect, and maintain stormwater BMPs. Technical assistance costs for the annual field monitoring program should also be considered. Clearly, funding is a critical element of sustaining the restoration process, and, once it is established, the management plan can be fully vetted and restoration activities can move forward.

- ***Synthesizing Restoration Actions*.** This watershed management plan provides prioritized recommendations to support restoration (e.g., structural/nonstructural recommendations for priority areas). All recommendations were developed by the Province Lake Project Management Team with feedback from the local community. These recommendations, or action items, need to be revisited and synthesized to create a unified watershed restoration strategy. Once a funding mechanism is established, the lake watershed restoration program should begin in earnest by developing detailed designs for priority restoration activities on a project area basis and scheduling their implementation accordingly.
- ***Continuing the Community Participation Process.*** The development of the Province Lake Watershed Management Plan has greatly benefited from the active involvement of an engaged group of watershed stakeholders with a diversity of skills and interests. The implementation of the plan will require their continued and ongoing participation as well as additional community outreach efforts to involve even more stakeholders throughout the watershed. A sustained public awareness and outreach campaign is essential to secure the long-term community support that will be necessary to successfully implement this project.
- ***Developing a Long-Term Monitoring Program.*** Although current monitoring efforts are strong, a detailed monitoring program (including ongoing monitoring of watershed tributaries) is necessary to track the health of the lake. Indeed, the overall goal of the watershed management planning process is the improvement of water quality and long-term health of the lake. For more information on future monitoring see Section 5.6.
- ***Establishing Measurable Milestones.*** A restoration schedule that includes milestones for measuring the restoration actions and monitoring activities in the Province Lake watershed is critically important to the success of the plan. In addition to monitoring, 26 environmental, social, and programmatic indicators have been identified to measure the progress of the Province Lake Watershed Management Plan. These indicators are listed in Section 5.3, and include benchmarks at 1-2 years, 2-5 years and 5-10 years for environmental, programmatic, and social indicators. Benchmarks and indicators are intricately tied to the action items identified in the action plan in Section 5.2.

5. PLAN IMPLEMENTATION

5.1 Plan Oversight

WHO WILL IMPLEMENT THE PLAN?

The Province Lake action plan will be led by the combined efforts of the PLA and AWWA in coordination with a watershed steering committee. Local participation is an integral part of the success of this plan, and should include the leadership of NH DES, Maine DEP, local municipalities (including Wakefield and Effingham, New Hampshire, and Parsonsfield, Maine) schools, community groups, local businesses, road associations, and individual landowners. The steering committee will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce nonpoint source pollution in the Province Lake watershed, thereby eliminating the occurrence of toxic cyanobacteria blooms in the lake.

5.2 Action Plan

WHY IS AN ACTION PLAN NEEDED?

Province Lake is listed on the New Hampshire Department of Environmental Services (NH DES) 2010 and 2012 303(d) list as impaired for Aquatic Life Use due to low pH, high levels of chlorophyll-a and total phosphorus, and is impaired for fish consumption due to mercury. It is also on the 2012 list as impaired for Primary Contact Recreation (swimming) due to reoccurring cyanobacteria blooms. Since 2010, there has been an increasing prevalence of documented cyanobacteria blooms in localized areas within Province Lake. Algal blooms and cyanobacteria blooms are indicators that the lake is out of balance. Since some forms of cyanobacteria are toxic to people as well as other animals, these blooms have resulted in beach advisories for targeted areas along the shore to protect public health.

A decline in water quality, including an increase in documented blooms, is a signal that current land-use practices may be impacting the health and function of the lake system. Land-uses practices on developed land can result in the delivery of excess sediment and nutrients from soil erosion, aging septic systems, and roads throughout the watershed.

HOW WAS THE ACTION PLAN DEVELOPED?

The action plan was developed through the combined efforts of the PLA and the Province Lake Project Management Team, as well as the public, by way of feedback provided during the community forum held at the Greater Wakefield Resource Center in Union, NH on January 18, 2014. It was further supplemented by those unable to attend via feedback received from a posting of a draft plan on the PLA website in February 2014.

HOW DOES THE ACTION PLAN WORK?

This action plan is a critical component of the Province Lake Watershed Management Plan because it provides a list of specific strategies for improving water quality, and associated pollutant load reductions. The Province Lake Project Management Team comprised of representatives from the PLA, AWWA, NH DES, and the Maine DEP, and with technical support from FB Environmental Associates, set a water

quality goal to prevent the future occurrence of toxic cyanobacteria blooms on Province Lake. This will require reducing the amount of pollutants (especially phosphorus) that are getting into the lake by 25% over the next 10-15 years. This reduction will prevent 250 lbs (113 kg) of phosphorus from entering the lake annually. Load reduction estimates are presented for each of the action categories.

THREATS TO WATER QUALITY

Many of the threats to Province Lake have been introduced earlier in this plan. However, nonpoint source pollution is diverse, and comes in many forms. The following threats to water quality were identified by more than sixty attendees at the January 2014 community forum. These threats were developed by subgroups of individual stakeholders as outlined below for six major categories: septic systems, shoreline development, municipal ordinances, roads, recreation/boating, and water quality monitoring. The action plan was designed to address these threats.

IDENTIFIED THREATS TO PROVINCE LAKE

CATEGORY	DESCRIPTION OF THREATS
Septic Systems	• Leaking systems (lack of awareness about problem systems), old systems • No systems – cesspools, outhouses • Water quality impacts during septic system replacement (e.g., tree removal and erosion) • Small lot size • High-density lots • Proximity to wetlands, and lake • Overuse • Lack of adequate maintenance/ pumping (lack of knowledge of necessity to do so)
Shoreline Residential BMPs	• Shoreline erosion along Bailey Road • Dog waste; lack of education about effects of waste • Lack of knowledge of programs and threats • Erosion at campgrounds • Large lawns at water's edge • Lack of well vegetated shoreline buffers • Uncontrolled runoff from developed features on residential lots
Municipal Ordinances & Land Conservation	• Building density • Inappropriate land use (chemical hoarding) • Conversion of forest land to other uses • Full build-out more dense than desired • Impervious cover regulation inconsistencies; types and extent of allowable impervious (e.g. decks vs. pavement) • Stream buffer encroachment • Inconsistent regulations among watershed towns • Insufficient communication between stakeholders and planning boards • Lack of consistent septic system regulations • Conversion of camps to year-round use • Lack of funding to fix problems • Old septic systems & outhouses
Roads	• Excessive road widening (especially on Bonnyman Road) • Public use in sensitive shoreline areas • Lack of educational efforts (signs, pamphlets) • Improper road maintenance • Poor road design
Recreation/Boating	• Boating (shallow coves - easy to ground propeller, "powering on" to boat trailers creates holes) • Fireworks discharged over the lake (effect of chemical and plastic pollution) • Use of Styrofoam in the lake to provide flotation, such as for swim rafts. It degrades in sunlight and muskrats reportedly like to dig holes in it. Lots of blue flecks have been seen floating in the lake and washed up on the shoreline. • Lack of bathrooms for swimmers at non-residential locations • Swimmers urinating in the water while swimming at their own or host's lakeside properties, or while boating • Parking - parking and launching boats destroys ground

IDENTIFIED THREATS TO PROVINCE LAKE	
CATEGORY	**DESCRIPTION OF THREATS**
Water Quality Monitoring & Assessment	• Potential effect of dam management on lake flushing rate • Beaver dams on South River • Development (existing and future), including campgrounds • Logging • Frequency/timing of monitoring (weekday vs. weekend monitoring) • Small drainages carrying pollutants from developed land • Outhouses • Air quality • Climate change • Invasive aquatic plants • Canada geese • Lake level too high resulting in shoreline damage • Feeding ducks

THE ACTION PLAN

The Province Lake Watershed Management Plan Steering Committee should work toward improving and implementing the action plan that helps address threats identified within the following six major categories:

1) Septic Systems
2) Shoreline Best Management Practices (BMPs)
3) Roads
4) Municipal Ordinances and Land Conservation
5) Recreation/Boating
6) Water Quality Monitoring

In addition to the goal of nutrient (phosphorus) reduction, the action plan was developed to foster further thinking about long-term strategies for improving the water quality and related natural resources within the Province Lake watershed, and to promote communication between citizens, municipalities, and state agencies. The action plan outlines pollution reduction targets, responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each of the five categories. Current cost estimates for each action item will need to be adjusted based on further research and site design considerations.

5.2.1 Septic Systems

Septic system effluent typically stores a thousand times the concentration of phosphorus in lake waters; which means that a small amount of effluent could have a major impact on the lake. An old or improperly maintained septic system can also result in the delivery of disease-causing bacteria or viruses that can result in gastro-intestinal illness in swimmers. Untreated septic waste may contain chemicals and hormones used in pharmaceutical and personal care products, which can reach lake water if a system is not working properly. Inundation of systems by groundwater greatly enhances the transport of phosphorus and pathogens to the lake. Therefore, it is critical to ensure adequate setbacks and good vertical separation from the seasonally high groundwater table.

Based on the watershed modeling that has been completed, wastewater systems, including septic systems, outhouses and cesspools are the second largest source of phosphorus to Province Lake. The combined

categories of old septic systems (>20 years), cesspools, and outhouses were estimated to provide over 81% 146 lbs (66.2 kg) of the phosphorus load from the wastewater category. A strong wastewater inspection and maintenance program will reduce phosphorus and bacteria loading to Province Lake.

Load reduction estimates for **septic systems** are based on the results of the 2013 Province Lake Septic Survey, and a septic system model that estimates phosphorus loading from septic systems. The target pollutant loading reduction goal assumes that 50% of property owners with old septic systems, outhouses or a cesspool will upgrade their system. Significant reductions in phosphorus loading to the lake will be achieved if landowners take responsibility to check their systems, and make necessary upgrades, especially to old systems, cesspools and outhouses.

SEPTIC SYSTEMS *Target Pollutant Reduction Goal = [44 - 55 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Septic System Upgrades & Technical Assistance					
Mandatory Inspections & Pumping	• Require inspections and maintenance of septic systems and repair at time of property transfer. • Require inspections and maintenance of septic systems for all new permit requests.	PLA, Towns, State, Landowners	Grants, Towns, Landowners	2015-2025	$250/system
Community Septic Systems	Install community septic systems for cluster developments (campgrounds & small camps with outhouses).	PLA, Towns, Landowners	NH DES, Grants, Low-interest loans	2016-2018	$20-$30,000 per community for initial installation
Targeted Septic Installation	Install new septic systems at high-risk sites (old systems, on slope, close to water).	PLA, landowners	NH DES, Grants, Landowners	2014--2018	TBD
Landowner Assistance	Offer free landowner assistance (technical, permitting and grants) for septic system maintenance and upgrades.	PLA, AWWA, Towns	NH DES	2015-2017	$1,500
Dye Testing	Encourage and help fund voluntary dye testing for homeowners to evaluate septic system performance.	PLA, AWWA	NH DES, Towns	2015-2017	$75-$125/system
Group Discounts	Coordinate group septic system pumping discounts (PLA member pumping discounts).	PLA, AWWA	NH DES	Start 2015	n/a
Cost Sharing	Investigate grants and low-interest loans to provide cost-share opportunities for septic system upgrades.	PLA, AWWA	Volunteers	Immediately	n/a
Septic System Fund	Designate a single pot of conservation dollars for the lake that can be used for septic system upgrades.	PLA, AWWA	Volunteers	Beginning 2015	$1,000
Septic Education & Outreach					
Targeted Septic Outreach	Focus outreach on septic survey results with focus on older systems, close to the shoreline, rarely pumped, outhouses and cesspools.	PLA	Grants, Volunteers	2014-2016	$1,000
Campgrounds	Focus septic maintenance education at campgrounds.	PLA, AWWA	Volunteers	2014-2016	$500
Door to Door	Conduct door-to-door septic education to follow-up on septic survey.	PLA, volunteers	Volunteers	2015-2016	$250
Septic Socials	Host septic socials, and develop a "Poop Troop".	PLA, AWWA	Grants	2015-2017	$500

SEPTIC SYSTEMS *Target Pollutant Reduction Goal = [44 - 55 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Septic System Flyer	Distribute an educational flyer about septic systems and disseminate with tax bills.	PLA, AWWA	Volunteers, Grants	2014-2015	$1,000
Septic Provider List	Create and distribute a list of septic service providers (create magnets, etc.).	PLA	Volunteers, Fundraisers	2015	$500
Septic System Tracking					
Septic Database	Encourage town officials to track septic system pumping and upgrades; develop database.	PLA, Towns, States	Volunteers, Towns	2014-2016	$500

5.2.2 Shoreline Best Management Practices (BMPs)

Direct shoreline areas are typically among the highest for pollutant loading for most lakes given their close proximity to the lake, and desirability for development. It is estimated that the greatest loading to Province Lake is from the direct shoreline area, which includes the area within 250 feet of the lake. The shoreline deserves special attention in any lake protection plan, and Province Lake is no exception.

Best Management Practices (BMPs) are restoration tools that property owners can use to minimize impacts from stormwater runoff and restore degraded shoreline areas. This could be as simple as planting vegetated buffers, installing gravel driplines along roof edges, and ensuring that paths and driveway runoff is filtered into the ground rather than running overland and into the lake. Coordination with landowners is crucial for successful implementation of BMPs identified in this action plan because mitigation measures will need to be implemented on private land. Roads and septic systems are not included in this portion of the action plan, but are addressed as their own category within the action plan.

The target load reduction estimate of 66-99 lbs TP/yr is based on Region 5 nutrient and sediment loading estimates conducted by AWWA for sites identified during the 2013 watershed survey. The sites include shoreline residential and commercial (campgrounds) properties, the boat launch on Bonnyman Rd., and the golf course. Education and outreach to landowners is an important and necessary component of this portion of the action plan.

SHORELINE BEST MANAGEMENT PRACTICES (BMPs) *Target Pollutant Reduction Goal = [66 - 99 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Shoreline BMPs & Technical Assistance					
High Priority BMPs	Implement BMPs at high priority sites identified following the 2013 watershed survey. Includes residential properties, beach and boat launches, etc.	PLA, AWWA	NH DES, MEDEP, Towns, States	Beginning 2014	$60,782*
Medium & Low Priority BMPs	Utilize the BMP matrix to prioritize and address medium and low priority BMPs.	PLA, AWWA	NH DES, AWWA	2016-2018	$66,694*
Golf Course	Work with the golf course to review 2013 report recommendations and implement strategies for protecting lake water quality.	PLA, AWWA	Volunteers, golf course	2014-2016	Cost included in total above

SHORELINE BEST MANAGEMENT PRACTICES (BMPs)

Target Pollutant Reduction Goal = [66 - 99 lbs Phosphorus/yr]

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	SUGGESTED ANNUAL COST
Boat Launch	Stabilize the boat launch on Bonnyman Rd.	PLA and Towle Farm	NH DES, Donations	2014-2015	Cost included in total above
Youth Conservation Corps (YCC)	Coordinate with the Acton Wakefield Watersheds Alliance (AWWA) to enlist Youth Conservation Corps (YCC) implementation and outreach activities throughout the watershed.	PLA, AWWA	NH DES, Towns, Private Landowners	Beginning 2014	$10,000
Training for Local Contractors	Require contractors to have adequate training in the installation and maintenance of Low Impact Development (LID) and BMPs for all permit work.	PLA, Towns	Contractors	Beginning 2014	n/a
Shoreline Vegetation	Install stormwater best management practices (vegetation) along beach side of road.	PLA, AWWA, Towns	Grants, Towns, States	2014-2016	Cost included in total above
Plant Sale	Organize and host an annual spring plant sale. Locally sourced, native plants can be used for shoreline buffer plantings.	PLA	N/A	Spring 2014 and ongoing	n/a
Conservation/ Water Quality Fund	Work with three watershed towns to develop a conservation or water quality fund.	PLA, AWWA, Towns	N/A	Start 2015	n/a
Shoreline Education & Outreach					
BMP Demonstrations	Working with partners, set-up demonstration projects with focus on high-visibility residential BMPs in targeted locations throughout the watershed.	PLA, AWWA, Towns	NH DES, Grants	Beginning in 2014	$10,000
Self-assessment Quiz	Develop and send/post on-line, a self-assessment quiz helping homeowners to determine whether or not they have an erosion problem.	PLA, AWWA	Grants, Donations	2015 and 2020	$500
Door-to-Door BMP Education	Enlist volunteers (including neighborhood reps) to go door-to-door to inform neighbors about erosion, BMPs, and programs that can help.	PLA	Volunteers	2015-2017	n/a
Educational Signage	Install educational signs at select locations, such as "Scoop the Poop!"	PLA, Towns	Grants, Fundraisers	2015-2017	$250
BMP Brochure	Develop and send letters to residents in the spring showing before/after photos of BMPs.	PLA, AWWA	Donations, Fundraisers	Spring 2015	$1,000
Beach Clean-Up	Organize an annual volunteer beach cleanup.	PLA, AWWA	Volunteers, Donations	Annually beginning in 2014	n/a
Discovery Cruises	Organize an annual discovery cruise/paddle on the lake.	PLA, AWWA	Volunteers, Grants	Annually beginning in 2015	$250
PLA Website	Keep Province Lake Association website current, and include up to date information about bloom conditions and beach closures.	PLA	Donations, Fundraisers	Annually, beginning in 2014	$100
Publicity	Publicize events and lake quality updates through local newspapers and PLA newsletter.	PLA	Donations, fundraisers	Annually, beginning in 2014	$500
Discourage swimmers from peeing in the lake	Educate people that urine contains phosphorus and can contribute to the excessive phosphorus in the lake.	PLA	Volunteers	Ongoing, beginning 2014	n/a

SHORELINE BEST MANAGEMENT PRACTICES (BMPs) *Target Pollutant Reduction Goal = [66 - 99 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
BMP Tracking					
BMP Tracking & Monitoring	Track BMPs as sites are identified and BMPs are implemented.	PLA, AWWA	Grants	Annually, beginning in 2014	$1,000
Long-term BMP Monitoring	Re-survey implemented BMP sites every five years and develop a tracking system to document long-term functionality.	PLA, AWWA	Grants	Every five years starting 2019	$1,000

**Total includes initial cost of BMP plus associated annual costs over a 10-year period. Cost estimate does not include engineering design fees.*

5.2.3 Roads

The 2013 Province Lake Watershed Survey identified 61 sites that are resulting in the delivery of nutrients and other pollutants entering the lake. Of these, 20% are associated with state, town or private roads. Five of these sites are located on Route 153, and deemed the most significant threat to water quality among road sites identified in the watershed due to proximity to the lake, and heavy use in the summer time. The remaining sites are located on private and town roads, many of which slope toward the lake, depositing sand and gravel directly into the water.

A target pollutant reduction goal of 100 - 165 lbs TP/yr is based on Region 5 load reduction measurements and calculations conducted by AWWA for road sites identified during the 2013 watershed survey. Load reduction estimates for individual sites are presented in Appendix C. Improvements to Route 153 are considered high priority for restoration due to the close proximity to the lake, extent of erosion, and potential for significant pollutant reductions.

ROADS *Target Pollutant Reduction Goal = [110 - 165 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Roadway BMPs					
State Roads	Assist state with BMP installation on state roadways.	States	MDOT NHDOT	2015-2017	$57,417*
Town Roads	Assist Towns with BMP installation on town roadways.	Towns	Towns MDEP Grants	2015-2017	$129,071*
Driveways	Work with watershed landowners to address NPS issues associated with driveways. Provide technical assistance & access to grant funds.	Landowners, PLA, AWWA	Grants	2015-2017	$15,085*
Upgrade public roads	• Upgrade public roads annually using recommended BMPs from watershed survey, UNH Roads Scholar reference and Maine Camp Road Manual. • Work with the towns to address erosion on Bonnyman and Bailey Roads.	Towns, States, PLA, Towns	Towns, MDOT, NHDOT, NH DES, MEDEP	Annually	TBD
On-Going Collaboration with States	• Continue relationship with both states about issues on Route 153 • Set up annual meeting to discuss road problems as needed.	PLA, AWWA, MDOT, NHDOT	n/a	Annually	n/a

ROADS *Target Pollutant Reduction Goal = [110 - 165 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Roadway BMPs					
Roadside Parking	• Work with NHDOT/MDOT to develop alternatives to minimize impacts from roadside parking, foot traffic & boat launching along Route 153 beach. • Work with stakeholders to develop design alternatives to reduce erosion. • Explore the possibility of adding signs and extending the existing guardrail along the north side of Route 153.	PLA, AWWA, States	MDOT, NHDOT	2014-2015	TBD
Rt. 153	Resurface Rt. 153 to drain away from the lake and prevent direct runoff.	Towns, MDOT, NHDOT, NH DES, Maine DEP	Towns, MDOT, NHDOT, NH DES, Maine DEP	TBD	TBD
Roadside Vegetation	Install stormwater Best Management Practices (e.g. vegetation) along beach side of road.	PLA, AWWA, Towns , States	NH DES grants, states, towns	Ongoing, beginning 2014	TBD
Roadway Education & Outreach					
Road Maintenance Workshop	Educate town officials, road maintenance personnel, and contractors through roadway BMP outreach workshops.	PLA, AWWA	Grants, towns	Annually, beginning 2015	$1,000
Road Associations	Host a workshop for road associations.	PLA, AWWA, Towns	Grants	Every 2 years, beginning 2015	$1,000

**Cost estimates include initial cost of BMP plus associated annual costs over a 10-year period.*

5.2.4 Municipal Ordinances

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 conducted by FB Environmental indicates that there is considerable need for improvement in protecting water quality through non-structural BMPs such as municipal ordinance adoption or revisions, especially as it relates to new development. Action items related to this element have been divided into those relating to septic systems, and the adoption of new ordinances or incorporation of new language (watershed-wide) including the need for a low impact development (LID) strategy (watershed-wide).

Pollutant loading reductions for this category are based on increased loading estimates from the Province Lake Buildout Analysis (FBE, 2014b), which estimates an increase of approximately 330 lbs TP/yr from new development (under current zoning standards and 30-year growth rates) over the next 30 years. Addressing future development and developing ordinances that require retrofits for upgrading existing structures, and imposing limits on impervious cover is expected to prevent between 187 - 209 lbs TP/yr from entering Province Lake.

MUNICPAL ORDINANCES & LAND CONSERVATION *Target Pollutant Reduction Goal = [187-209 lbs Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Septic Systems					
Site Plan Review & Septic System Regulations Assessment	Review town site plans and septic system rules.	PLA, Towns, Consultant	Grants	2014-2016	$1,500
Planning Board Meetings	Communicate regularly with the Planning Boards of the three towns about Province Lake efforts by attending regular meetings.	PLA	Volunteers	Ongoing	n/a
Grandfathering	Develop non-regulatory approaches for addressing grandfathered wastewater systems.	PLA, Consultant	Towns, Grants	2014-2015	$1,000
Expansions	Improve ordinances to consider more than just number of bedrooms when doing expansions.	PLA, Consultant	Towns	2015-2017	$1,500
Municipal Ordinances- New & Upgrades to Existing					
Conservation Subdivisions	Increase incentives for conservation subdivisions in town ordinances.	PLA, Towns, AWWA	Towns, Grants	2015-2017	$1,500
Low Impact Development (LID)	Develop new policy to encourage Low Impact Development (LID) for all future development including additions.	PLA, Towns, AWWA	Towns, Grants	2015-2017	$1,500
Setbacks, Buffers & Lot Coverage	Improve ordinances to include mandatory setbacks, riparian buffers between development and waterbodies, and maximum lot coverage restrictions.	PLA, Towns, AWWA	Towns, Grants	2015-2017	$1,500
Open Space	Encourage towns to adopt open space guidelines for conservation subdivisions.	PLA, Towns, AWWA	n/a	Beginning 2015	n/a
Land Conservation					
Landowner Outreach	Conduct outreach to large landowners (particularly those facing generational change) to discuss conservation options.	PLA, Local Land Trust	n/a	2015-2016	$100
Land Conservation Workshop	Ask Moose Mountain Regional Greenways (MMRG) Green Mountain Conservation Group (GMCG) and Francis Small Heritage Trust to host a land conservation workshop for landowners in the watershed.	PLA, AWWA	Grants, Donations	2015-2016	$500

5.2.5 Recreational Boating

Recreational users of Province Lake may not be aware of the effects that their actions have on the water quality of the lake. Twenty-three percent of erosion sites identified in the 2013 watershed survey were located at beach access sites. Parking on the beach destroys the natural vegetation; undisturbed vegetation naturally filters pollutants in stormwater from roadways and other developed land areas. Maintenance of boat launches is needed to prevent erosion at these sites. Lastly, resuspension of sediments and nutrients by heavy boat traffic in the lake is a real concern that needs additional research and attention. Reduction of the physical stirring up of sediments by boat traffic would help reduce the potential for ongoing cyanobacteria blooms. It may also help prevent other negative effects of boating on the lake including increased turbidity, decreased water clarity, shoreline erosion, and effects on rooted aquatic plants, invertebrates, fish, waterfowl and other aquatic wildlife. Actions related to recreation and boating include a combination of BMPs, education and outreach, and strategic funding to implement the strategies.

Loading reduction estimates for recreation and boating are yet to be determined for Province Lake. Site specific information is needed to determine the impact of boat traffic on water quality. Education and outreach, and research are important components of this portion of the action plan.

Recreation & Boating *Target Pollutant Reduction Goal = [TBD kg Phosphorus/yr]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Best Management Practices (BMPs)					
Beach Bathrooms	Install port-a-potties at Rt. 153 beach area; utilize PLA sponsors.	PLA, beach landowners	Private Sponsors	2015-2016	TBD
Boat Traffic Study	Investigate the effects of boat traffic on in-lake water quality.	PLA	Grants, UNH, Plymouth State	2015	TBD
Education & Outreach					
Lake Host/Boat Launch Brochure	Continue the Lake Host program and distribute information about maintaining boat launches to landowners.	PLA & Towle Farm	Grants, Donations	2015-2016	$500
Recreational Boating Mailing	Create and distribute an informational mailing to landowners (including new landowners) about the effects of recreational boating on water quality; educate the public about boating issues and etiquette in shallow areas.	PLA, AWWA	Grants	2015	$1,000
Fireworks Research & Education	Investigate the effects of fireworks on lake water quality, and distribute information via website, or develop an informational brochure on results.	PLA, UNH	Grants	2015-2016	$500
Educational Kiosk	Install a kiosk with educational posters/signs conveying issues related to boat launch, no wake zone, cyanobacteria at swimming areas.	PLA, Towle Farm	Donations/ Grants	2015-2016	$1,500
Funding					
Donations	Build a donation box, and encourage landowners to donate to fixing boat launch, BMPs in common areas, water quality monitoring, etc.	PLA & Towle Farm	Donations	2014-2015	$100
501(C)(3)	PLA should consider getting certified by the IRS as a 501(C)(3) charitable organization.	PLA, broker	PLA	2015	TBD
Gifts of Appreciated Stocks	Following 501(C)(3) certification, PLA should consider opening a brokerage account to allow people to donate highly appreciated stock.	PLA, broker	PLA	2016	TBD

5.2.6 Monitoring and Assessment

Monitoring programs are crucial to evaluating the effectiveness of watershed planning activities, and to determine if water quality goals are being achieved over the long-term. This action plan includes recommendations for enhancing current water quality monitoring efforts, including sample collection from various tributaries, and continuation of the Weed Watch program. Since volunteers typically conduct many different monitoring activities, it will be critical to continue building on the success of PLA's ongoing education and outreach programs.

Since load reductions from monitoring and assessment are not applicable, this portion of the action plan focuses on the overall water quality goal of reducing in-lake phosphorus concentration by 25%; a reduction of 3.5 ppb. Implementation of actions from the categories featured above (septic, shorefront residential, roads and land conservation and municipal planning) will be needed to reach this goal.

MONITORING AND LAKE ASSESSMENT *Water Quality Goal = [25% reduction in Total Phosphorus or 10.8 ppb]*					
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Monitoring					
Extend Monitoring Season	Extend lake monitoring season April through November to capture spring and fall cyanobacteria bloom conditions.	PLA, UNH LLMP	PLA, NH DES	Beginning 2014	$500
Weekend Monitoring	Add weekends in addition to standard weekday measurements (DO and SDT, and TP) to get a better sense of high-use water quality conditions.	PLA, UNH LLMP	PLA, NH DES	Beginning 2014	n/a
Weed Watch & Lake Host Programs	Continue Weed Watch program to keep invasive species from entering Province Lake; conduct routine surveys of dam, tributaries and shallows during summer months.	PLA	PLA, Volunteers	Ongoing 2014	n/a
Volunteer Monitors	Recruit and train additional LLMP volunteers.	PLA, UNH LLMP	Volunteers, UNH LLMP	2014	n/a
Secchi Disk Monitoring Frequency	Extend Secchi Disk Transparency Frequency from once/month to weekly or biweekly (esp. for transparency).	PLA, UNH LLMP	Volunteers	Beginning 2014	n/a
Tributary Monitoring	Continue monitoring key tributaries throughout the watershed; include wet weather, or storm samples.	PLA, UNH LLMP	PLA	Beginning 2014	$1,200
Weed Watch Program Leader	Recruit a new volunteer Weed Watch Program leader.	PLA	PLA, Volunteers	2014	n/a
Weather Station	Investigate the benefits of weather monitoring for air quality/wind/visibility; if feasible, set up monitoring station using automated data loggers, or simple personal weather station.	PLA	PLA, UNH, Grants	2015	TBD
Cyanobacteria Monitoring	Work with UNH and NH DES to implement a formal cyanobacteria monitoring program for Province Lake.	PLA, UNH, NH DES	PLA, NH DES, UNH	2015	TBD
Cyanobacteria Workshop	Host a hands-on cyanobacteria workshop in coordination with UNH.	PLA, UNH, AWWA	UNH, Grants, Donations	2015-2016	$500
Sediment Cores	Work with UNH to examine sediment cores for phosphorus, copper and other parameters; use students to assist with studies.	PLA, UNH	UNH	2013/2014	n/a
Dam Management	Utilize long-term dam level information to determine stream discharge at outlet; determine if dam management needs adjustment to prevent cyanobacteria blooms.	PLA, Dam Committee, NH DES Dam Bureau	PLA, Consultant	2015	$1,500

SUMMARY

The Province Lake Watershed Management Plan Steering Committee should work toward implementing the action plan and identifying improvements as needed. The formation of smaller action committees would result in more efficient implementation of the Province Lake Action Plan.

The estimated load reductions for each of the categories above were designed to meet the target goal of a 25% phosphorus reduction in Province Lake. These actions will improve lake water quality so that all residents and visitors will be able to swim, fish, boat and enjoy the many benefits that Province Lake has to offer now and for future generations. To be successful, the action strategies listed above will require an integrated and adaptive approach across many different parts of the watershed community to be successful. The action plan provides the means by which to make the water quality goal a reality.

5.3 Indicators and Benchmarks to Measure Progress

Establishing indicators and numeric targets (benchmarks) to quantitatively measure the progress of the Province Lake Watershed Plan will provide both short and long-term input about how successful the plan has been in meeting the established goals and objectives for the watershed.

Indicators are derived directly from tasks identified in the action plan. While the action plan provides a description of tasks, responsible party, a schedule, and estimated annual costs associated with each task, the indicators are developed to reflect how well implementation activities are working, and provides a means by which to track progress toward established goals and objectives.

The following environmental, programmatic, and social indicators and associated benchmarks will help measure the progress of the Province Lake Watershed Management Plan (Tables 15-17). These benchmarks represent short-term (1-2 years), mid-term (2-5 years), and long-term (5-10+ years) targets for improving water quality in Province Lake. Setting benchmarks allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The steering committee will 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 if the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They include:

Table 15. *Environmental indicators and associated benchmarks.*

ENVIRONMENTAL INDICATORS			
INDICATORS	**BENCHMARKS***		
	(1-2 years)	*(2-5 years)*	*(5-10 years)*
a) Improvement in average annual water clarity Goal: 3.0 meters	+ 0.1 m	+ 0.25 m	+ 0.4 m
b) Reduction in the in-lake phosphorus concentration Goal: 10.8 ppb	10% of goal= 14.0 ppb	30% of goal= 13.3 ppb	75% of goal= 11.7 ppb
c) Percent reduction in the number of reported algal blooms Goal: No reported blooms	10%	50%	90-100%
d) Decreasing trend in apparent color Goal: Non-colored, decreasing trend	< 30 PCU	< 25 PCU	< 20 PCU

** Benchmarks are cumulative starting at year 1.*

Programmatic Indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. They include:

Table 16. *Programatic indicators and associated benchmarks.*

PROGRAMATIC INDICATORS			
INDICATORS	**BENCHMARKS***		
	(1-2 years)	*(2-5 years)*	*(5-10 years)*
a) Amount of funding secured for plan implementation through fundraisers, donations and grants	$150,000	$350,000	$500,000
b) Number of high priority sites remediated	5	10	20
c) Number of medium and low priority sites remediated	20	50	65
d) Number of high-visibility residential BMP demonstration projects completed	1-2	4-8	10-15
e) Linear feet of roadway addressed by BMPs	150 ft.	300 ft.	650 ft.
f) Number of culverts stabilized	1-2	3-5	N/A
g) Number of voluntary septic system inspections	50	150	300
h) Number of waste water or septic system upgrades	10	100	225
i) Number of acres of new land in conservation	50	100	1,000
j) Number of watershed-based educational materials distributed	250	500	1,000

** 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. They include:

Table 17. *Social indicators and associated benchmarks.*

SOCIAL INDICATORS			
INDICATORS	**BENCHMARKS***		
	(1-2 years)	*(2-5 years)*	*(5-10 years)*
Number of new PLA members or stakeholders on the steering committee	25 new members; 1 new steering committee member	45-75 new members; 2 new steering committee members	75- 125 new members; 5 new steering committee members
Number of homeowners who participate in "septic socials" or join the "Poop Troop"	20	40	100
Number of people who sign up for YCC implementation projects	10-20	20-50	50-100
Number of contractors completing a BMP or LID training	5	10	15
Citizen support as evidenced by the number of ordinances amended to support the plan	Develop 1 new ordinance	1 ordinance approved or amended	2 new ordinances (septic & LID)
Number of volunteers participating in door-to-door education campaigns	10	20	30
Number of volunteers participating in annual beach clean-ups	10	30	60
Number of people participating in road workshops	10	30	60
Number of landowners with >10 acre lots participating in land conservation programs	2	10	20
Number of new "Lake Hosts"	2	5	10
Number of active "Weed Watchers"	10	15	20
Number of trained newly trained UNH LLMP volunteers	1	3	5

** Benchmarks are cumulative starting at year 1.*

5.4 Estimated Costs and Technical Assistance Needed

The cost of successfully implementing this watershed plan for Province Lake is estimated at $693,000 over the next ten years (Table 18). However, many costs are still unknown and should be incorporated into the action plan as information becomes available. This includes both structural BMPs, such as fixing eroding roads and planting shoreline buffers, and non-structural BMPs such as improving ordinances. Annual BMP costs were estimated based on a ten-year total for the initial BMP installation plus ten years of maintenance. Therefore, the annual BMP costs are not truly representative of how funds will likely be allocated during implementation since the highest priority BMPs such as Rt. 153 may be the more costly BMPs, and therefore, the annual costs may be higher earlier in the ten-year plan cycle, and less toward the end of the ten years.

Table 18. *Estimated annual and 10-year costs for watershed restoration*

Category	Estimated Annual Costs	10-year Total
Education & Outreach	$22,000	$220,000
Ordinances	$9,600	$96,000
BMPs	$34,000	$340,000
Monitoring	$3,7000	$37,000
Total Cost	**$ 69,300**	**$693,000**

A diverse source of funding and a funding strategy will be needed to match these implementation activities. Funding to cover **ordinance revisions** and third-party review could be supported by municipalities through tax collection, permit fees, or violation fees. **Monitoring and assessment** funding could come from a variety of sources, including state and federal grants (Section 319, ARM, Moose Plate, etc.), AWWA, and PLA. Funding for **education and outreach** might also be expected to come from the PLA and AWWA. Funding to improve **septic systems, public and private roads, and shoreland buffers** could be expected from property owners most affected by the improvements. As the Watershed Plan evolves into the future, the PLA will be a key part of how the funds are raised, tracked and spent to implement and support the plan.

5.5 Educational Component

This watershed management plan includes an educational component that can be used to enhance public understanding of the project and encourage community participation in watershed restoration and protection activities. As discussed in Section 1, the Province Lake Association was established to educate, communicate and coordinate with its members and the community what is and can be done to protect, preserve and improve the quality of Province Lake. Working in collaboration AWWA, whose mission is dedicated to protecting and restoring the water quality of the lakes, ponds, rivers and streams of Wakefield, New Hampshire and the border region of Acton, Maine, AWWA will work closely with the PLA and residents of the watershed communities to strengthen the understanding that what happens on land determines the health of the local waters. Together, PLA and AWWA can offer educational events

described in the action plan (Section 5.2). Through the YCC, AWWA has already completed eleven YCC projects on Province Lake and prevented an estimated total of 41 tons of sediment and over 35 lbs. of phosphorus from reaching the lake, educating landowners along the way.

Efforts should be made to encourage understanding of current problems associated with cyanobacteria blooms and the need to improve the water quality in Province Lake. The educational goal of the Plan is to elevate public understanding of these connections and to encourage actions that reduce the occurrence of toxic cyanobacteria blooms and improve the health of the watershed ecosystem. Action items related to education and outreach are outlined in the action plan (Section 5.2).

5.6 Monitoring Plan

A well designed monitoring program is crucial for evaluating the effectiveness of watershed improvement activities and to determine if nutrient reductions are being achieved. The Province Lake Association (PLA), in coordination with the NH DES Volunteer Lake Assessment Program (VLAP), has been collecting water quality data for Province Lake consistently since 1991. The PLA should continue to take the lead on coordinating future monitoring activities in order to track changes in water quality over time.

(Photo: Donna Davis)

A consistent funding source, strong partnerships with UNH and NH DES, and a dedicated group of volunteer monitors will be needed to implement this plan. The action plan provides a list of proposed monitoring and assessment tasks to determine if watershed restoration efforts are effective over the long term. The monitoring plan provides a summary of existing and proposed monitoring activities for Province Lake:

Province Lake- Deep Spot

Dedicated VLAP volunteers have been consistently collecting water quality data at the deep spot (PROEFFD) on Province Lake on a monthly basis from mid-May through the end of September. Sampling parameters include temperature, dissolved oxygen, Secchi disk transparency, pH, specific conductivity, chlorophyll-a, and total phosphorus. Historically, samples have been collected on Thursdays. In addition, several other parameters have been collected, but not consistently. These include apparent color, alkalinity, chloride, acid neutralizing capacity, turbidity, calcium, total nitrogen and potassium. In addition to the core monitoring parameters, the following are sampling recommendations for Province Lake at the deep spot:

- Increase sampling frequency from monthly to bi-weekly (especially for SDT and DO).
- Recruit new volunteers to help collect biweekly SDT and/or dissolved oxygen data.

- Extend the sampling season to encompass spring and fall mixing to collect more specific information about the timing of spring and fall algal blooms.
- Add apparent color as a regular monitoring parameter to determine if the steep increasing trend (1979-2007) is an on-going issue.
- Consider collecting data (TP, Chl-a, Color, Turbidity and SDT) before, during, and after busy holiday weekends to examine effects of boat traffic. Consider adding boat counts, time lapse photography, and the use of a submerged sonde to quantify the effects of boat traffic.
- Collect wind speed data when conducting lake sampling.
- Limited total nitrogen data exists for Province Lake. A close examination of TN:TP ratios may provide information relative to phytoplankton communities, the source of nutrients flowing into the lake, and help answer the question of appropriate trophic classification. Collection of total nitrogen data should be coupled with collection of total phosphorus data.

Tributaries

The Province Lake Association, in coordination with the NH DES VLAP Program has been consistently collecting tributary monitoring data at the Route 153 Inlet (PROEFR) and Island Inlet (PROEFFI) since 1991. Parameters collected include total phosphorus, specific conductivity and pH. In addition, E.coli, turbidity (since 1997), and apparent color have been collected, but not consistently with the exception of turbidity. Several other tributary sites have been sampled for E.coli in the past. In 2013, NH DES helped the PLA conduct tributary monitoring at six tributaries each month between June and October plus the mouth of Hobbs Brook. The sites include the outlet, golf course tributary, Rte. 153 inlet, Bonnyman Rd., Campground inlet and Molly Philbrick Rd. tributary. Results of this monitoring indicate elevated phosphorus levels at the golf course tributary (Range 25-78 ppb), and levels above EPA recommendations at several other locations. Ongoing monitoring at these sites under both dry and wet weather conditions should be conducted in the future, especially at locations with consistently high results.

Several tributaries such as South River and several of the unnamed tributaries have been monitored consistently by volunteers since 1991. (Photo: Donna Davis)

- Conduct intensive tributary monitoring at new (2013) and existing stations in the watershed to better understand the effects of nutrient and sediment loading to the lake. Include both wet and dry weather sampling events and collect flow data to help further quantify nutrient loading from individual tributaries.
- Consider collecting year round and/or continuous monitoring data in several of the streams to further characterize loading and flow during different times of the year.

- Document rainfall for past 12, 24 and 48 hours prior to sampling.
- Conduct bracket sampling upstream of sampling location to identify potential source of increased loading.
- Examine the relationship between dissolved organic carbon (DOC) and metals as they relate to phosphorus cycling in the lake. This may include collecting DOC data in major wetlands that flow to the lake.
- Train volunteers to monitor during storm events at road crossings and culverts near the shorelines. Use information to identify problem areas and recommend solutions.
- Identify stream crossings that do not meet specifications according to the NH Stream Crossings Guidelines and replace non-conforming stream crossings.

Cyanobacteria

Based on recent accounts and testing of cyanobacteria in Province Lake, the lake is considered non-supporting for primary contact recreation. Blooms of cyanobacteria were reported to NH DES for the past 4 years (2010 - 2013). Samples were tested for toxic cyanobacteria in 2010 and twice in 2012. Cyanobacteria are a concern in Province Lake for many reasons, including lake aesthetics, concern about declining water clarity and the associated economic effects to the area, and most importantly, the potential affects to wildlife, domestic animals and human health.

- Consistent analysis is needed for water samples collected during bloom conditions to better quantify cyanobacteria blooms and to determine the extent and type of harmful toxins.
- Keep consistent records of significant wind events and cyanobacteria blooms to determine if mixing by wind is playing a role in internal loading, and to track when blooms are occurring.
- Evaluate fish population effects on zooplankton/phytoplankton abundance to help determine if fish controls should be implemented.
- Collect sediment profiles to assess historical levels of biological assemblages, and chemical information such as total phosphorus.

Watershed/Shoreline

- Document and assess baseline standards for land use practices around the shoreline using GPS cameras. Information relevant to towns for code enforcement in the shoreland zone.
- Continue to survey for invasive aquatic plant species to prevent establishment and spread of plants throughout this shallow lake. Conduct frequent routine surveys of the dam, tributaries, and shallow areas during summer months.
- Resurvey documented NPS sites identified in this plan every five years for BMP implementation and develop a tracking system to document long-term functionality.

- Develop a septic survey tracking program which tracks the location and date of septic system pumping and upgrades. May require ordinance amendments which require mandatory reporting by septic installers, or similar reporting requirements.
- A preliminary analysis of historical information indicates that Province Lake experienced much higher levels of TP and more frequent cyanobacteria blooms in the past. Ongoing volunteer research is needed to continue putting pieces together to determine how historical practices may have effected current trophic state classification and in-lake TP values. This may include plant dredging/weed harvesting, timber harvesting, artificial mixing in the 1970's and the effects of copper sulfate applications in the 1960's.

5.7 Evaluation Plan

All achievements, such as press releases, outreach activities, number of sites repaired, number of volunteers, amount of funding received, and number of sites documented should be tracked by the steering committee. This includes tracking estimated load reductions for management measures that are completed over time, and using the established indicators (Section 5.3) to determine the effectiveness of the plan.

Annual steering committee meetings should be organized to review the status of goals and objectives presented in this plan. It is recommended that an adaptive management approach be used to assess annual progress, determine key projects for the following year, and provide a venue for sharing information with watershed stakeholders. Adaptive management is the process by which new information about the health of the watershed is incorporated into the Plan. This process allows stakeholders the opportunity to evaluate the effectiveness of restoration and monitoring activities before implementing future actions. Tasks listed in the action plan should be tracked and recorded as they occur, and new tasks should be added to the plan as determined through the adaptive management process.

5.8 Conclusion

Watershed residents, landowners, business owners, and recreationalists alike should have a vested interest in improving the long-term water quality of Province Lake so that everyone can have access to clean water, free of toxic cyanobacteria blooms. The objective of the Province Lake Watershed Management Plan is to reduce the probability of nuisance algae blooms in Province Lake by reducing the in-lake total phosphorus concentration 3.5 ppb TP (a 25% reduction from the median, summer in-lake concentration, over the next 10 years). Reducing TP in Province Lake from 14.3 to 10.8 ppb will cost approximately $70,000 per year over the next 10 years. Cost estimates are based on tasks identified in the action

Rainbow over Province Lake. (Photo: Pete Dinger)

plan, which will need to be updated as the plan is implemented and new action items are added. Implementation of this plan over the next ten years will require the dedication and hard work of state and municipal employees, watershed groups, and volunteers to ensure that the actions identified in this plan are carried out accordingly.

PROJECT SPECIFIC RESOURCES

Province Lake Buildout Analysis

Province Lake Watershed Build-Out Analysis: Effingham and Wakefield, New Hampshire & Parsonsfield, Maine. FB Environmental Associates. March 2014.
Online: http://provincelake.org/watershed-management-plan/Province-Lake-Buildout.pdf

Province Lake Golf Club Site Report

Province Lake Golf Club: Recommendations for Phosphorus Control. FB Environmental Associates. September 2013. http://provincelake.org/watershed-management-plan/Province-Lake-GolfCourse.pdf

Province Lake Municipal Ordinance Review

a) *2012 Wakefield Stormwater Planning Project: Proposed Improvements to the Site Plan Regulations and Subdivision Regulations*. FB Environmental Associates. Revised June 2013.

b) DRAFT Province Lake Watershed Municipal Ordinance Review: Effingham & Wakefield, New Hampshire and Parsonsfield, Maine. FB Environmental Associates. June 2014.
Online: http://provincelake.org/watershed-management-plan/Province-Lake-Ordinance-Review.pdf

Province Lake Nutrient Modeling

Province Lake Nutrient Modeling: Estimating Phosphorus Loads using Lake Loading Response Modeling. FB Environmental Associates. March 2014.
Online: http://provincelake.org/watershed-management-plan/Province-Lake-LLRM.pdf

Province Lake Septic Survey

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Province Lake Site Specific Project Plan

Site Specific Project Plan for Development of the Province Lake Watershed Plan: Phase 1 (NH DES Project # R-12-S-08). FB Environmental Associates. April 11, 2013 (Final).
Online: http://provincelake.org/watershed-management-plan/Province-Lake-SSPP.pdf

Province Lake Watershed Survey Report

Province Lake Watershed Survey Report. Acton Wakefield Watersheds Alliance. July 2013.
Online: http://provincelake.org/cms/wp-content/uploads/2014/01/Province-Lake-Watershed-Survey-Report.pdf

Province Lake Water Quality Analysis

Province Lake Water Quality Analysis. FB Environmental Associates. January 2014.
Online: http://provincelake.org/watershed-management-plan/Water-Quality-Report.pdf

ADDITIONAL RESOURCES

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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: http://des.nh.gov/organization/divisions/water/wmb/repp/innovative_land_use.htm

Landscaping at the water's edge: an ecological approach. University of New Hampshire, Cooperative Extension. 2007. Online: http://extension.unh.edu/news/2007/05/new_landscaping_at_the_waters_1.html

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APPENDICES

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Appendix A:
Thematic GIS Maps

Appendix A. Thematic GIS Maps..... 86

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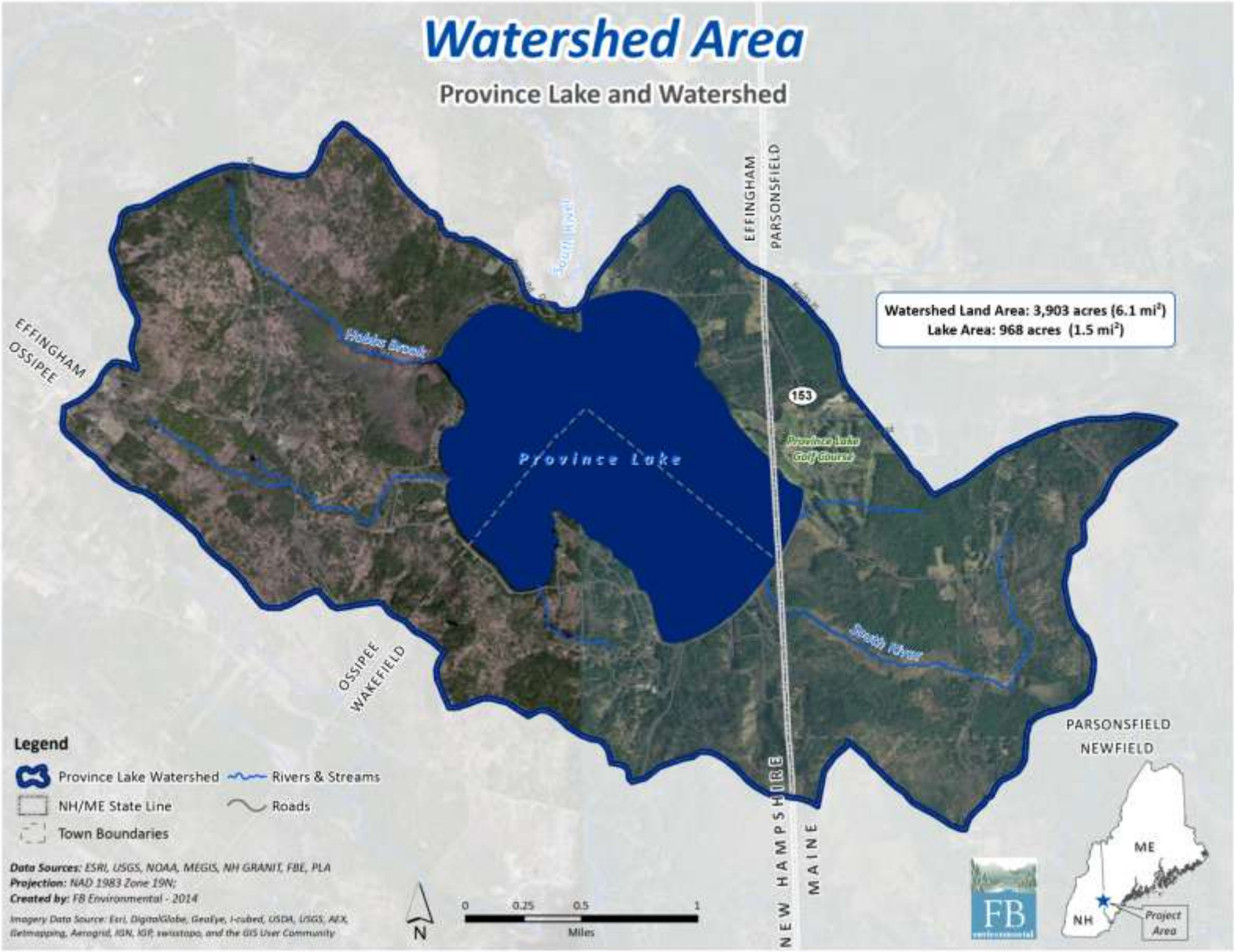
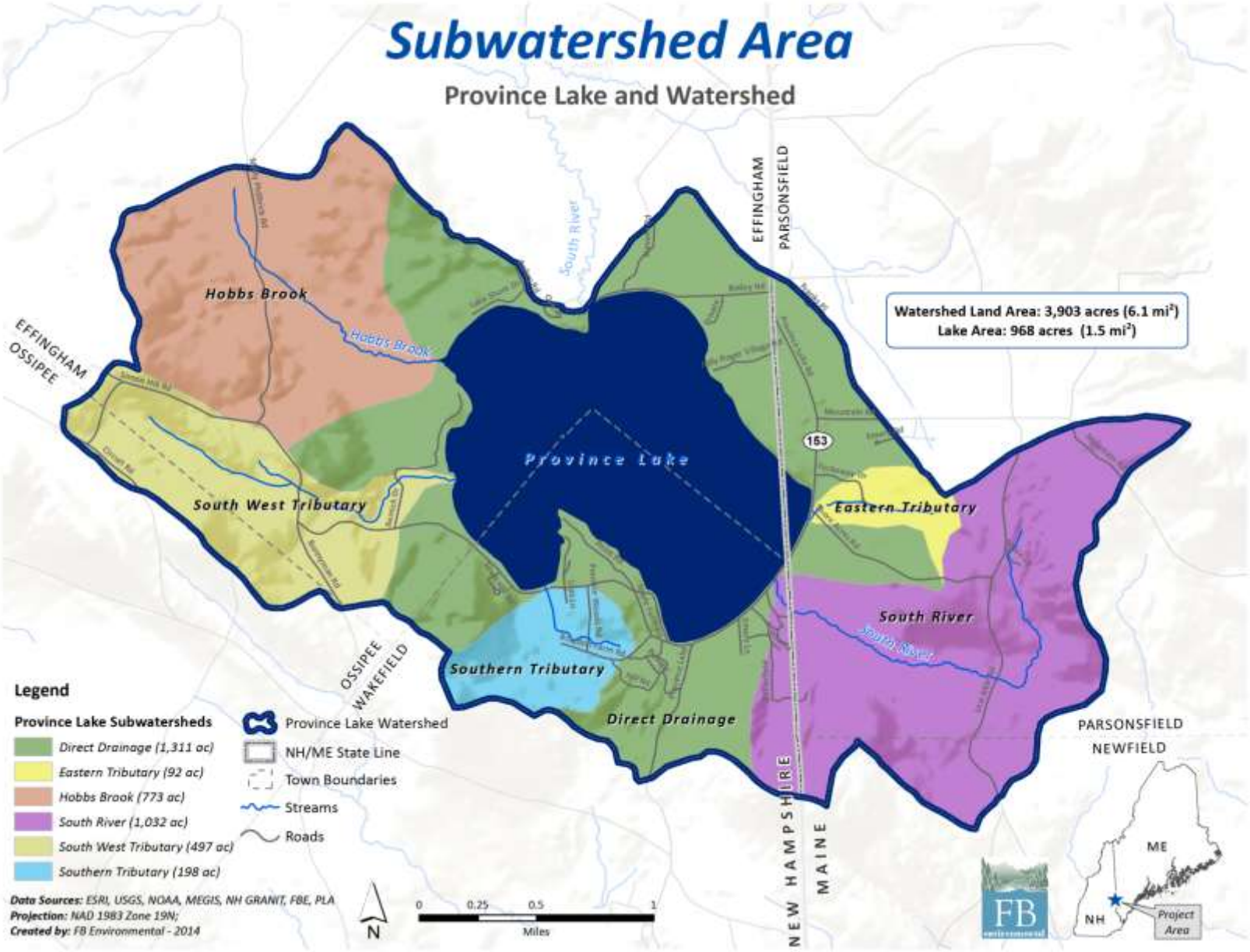
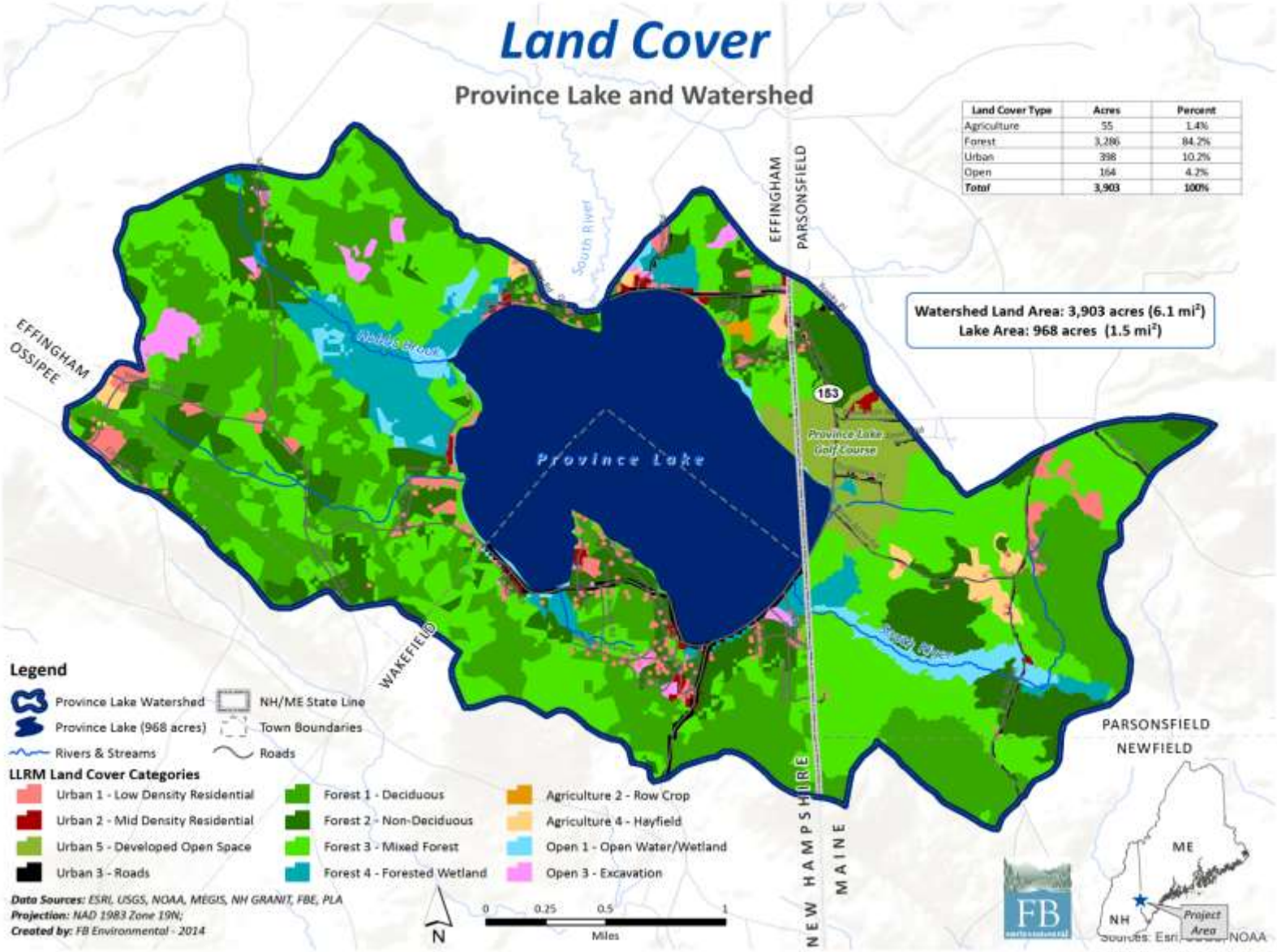

Watershed Area
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
Hobbs Brook
South River
Province Lake Golf Course
153
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Legend
Province Lake Watershed
Rivers & Streams
NH/ME State Line
Roads
Town Boundaries
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
Imagery Data Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

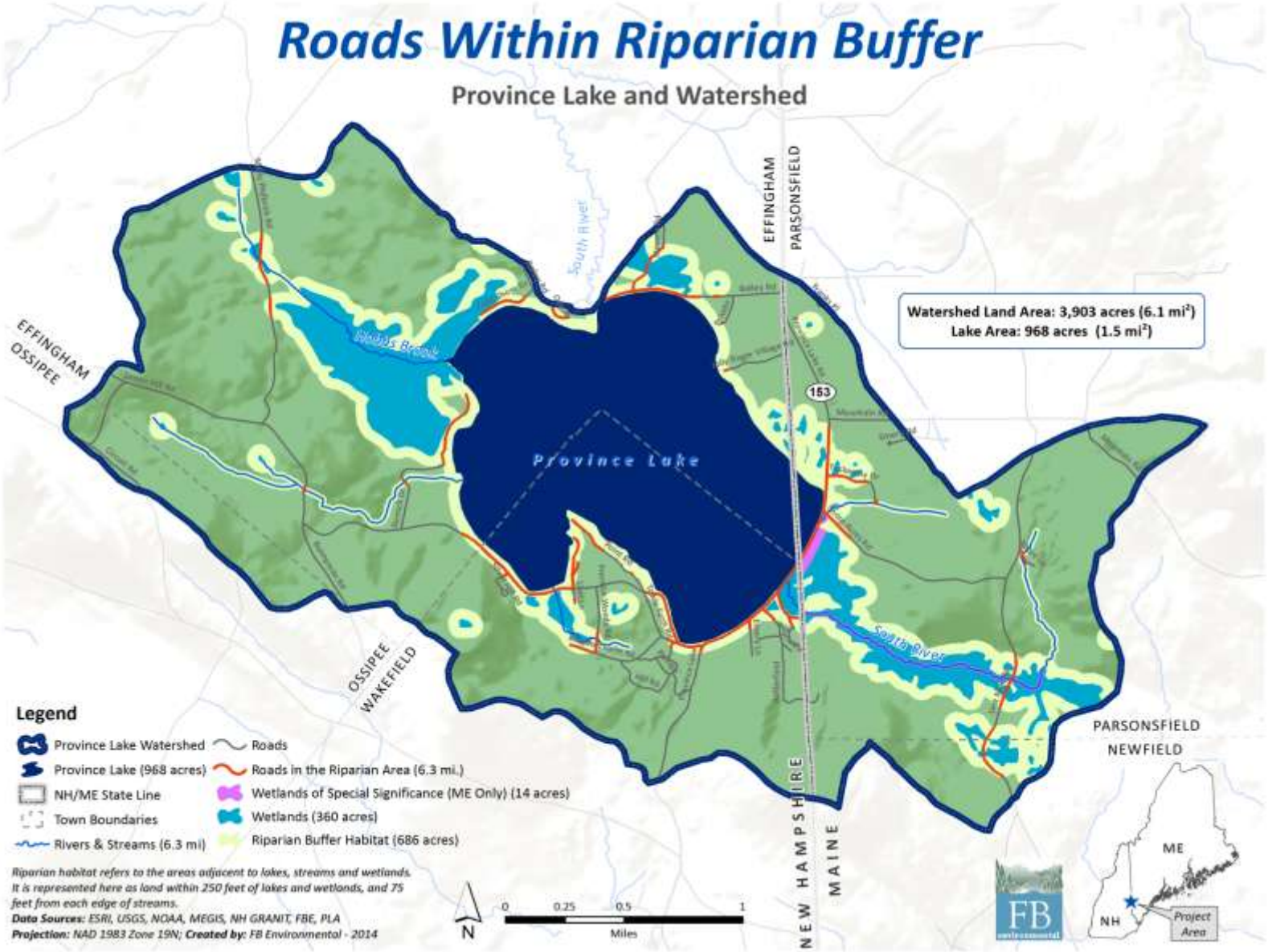
Map 1


Subwatershed Area
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Hobbs Brook
Hobbs Brook
South River
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
Province Lake
153
South West Tributary
Eastern Tributary
South River
South River
OSSIPEE
WAKEFIELD
Southern Tributary
Direct Drainage
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Legend
Province Lake Subwatersheds
Direct Drainage (1,311 ac)
Eastern Tributary (92 ac)
Hobbs Brook (773 ac)
South River (1,032 ac)
South West Tributary (497 ac)
Southern Tributary (198 ac)
Province Lake Watershed
NH/ME State Line
Town Boundaries
Streams
Roads
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

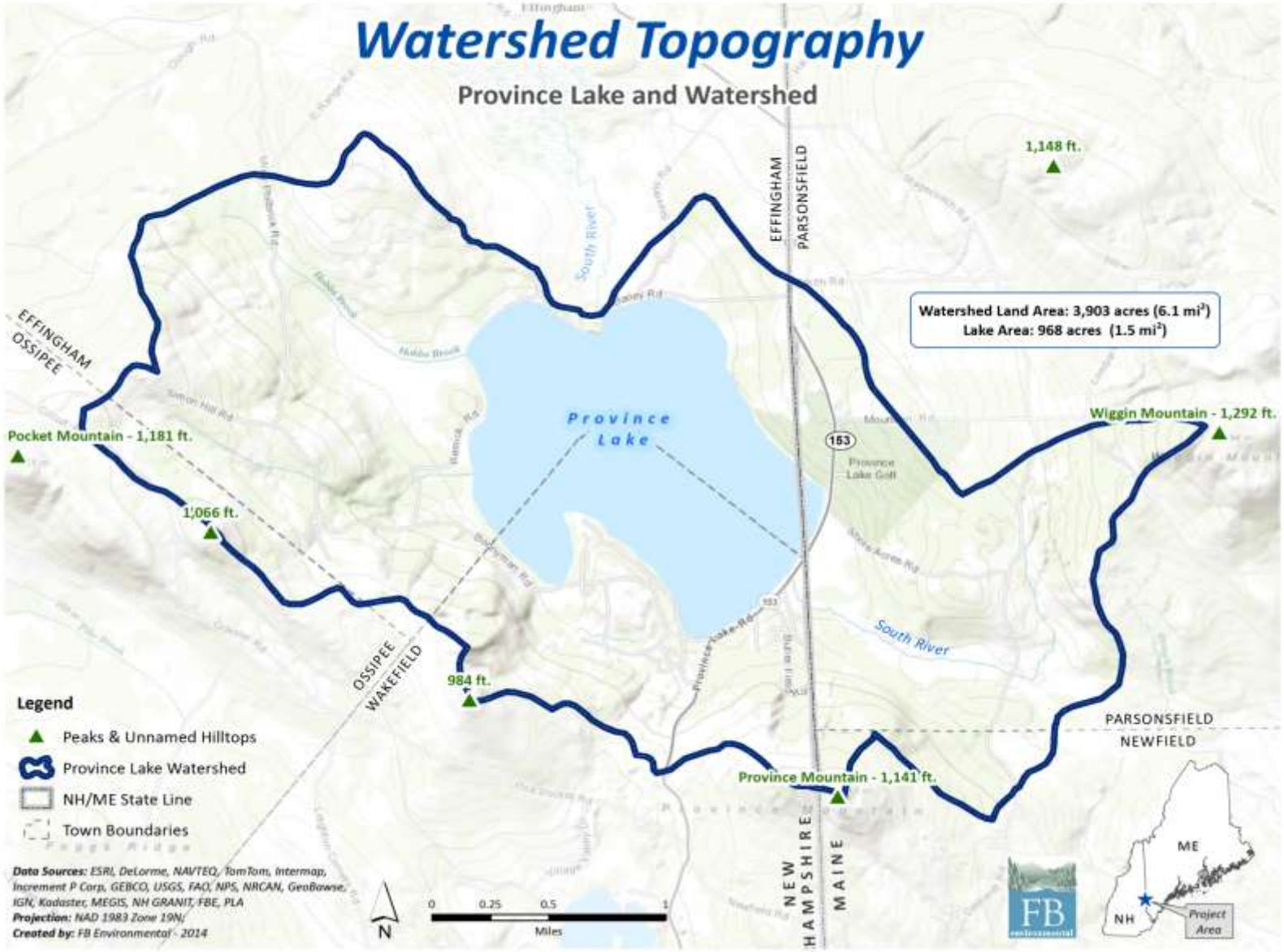
Map 2


Land Cover
Province Lake and Watershed
Land Cover Type | Acres | Percent
Agriculture | 55 | 1.4%
Forest | 3,286 | 84.2%
Urban | 398 | 10.2%
Open | 164 | 4.2%
Total | 3,903 | 100%
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Province Lake
South River
Province Lake Golf Course
153
Legend
Province Lake Watershed
Province Lake (968 acres)
Rivers & Streams
NH/ME State Line
Town Boundaries
Roads
LLRM Land Cover Categories
Urban 1 - Low Density Residential
Urban 2 - Mid Density Residential
Urban 5 - Developed Open Space
Urban 3 - Roads
Forest 1 - Deciduous
Forest 2 - Non-Deciduous
Forest 3 - Mixed Forest
Forest 4 - Forested Wetland
Agriculture 2 - Row Crop
Agriculture 4 - Hayfield
Open 1 - Open Water/Wetland
Open 3 - Excavation
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
ME
NH
Project Area
FB

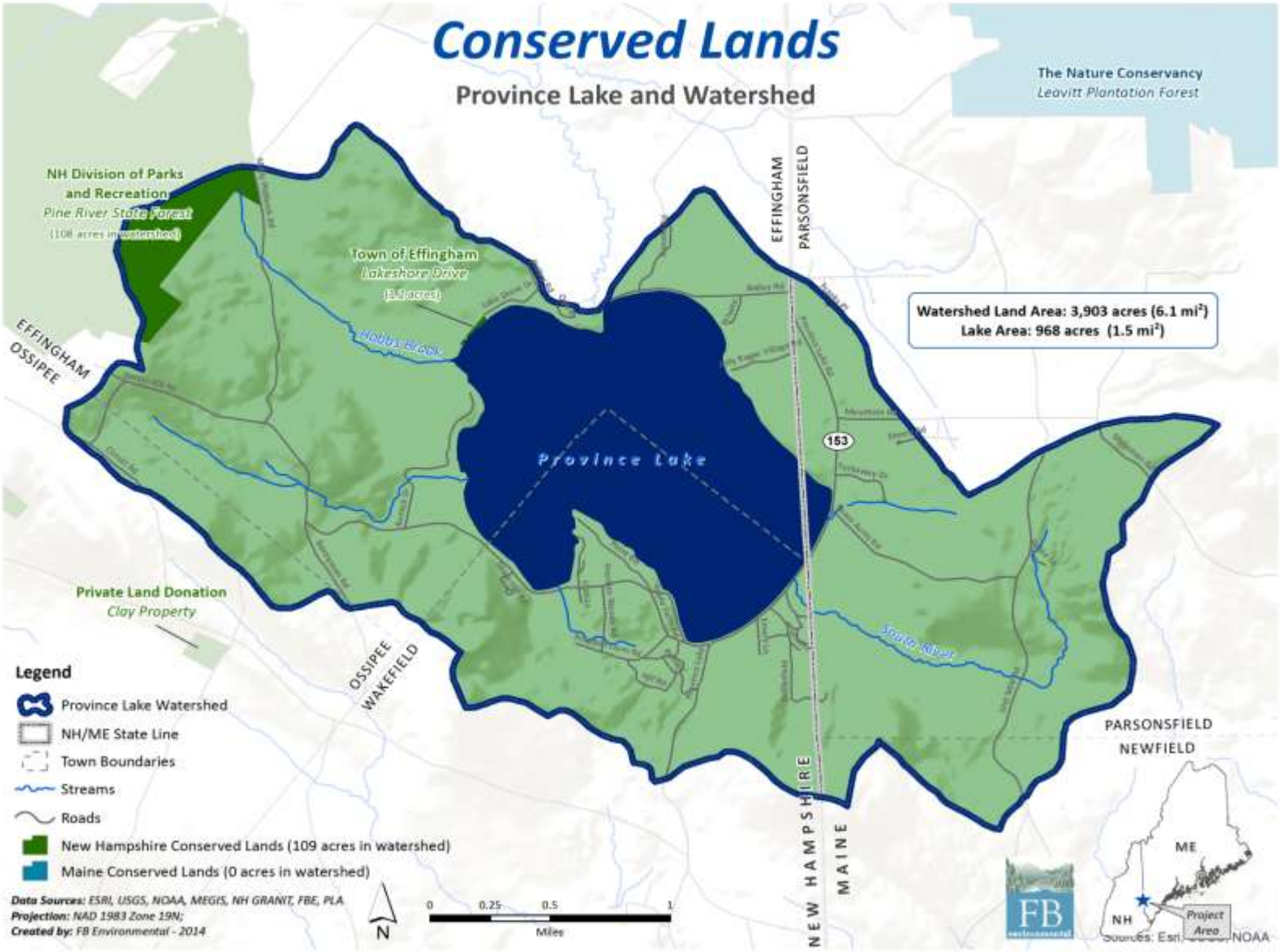
Map 3


Roads Within Riparian Buffer
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
Hobbs Brook
South River
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
153
Legend
Province Lake Watershed
Province Lake (968 acres)
NH/ME State Line
Town Boundaries
Rivers & Streams (6.3 mi)
Roads
Roads in the Riparian Area (6.3 mi.)
Wetlands of Special Significance (ME Only) (14 acres)
Wetlands (360 acres)
Riparian Buffer Habitat (686 acres)
Riparian habitat refers to the areas adjacent to lakes, streams and wetlands. It is represented here as land within 250 feet of lakes and wetlands, and 75 feet from each edge of streams.
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N; Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

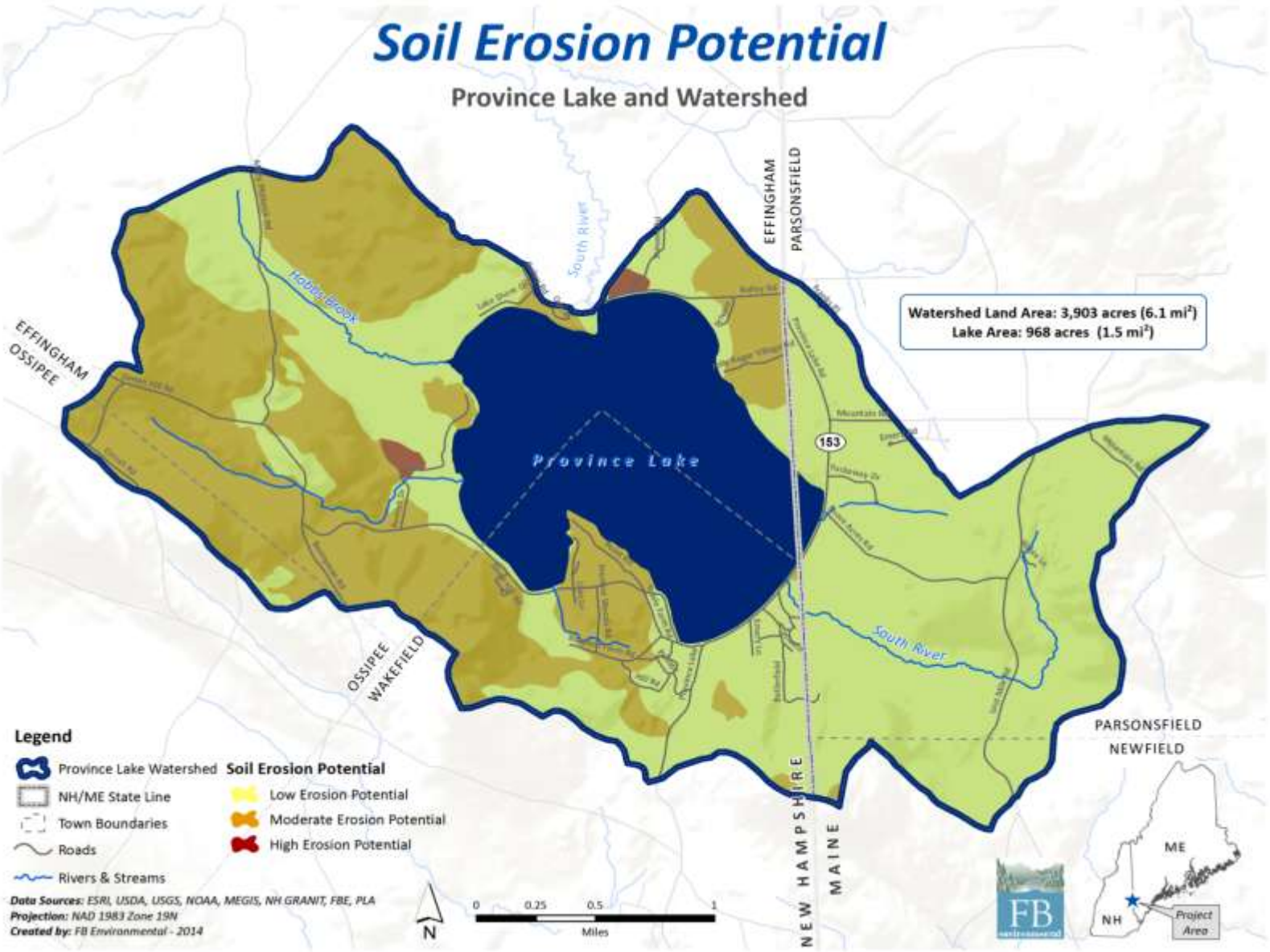
Map 4


Watershed Topography
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
1,148 ft.
Wiggin Mountain - 1,292 ft.
Pocket Mountain - 1,181 ft.
1,066 ft.
984 ft.
Province Mountain - 1,141 ft.
Province Lake
South River
EFFINGHAM
PARSONSFIELD
OSSIPEE
WAKEFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
153
Legend
Peaks & Unnamed Hilltops
Province Lake Watershed
NH/ME State Line
Town Boundaries
Data Sources: ESRI, DeLorme, NAVTEQ, TomTom, Intermap, Increment P Corp, GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

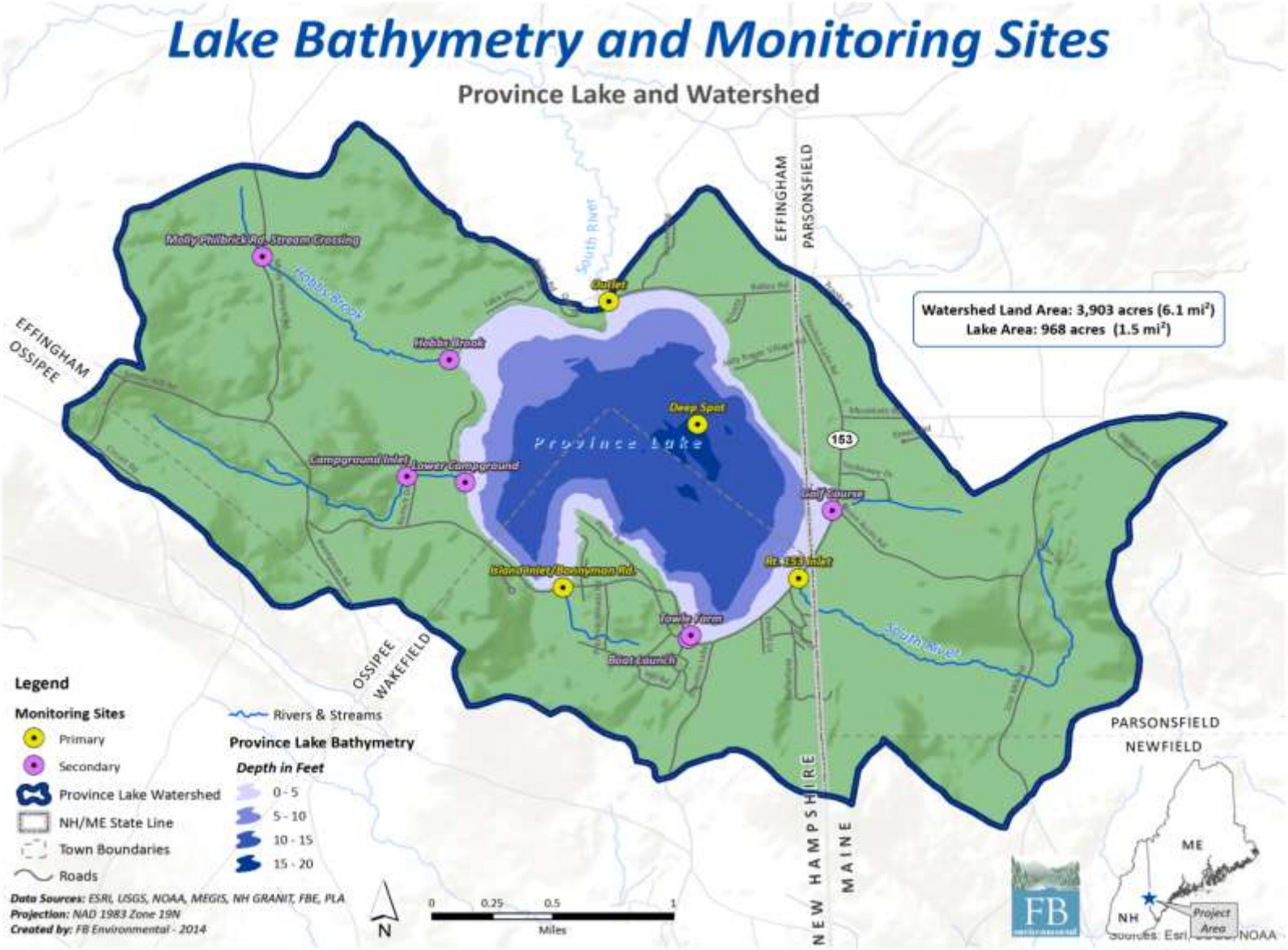
Map 5


Conserved Lands
Province Lake and Watershed
The Nature Conservancy
Leavitt Plantation Forest
NH Division of Parks and Recreation
Pine River State Forest
(108 acres in watershed)
Town of Effingham
Lakeshore Drive
(38 acres)
Hobbs Brook
EFFINGHAM
OSSIPEE
EFFINGHAM
PARSONSFIELD
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
153
Private Land Donation
Clay Property
OSSIPEE
WAKEFIELD
Stoker Brook
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Legend
Province Lake Watershed
NH/ME State Line
Town Boundaries
Streams
Roads
New Hampshire Conserved Lands (109 acres in watershed)
Maine Conserved Lands (0 acres in watershed)
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area
Sources: Esri, NOAA

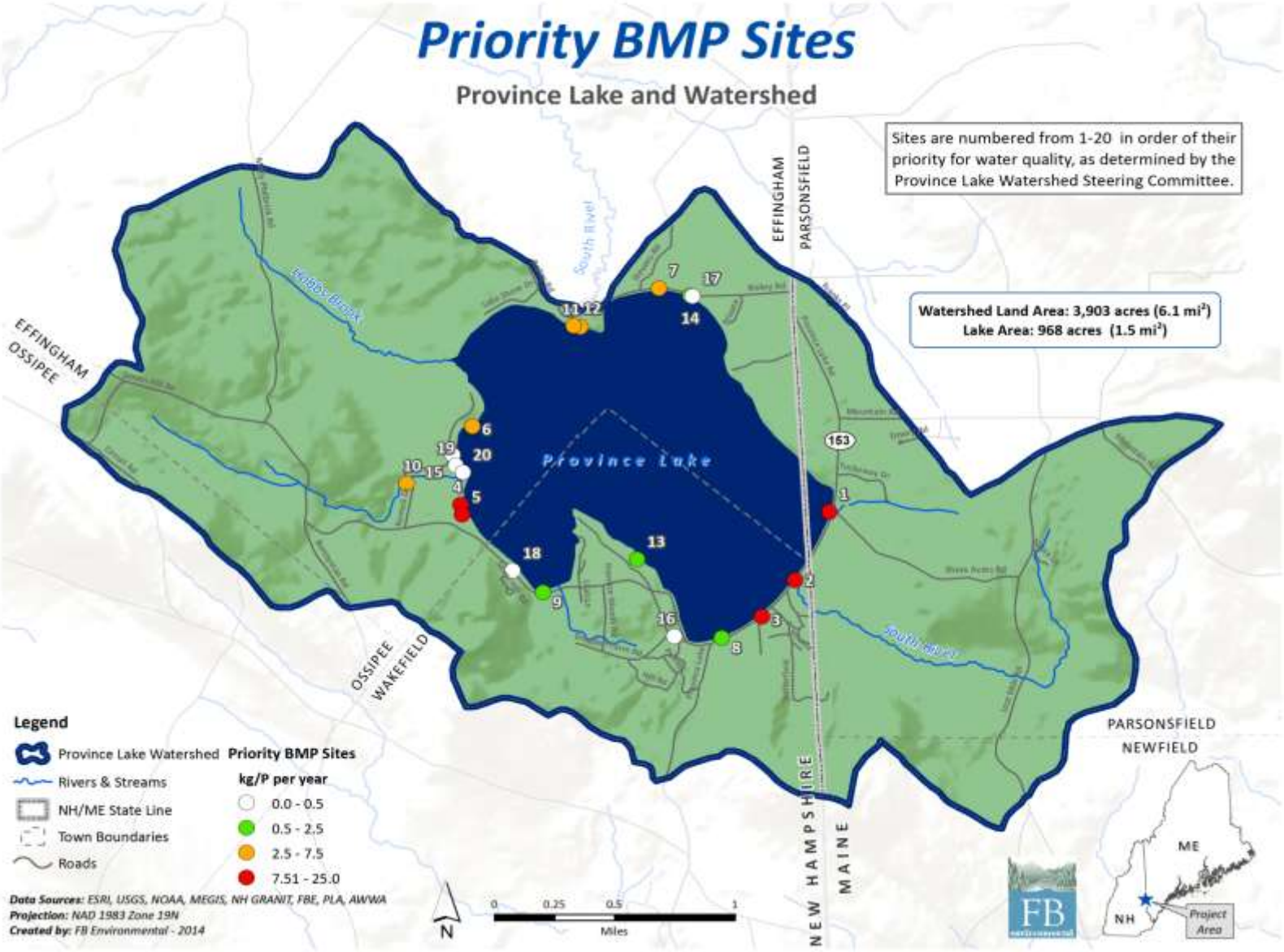
Map 6


Soil Erosion Potential
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
South River
Halls Brook
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
153
Legend
Province Lake Watershed
NH/ME State Line
Town Boundaries
Roads
Rivers & Streams
Soil Erosion Potential
Low Erosion Potential
Moderate Erosion Potential
High Erosion Potential
Data Sources: ESRI, USDA, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
ME
NH
Project Area
FB

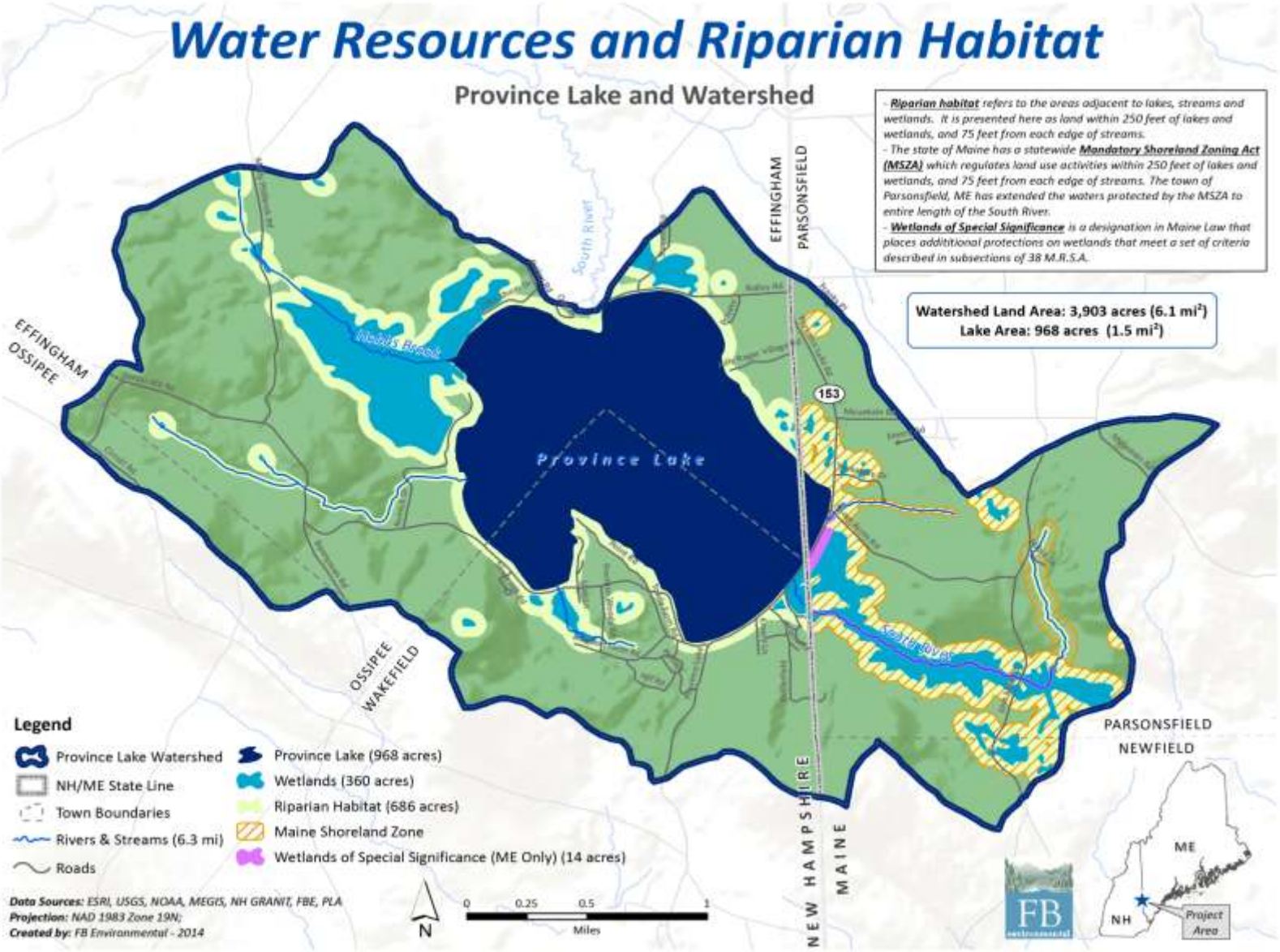
Map 7


Lake Bathymetry and Monitoring Sites
Province Lake and Watershed
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
South River
Hobbs Brook
Molly Philbrick Rd. Stream Crossing
Outlet
Deep Spot
Campground Inlet
Lower Campground
Golf Course
Rt. 153 Inlet
Island Inlet/Bonnyman Rd.
Towle Farm
Boat Launch
South River
153
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Legend
Monitoring Sites
Primary
Secondary
Province Lake Watershed
NH/ME State Line
Town Boundaries
Roads
Rivers & Streams
Province Lake Bathymetry
Depth in Feet
0 - 5
5 - 10
10 - 15
15 - 20
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N
Created by: FB Environmental - 2014
N
0
0.25
0.5
1
Miles
FB
ME
NH
Project Area
NOAA

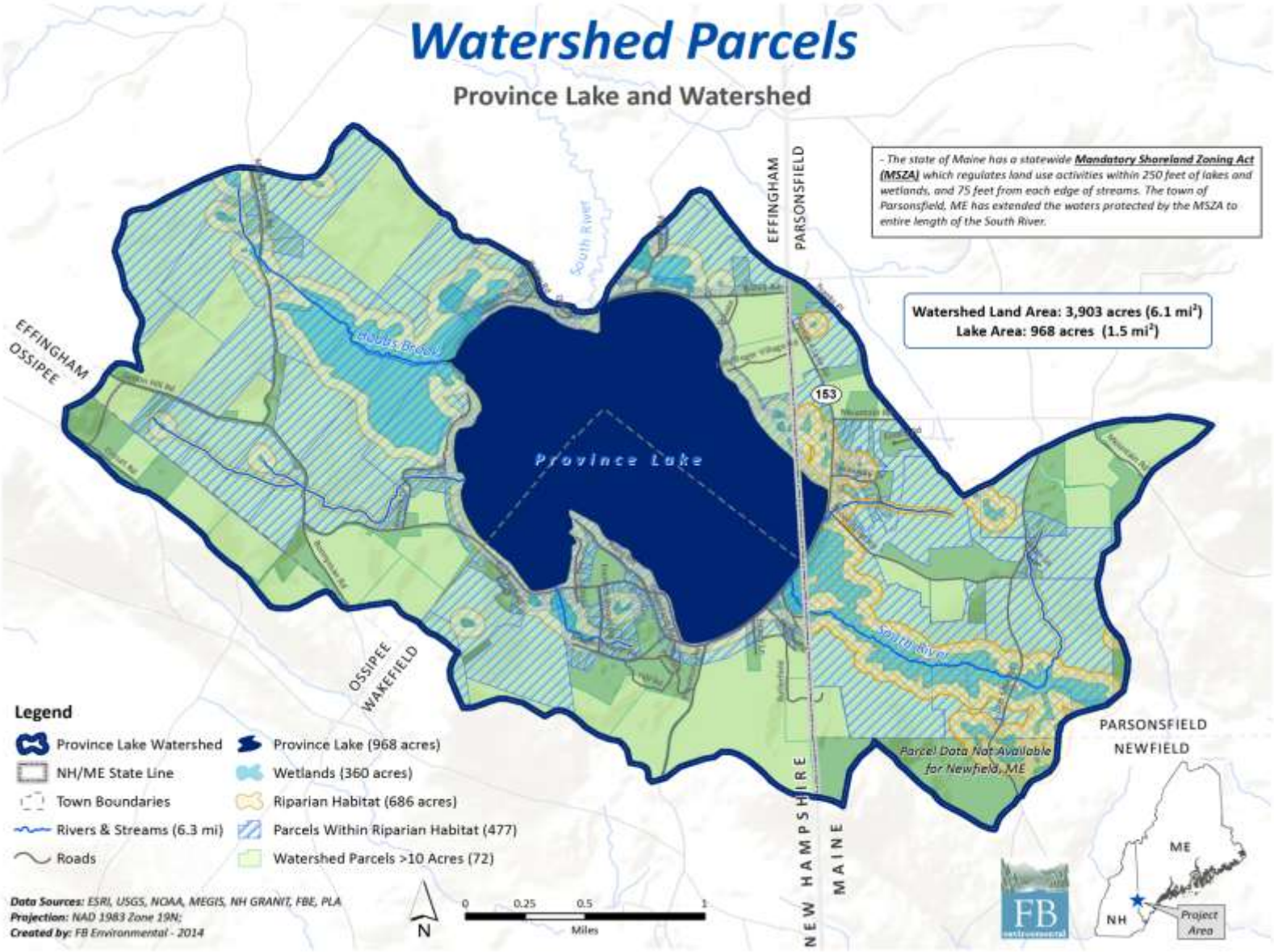
Map 8


Priority BMP Sites
Province Lake and Watershed
Sites are numbered from 1-20 in order of their priority for water quality, as determined by the Province Lake Watershed Steering Committee.
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
Province Lake
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
South River
Hobbs Brook
153
Legend
Province Lake Watershed
Rivers & Streams
NH/ME State Line
Town Boundaries
Roads
Priority BMP Sites
kg/P per year
0.0 - 0.5
0.5 - 2.5
2.5 - 7.5
7.51 - 25.0
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA, AWWA
Projection: NAD 1983 Zone 19N
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

Map 9


Water Resources and Riparian Habitat
Province Lake and Watershed
- Riparian habitat refers to the areas adjacent to lakes, streams and wetlands. It is presented here as land within 250 feet of lakes and wetlands, and 75 feet from each edge of streams.
- The state of Maine has a statewide Mandatory Shoreland Zoning Act (MSZA) which regulates land use activities within 250 feet of lakes and wetlands, and 75 feet from each edge of streams. The town of Parsonsfield, ME has extended the waters protected by the MSZA to entire length of the South River.
- Wetlands of Special Significance is a designation in Maine Law that places additional protections on wetlands that meet a set of criteria described in subsections of 38 M.R.S.A.
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
South River
Hobbs Brook
Province Lake
153
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Legend
Province Lake Watershed
NH/ME State Line
Town Boundaries
Rivers & Streams (6.3 mi)
Roads
Province Lake (968 acres)
Wetlands (360 acres)
Riparian Habitat (686 acres)
Maine Shoreland Zone
Wetlands of Special Significance (ME Only) (14 acres)
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

Map 10


Watershed Parcels
Province Lake and Watershed
- The state of Maine has a statewide Mandatory Shoreland Zoning Act (MSZA) which regulates land use activities within 250 feet of lakes and wetlands, and 75 feet from each edge of streams. The town of Parsonsfield, ME has extended the waters protected by the MSZA to entire length of the South River.
Watershed Land Area: 3,903 acres (6.1 mi²)
Lake Area: 968 acres (1.5 mi²)
EFFINGHAM
PARSONSFIELD
EFFINGHAM
OSSIPEE
OSSIPEE
WAKEFIELD
PARSONSFIELD
NEWFIELD
NEW HAMPSHIRE
MAINE
Province Lake
South River
Hobbs Brook
153
Parcel Data Not Available for Newfield, ME
Legend
Province Lake Watershed
NH/ME State Line
Town Boundaries
Rivers & Streams (6.3 mi)
Roads
Province Lake (968 acres)
Wetlands (360 acres)
Riparian Habitat (686 acres)
Parcels Within Riparian Habitat (477)
Watershed Parcels >10 Acres (72)
Data Sources: ESRI, USGS, NOAA, MEGIS, NH GRANIT, FBE, PLA
Projection: NAD 1983 Zone 19N;
Created by: FB Environmental - 2014
N
0 0.25 0.5 1
Miles
FB
ME
NH
Project Area

Map 11

Appendix B: Land Trust Resources

The Green Mountain Conservation Group (GMCG) is a non-profit New Hampshire charitable organization founded in 1997 dedicated to the conservation of natural resources in the Ossipee Watershed including the towns of Effingham, Freedom, Madison, Ossipee, Sandwich and Tamworth. Through research, education, advocacy, and land conservation GMCG strives to promote an awareness and appreciation of Watershed natural resources and encourages a commitment to protect them. GMCG's primary focus is on the protection of water resources. GMCG's guiding principle is to present objective information in a non-confrontational format thereby enabling the public to make informed natural resource decisions.

The Francis Small Heritage Trust (FSHT), conserves natural resources and provides for public access. To reach that end FSHT accepts donations of land and conservation easements, presents educational programs to help foster an appreciation of land and nature, acquires land through purchase, and provides information and support to towns and landowners. These activities protect the present character of the land centered around the five Maine towns of Limerick, Cornish, Limington, Newfield, and Parsonsfield by ensuring the continuation of natural areas while supporting compatible uses, such as agriculture and forestry.

Moose Mountains Regional Greenways (MMRG), is a land trust serving the towns of Brookfield, Farmington, Middleton, Milton, New Durham, Wakefield and Wolfeboro, New Hampshire. Founded in 2000, MMRG has worked with landowners, towns and nonprofit partners to protect over 4,400 acres in its service area. MMRG assists landowners who wish to maintain their land forever in its natural state by donating their development rights through the process of placing a conservation easement on the land. They also help acquire conservation land needed to protect water quality, secure wildlife habitat, and provide opportunities for traditional, low-impact recreation such as hiking, hunting, and fishing.

Appendix C:
BMPs in the Province Lake Watershed

Province Lake Watershed Plan
Pollutant Removal, Pollutant Reductions & BMP Cost Estimates
Methodology

Overview: Provided below is a description of the prioritization process and methodology used for estimating load reductions and cost estimates for recommended Best Management Practices (BMPs) documented during the 2013 Province Lake Watershed Survey. Results are presented below. Table C.1. provides a listing of the top 20 prioritized BMPs, while Table C.2. provides a list of all sites, organized by the sites with the lowest cost per pound of phosphorus removed. A map of the top 20 sites is provided in Appendix A (Map 9). The purpose of these tables is to provide the Province Lake Association with cost estimates and loading reduction targets that can be used when deciding which sites to address first, and for applying for grants. This evaluation included field surveys and data collection provided by the Action Wakefield Watersheds Alliance (AWWA) and FB Environmental Associates (FBE) and prioritization of the top 20 sites by the Province Lake Project Management Team.

Region 5 Measurements and Calculations: A total of 61 sites were identified by volunteers from PLA, and technical staff from NH DES, AWWA and FBE in 2013. Follow-up field work was conducted by AWWA and FBE to gather site specific information about each site that could be used in the EPA Region 5 model. This model requires measurements for the size (width, depth, length), age, and soil type for each erosion problem. In some cases, multiple gullies were document on a single site. For sites with multiple erosion problems, the sum of the total sediment and nutrient load was used in the final pollutant loading reduction estimates. Region 5 calculations were conducted by AWWA and provided to FBE for the watershed plan. The model calculates phosphorus, nitrogen and sediment loading estimates for each of the sites.

Prioritization of BMPs: Once Region 5 loading reduction estimates were complete for the BMP sites, FBE led the Province Lake Project Management Team through a prioritization exercise to identify the top 20 highest priority sites (or 1/3 of total sites). Factors such as impact on water quality, proximity to the lake, cost, technical difficulty to implement, and landowner willingness were factored into the decision making process. A map entitled "Priority BMPs" was developed for the watershed plan (Appendix A, Map 9), showing the location and expected phosphorus load reductions if BMPs were implemented. The final list of 20 sites is presented in Table C.1, Appendix C.

BMP Cost Estimates: FBE developed cost estimates for the list of recommendations listed for each site. Cost estimates for common BMPs (buffers, culverts, water bars, etc.) were based on estimates developed by the Cumberland County Soil and Water Conservation District in 2008. Additional cost estimates for more technical/structural BMPs (e.g. guard rails, plunge pools, paving, etc.) were provided by the UNH Stormwater Center (UNH SC), while other estimates were based on contractors rates (e.g. retaining walls)(Table C.3, Appendix C). UNH SC, recommended adding annual maintenance costs, which were used to calculate a 10-year cost to correspond with the first phase of watershed restoration activities. Using Region 5 loading reduction estimates for each site, a 10-year cost for phosphorus removal was calculated for each BMP, and then sorted by lowest to highest cost per pound of phosphorus removed (Tables C.1 and C.2, Appendix C). BMP cost estimates are for material and labor and annual maintenance where applicable. Cost of engineering is not included in the cost estimate.

C.1 Top 20 Priority BMPs

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
5-4	**1**	Rte 153 Culverts @ Shore Acres Road	State Road	54.80	Armor Culvert Inlet/Outlet; Reshape/Install Ditch; Vegetate Shoulder	$ 2,730.00	$ 750.00	$ 10,230.00	$ 186.68
5-2	**2**	NH Rte 153 - culvert inlet	State Road	18.90	Armor culvert inlet, lengthen inlet, install plunge pool	$ 3,200.00	$ 500.00	$ 8,200.00	$ 433.86
5-1	**3**	Rte 153 - NH Stretch from Robeson to ME line	State Road	11.00	Remove Grader/Plow Berms; Armor Shoulder; Water Retention Berms; Establish Buffer; Extend guard rail to ME line	$ 12,839.00	$ 500.00	$ 17,839.00	$ 1,621.73
2-1	**4**	Bonnyman Road	Residential	39.70	Retaining Wall; Infiltration Trench, Water Retention Swales; Establish a Buffer	$ 26,500.00	$ 250.00	$ 29,000.00	$ 730.48
2-2	**5**	Bonnyman Road	Residential	17.14	Replace Wall; Install Trench; Plants behind wall to take up water; Establish Buffer	$ 6,500.00	$ 250.00	$ 9,000.00	$ 525.05
1-9	**6**	Remick Road	Residential	9.10	Ditch - Vegetate, Armor w/ Stone; Install Runoff Diverters; Establish Buffer & Add to	$ 1,500.00	$ 250.00	$ 4,000.00	$ 439.56
8-5	**7**	Bank Across from 120 Bailey	Beach Access	6.90	TBD	N/A	N/A	N/A	N/A
4-16	**8**	Just off 153 onto Bonnyman Rd	Beach Access	5.10	Install Plunge Pool	$ 500.00	$ 250.00	$ 3,000.00	$ 588.24
2-8	**9**	On Bonnyman Road Beach Access @ Summer Camps	Beach Access	2.10	Install Infiltration Steps; Open Top Culvert	$ 743.00	$ 50.00	$ 1,243.00	$ 591.91
1-1	**11**	Bridge over campground stream	Town Road	2.40	Armor Culvert; Install Runoff Diverters - Broad-based Dip; Add Vegetation to Buffer	$ 3,000.00	$ 100.00	$ 4,000.00	$ 1,666.67
6-1	**12**	Oak Avenue	Residential	6.00	Undercutting of bank, roots exposed	$ 1,500.00	$ 100.00	$ 2,500.00	$ 416.67
6-3	**13**	Oak Avenue	Residential	5.90	Add Buffer	$ 500.00	$ 50.00	$ 1,000.00	$ 169.49

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
3-4	**14**	Point Road	Residential	4.80	Dripline Trench; ECM; Infiltration Trench; Add to Buffer	$ 950.00	$ 100.00	$ 1,950.00	$ 406.25
8-8	**15**	Gulley At 92 Bailey Rd	Beach Access	3.70	TBD	N/A	N/A	N/A	N/A
1-5	**16**	Remick Road	Residential; Boat Access	0.90	New Surface Material - Gravel	$ 500.00	$ 250.00	$ 3,000.00	$ 3,333.34
1-2	**17**	Remick Road	Residential	0.00	Armor Culvert; ECM; Establish Buffer	$ 329.00	$ 250.00	$ 2,829.00	N/A
4-14	**18**	Towle Farm Road		0.00	Ditch - armor with stone, reshape ditch, install turnouts, install ditch, check dams; Recycled asphalt; reshape, vegetate shoulder	$ 88,856.00	$ 500.00	$ 93,856.00	N/A
5-11	**19**	Bailey Road Beach	Beach Access	0.20	Berms and/or diverters to slow water as it hits beach	$ 760.00	$ 250.00	$ 3,260.00	$ 16,300.03
2-6	**20**	Base of Silver Hill Road	Town Road	0.00	Reshape Road	$ 2,500.00	$ 1,000.00	$ 12,500.00	N/A
TOTAL:				**189**		**$ 153,407.00**	**$ 5,400.00**	**$ 207,407.00**	**$ 1,957.85**

Average

C.2 Province Lake BMP Matrix *(Prioritized by cost/lb TP removed.)*

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
6-3	13	Oak Avenue	Residential	5.90	Add Buffer	$ 500.00	$ 50.00	$ 1,000.00	$ 169.49
5-4	1	Rte 153 Culverts @ Shore Acres Road	State Road	54.80	Armor Culvert Inlet/Outlet; Reshape/Install Ditch; Vegetate Shoulder	$ 2,730.00	$ 750.00	$ 10,230.00	$ 186.68
3-4	14	Point Road	Residential	4.80	Dripline Trench; ECM; Infiltration Trench; Add to Buffer	$ 950.00	$ 100.00	$ 1,950.00	$ 406.25
6-1	12	Oak Avenue	Residential	6.00	Undercutting of bank, roots exposed	$ 1,500.00	$ 100.00	$ 2,500.00	$ 416.67
7-2		Bailey Road	Residential	1.20	Re-armor shoreline with boulders	$ 500.00	$ -	$ 500.00	$ 416.67
5-2	2	NH Rte 153 - culvert inlet	State Road	18.90	Armor culvert inlet, lengthen inlet, install plunge pool	$ 3,200.00	$ 500.00	$ 8,200.00	$ 433.86
1-9	6	Remick Road	Residential	9.10	Ditch - Vegetate, Armor w/ Stone; Install Runoff Diverters; Establish Buffer & Add to	$ 1,500.00	$ 250.00	$ 4,000.00	$ 439.56
7-6		End of Lakeshore Drive	Lake Access	2.00	Install Runoff Diverter	$ 500.00	$ 50.00	$ 1,000.00	$ 500.00
2-2	5	Bonnyman Road	Residential	17.14	Replace Wall; Install Trench; Plants behind wall to take up water; Establish Buffer	$ 6,500.00	$ 250.00	$ 9,000.00	$ 525.05
4-16	8	Just off 153 onto Bonnyman Rd	Beach Access	5.10	Install Plunge Pool	$ 500.00	$ 250.00	$ 3,000.00	$ 588.24
2-8	9	On Bonnyman Road Beach Access @ Summer Camps	Beach Access	2.10	Install Infiltration Steps; Open Top Culvert	$ 743.00	$ 50.00	$ 1,243.00	$ 591.91
7-3		Senter Lane	Residential	2.20	ECM; Establish Buffer; Add to Buffer	$ 550.00	$ 100.00	$ 1,550.00	$ 703.07
2-1	4	Bonnyman Road	Residential	39.70	Retaining Wall; Infiltration Trench, Water Retention Swales; Establish a Buffer	$ 26,500.00	$ 250.00	$ 29,000.00	$ 730.48

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
5-1	3	Rte 153 - NH Stretch from Robeson to ME line	State Road	11.00	Remove Grader/Plow Berms; Armor Shoulder; Water Retention Berms; Establish Buffer; Extend guard rail to ME line	$ 12,839.00	$ 500.00	$ 17,839.00	$ 1,621.73
1-1	11	Bridge over campground stream	Town Road	2.40	Armor Culvert; Install Runoff Diverters - Broad-based Dip; Add Vegetation to Buffer	$ 3,000.00	$ 100.00	$ 4,000.00	$ 1,666.67
4-10		Bonnyman Road	Driveway	0.50	Open Top Culvert; Rubber Razor	$ 380.00	$ 50.00	$ 880.00	$ 1,760.00
1-3		Remick Road	Boat Access	0.50	Install Runoff Diverters - Rubber Razors	$ 380.00	$ 50.00	$ 880.00	$ 1,760.00
4-15		Beach along Bonnyman Road	Beach Access	3.40	Infiltration Steps; Runoff Diverter; Infiltration Trench	$ 1,000.00	$ 500.00	$ 6,000.00	$ 1,764.71
4-1		Beach Access Along Bonnyman Road	Beach Access	1.00	Culvert - Remove Clog & Install Plunge Pool; Stabilize Foot Path	$ 400.00	$ 150.00	$ 1,900.00	$ 1,900.00
1-6		Remick Road	Residential	0.60	New Surface Material; ECM; Add Vegetation to Buffer; Rubber Razor	$ 650.00	$ 50.00	$ 1,150.00	$ 1,916.67
5-9		Jolly Roger Campground	Residential	0.70	Open up & Armor drainage to keep runoff off path; ECM	$ 1,000.00	$ 50.00	$ 1,500.00	$ 2,142.86
1-5	16	Remick Road	Residential; Boat Access	0.90	New Surface Material - Gravel	$ 500.00	$ 250.00	$ 3,000.00	$ 3,333.34
5-3		Rte 153 Maine - NH Border to shore acres road	State Road	5.70	Vegetate Shoulder; Water Retention Berm; Establish Buffer; Install guard rail to prevent parking	$ 14,248.00	$ 500.00	$ 19,248.00	$ 3,376.85
3-3		Point Road	Driveway	0.80	Construction - Mulch, Silt Fence/ EC Berms; Dripline Trench; ECM; Infiltration Trench; Establish Buffer	$ 2,275.00	$ 50.00	$ 2,775.00	$ 3,468.76
3-1		Driveway with red barn	Driveway	2.10	Pave Driveway; Reshape; Vegetate Shoulder	$ 5,000.00	$ 250.00	$ 7,500.00	$ 3,571.44
1-7		Remick Road	Residential	1.10	Armor Culvert, Install Plunge Pool; Install Check Dams; Change Drainage	$ 1,450.00	$ 250.00	$ 3,950.00	$ 3,590.92

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
4-6		Across from 153 Bonnyman Rd	Beach Access	0.30	Stabilize Foot Path; Infiltration Steps; ECM	$ 800.00	$ 50.00	$ 1,300.00	$ 4,333.34
4-17		Road and Forest side of 153, ~100 yards from Bonnyman	State Road	0.30	Armor culvert inlet/outlet; install plunge pool	$ 400.00	$ 150.00	$ 1,900.00	$ 6,333.35
2-7		Shore along lot 8-39	Beach Access	0.20	Add New Surface Material -Gravel; Open top Culvert	$ 594.00	$ 100.00	$ 1,594.00	$ 7,970.02
6-2		Next to Oak Avenue	Residential	0.20	ECM	$ 500.00	$ 125.00	$ 1,750.00	$ 8,750.02
4-9		Bonnyman Road	Driveway	0.10	Open Top Culvert; Rubber Razor	$ 380.00	$ 50.00	$ 880.00	$ 8,800.02
2-5		Bonnyman Road in front of lot 6-3	Town Road	0.10	Stabilize Slope	$ 500.00	$ 100.00	$ 1,500.00	$ 15,000.03
5-12		Bailey Road	Lake Access	0.20		$ 500.00	$ 250.00	$ 3,000.00	$ 15,000.03
5-6		ROW to lake - Jolly Roger Campground	Lake Access	0.10	Waterbar; Define Foot Path, Stabilize Foot Path; ECM	$ 600.00	$ 100.00	$ 1,600.00	$ 16,000.03
5-11	19	Bailey Road Beach	Beach Access	0.20	Berms and/or diverters to slow water as it hits beach	$ 760.00	$ 250.00	$ 3,260.00	$ 16,300.03
5-8		Jolly Roger Campground	Residential	0.10	Broad-based Dip, Rubber Razor; ECM; No raking	$ 1,300.00	$ 50.00	$ 1,800.00	$ 18,000.04
3-2		Sunset Road	Driveway	0.10	Build up Driveway; Vegetate Shoulder	$ 300.00	$ 250.00	$ 2,800.00	$ 28,000.06
4-7		Across from 115 Bonnyman Rd	Town Road	0.10	Build Up Road; Reshape	$ 5,875.00	$ 250.00	$ 8,375.00	$ 83,750.17
4-11		Across 111 Bonnyman Rd	Beach Access	0.00	Replace Retaining Wall	$ 6,000.00	$ -	$ 6,000.00	N/A
4-12		Across from 101 Bonnyman Rd	Beach Access	0.00	ECM	$ 450.00	$ 100.00	$ 1,450.00	N/A
4-13		Across from 93 Bonnyman Rd	Beach Access	0.00	ECM; Establish Buffer	$ 700.00	$ 100.00	$ 1,700.00	N/A

Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
5-5		Jolly Roger Campground	Residential	0.00	Infiltration Steps; ECM; Add to Buffer	$ 1,000.00	$ 50.00	$ 1,500.00	N/A
5-7		Jolly Roger Campground	Residential	0.00	Define & Stabilize Foot Path; ECM; Add to Buffer; No Raking; Reseed Bare Soils	$ 1,400.00	$ 100.00	$ 2,400.00	N/A
5-10		Bailey Road	Residential	0.00	Add to Buffer; Stabilize the Shoreline	$ 1,000.00	$ 100.00	$ 2,000.00	N/A
5-13		Next to 81 Bailey Rd	Lake Access	0.00	ECM	$ 250.00	$ 100.00	$ 1,250.00	N/A
7-1		Bailey Road	Residential	0.00	Define Foot Path; Infiltration Steps	$ 400.00	$ 50.00	$ 900.00	N/A
N/A			Golf Course	0.00	Multiple buffers	$ 3,000.00	$ 250.00	$ 5,500.00	N/A
8-5	7	Bank across from 120 Bailey	Beach Access	6.90	TBD	N/A	N/A	N/A	N/A
8-8	15	Gulley at 92 Bailey Rd	Beach Access	3.70	TBD	N/A	N/A	N/A	N/A
1-2	17	Remick Road	Residential	0.00	Armor Culvert; ECM; Establish Buffer	$ 329.00	$ 250.00	$ 2,829.00	N/A
4-14	18	Towle Farm Road		0.00	Ditch - armor with stone, reshape ditch, install turnouts, install ditch, check dams; Recycled asphalt; reshape, vegetate shoulder	$ 88,856.00	$ 500.00	$ 93,856.00	N/A
1-4		Remick Road	Residential	0.00	Define Foot Path, Infiltration Steps; ECM	$ 740.00	$ 100.00	$ 1,740.00	N/A
1-8		Remick Road	Residential	0.00	Infiltration Steps; ECM; Establish Buffer	$ 900.00	$ 100.00	$ 1,900.00	N/A
1-10		Remick Road	Residential	0.00	Infiltration Steps, Retrofit; ECM	$ 730.00	$ 375.00	$ 4,480.00	N/A
2-3		Bonnyman Road between #157 & 161	Town Road	0.00	Build Up Road & Add New Surface Material, Vegetate Shoulder, Install Runoff Diverters	$ 2,340.00	$ 500.00	$ 7,340.00	N/A
2-4		Bonnyman Road between #157 & 161	Town Road	0.00	Vegetate Shoulder	$ 500.00	$ 100.00	$ 1,500.00	N/A
2-9		At Wetland Stream Crossing Lot 8-46	Lake Access	0.00	Diverter w/ drywell or rain garden	$ 3,000.00	$ 50.00	$ 3,500.00	N/A

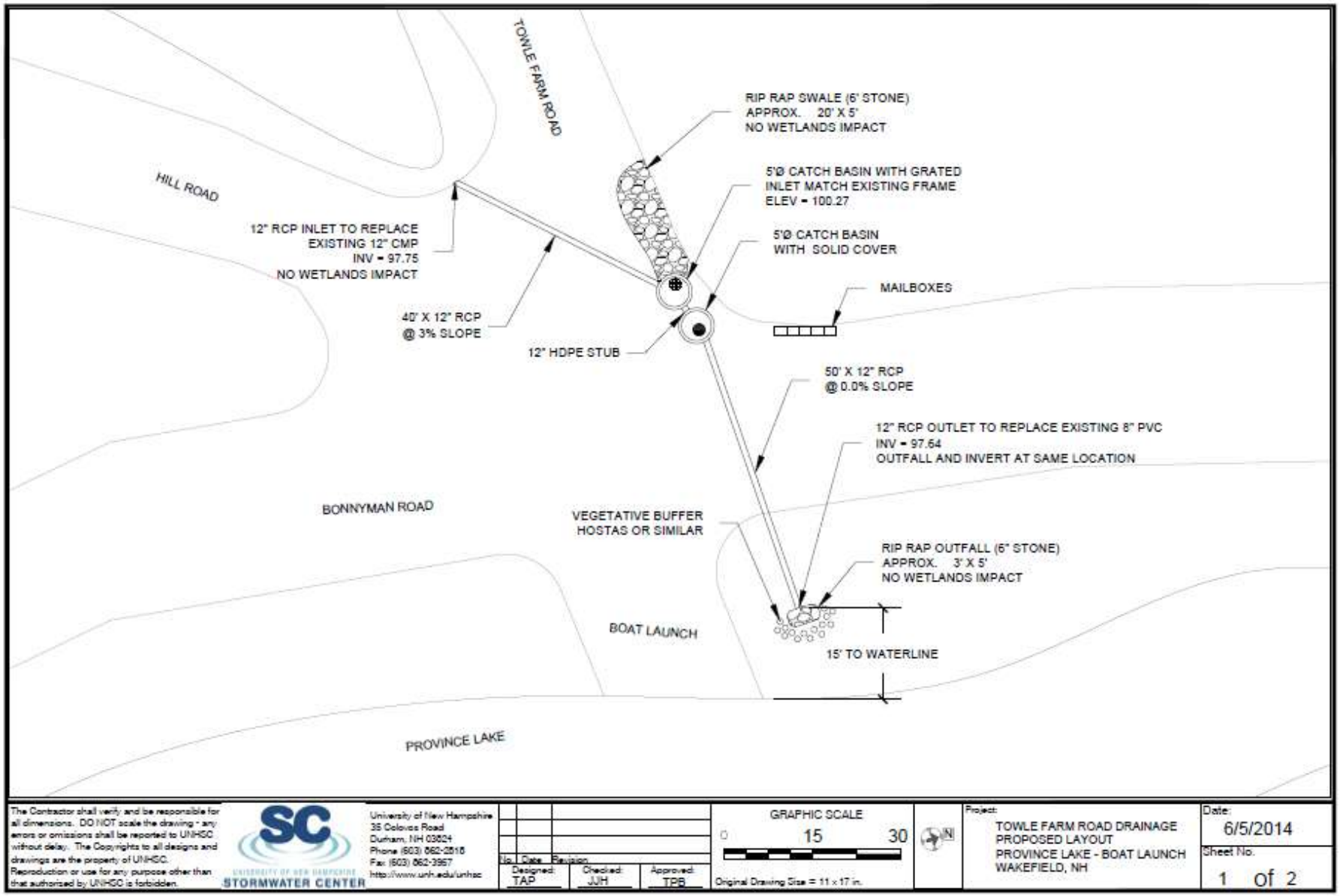
Site ID	Priority Ranking	BMP Location	Land Use Category	Phosphorus (lb/yr)	BMP Recommendations	BMP Cost Estimate	Annual Cost	10-yr Cost	10-yr Cost for TP Removed ($/lb)
4-3		Side of road across 165/167 Bonnyman	Beach Access	0.00	ECM; Establish Buffer	$ 700.00	$ 100.00	$ 1,700.00	N/A
4-4		Bonnyman Road	Driveway	0.00	Rubber Razor w/ Drywells	$ 630.00	$ 50.00	$ 1,130.00	N/A
4-5		Across from 159 Bonnyman Rd	Beach Access	0.00	Stabilize Foot Path; ECM; Establish Buffer	$ 700.00	$ 50.00	$ 1,200.00	N/A
7-5		Senter Lane	Residential	0.20	Ice Damage? TBD	N/A	N/A	N/A	N/A
8-1a		1st Gulley Next to Dam	Beach Access	0.40	TBD	N/A	N/A	N/A	N/A
8-1b		2nd Gulley Next to Dam	Beach Access	0.00	TBD	N/A	N/A	N/A	N/A
8-2		3rd Gulley Next to Dam	Beach Access	0.10	TBD	N/A	N/A	N/A	N/A
8-3		Bank Across from 114 Bailey	Beach Access	1.00	TBD	N/A	N/A	N/A	N/A
8-4		Gulley Across 114 Bailey	Beach Access	3.10	TBD	N/A	N/A	N/A	N/A
8-6		Bank across 104 bailey	Beach Access	0.20	TBD	N/A	N/A	N/A	N/A
8-7		Bank Across Tele. Pole 325-13 Bailey Road	Beach Access	1.50	TBD	N/A	N/A	N/A	N/A
2-6	20	Base of Silver Hill Road	Town Road	0.00	Reshape Road	$ 2,500.00	$ 1,000.00	$ 12,500.00	N/A
TOTAL:				**219**		**$ 217,929.00**	**$11,200.00**	**$ 329,929.00**	**$ 7,005.76**

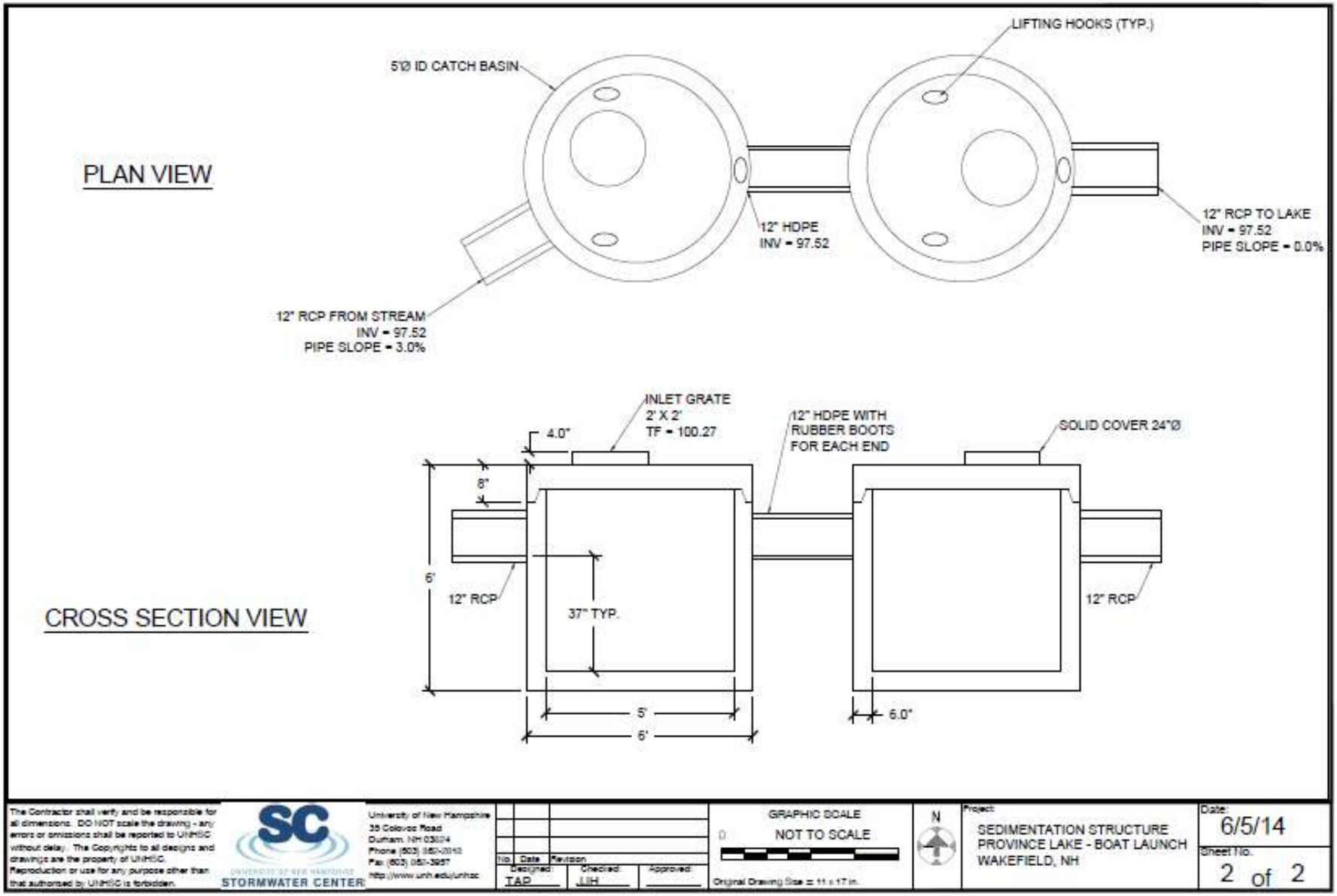
Average

C.3 BMP Cost List

BMP Type	***Materials***	***Labor***	***Total***	***Reference***
Vegetated Buffer (20')	$ 400	$ 80	$ 480	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
New Culvert (20' X18")	$ 500	$ 1,000	$ 1,500	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Gravel and Grading (200' x 16')	$ 500	$ 860	$ 1,360	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Dripline/ Infiltration Trench (18"x20'x8")	$ 150	$ 110	$ 260	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Rubber Waterbar (16')	$ 320	$ 60	$ 380	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Grass-lined Ditch (100')	$ 175	$ 400	$ 575	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Rock-lined Ditch (100')	$ 350	$ 400	$ 750	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Erosion Control Mulch (30' x 30' x 4")	$ 350	$ 120	$ 470	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Plunge Pool	$1.25/sq. ft.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Guard Rail	$20/ Linear ft.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Retention Swales	$1.35/sq. ft.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Recycled Asphalt	$3.80/sq. ft.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Check Dams & Turnouts	$500-600 ea.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Paving (Driveway)	$3.80/sq. ft.	$75/hr	-	*Correspondence with J. Houle - University of NH Stormwater Center*
Open-top Culvert	$ 100	$ 50	$ 150	*Estimate based on current lumber prices*
Retaining Walls	$40/sq. ft.	$75/hr	-	*Estimates from two landscaping companies for block/concrete walls: http://www.landscapingnetwork.com/walls/retaining-cost.html http://www.bahlerbrothers.com/blog/bid/111056/How-much-do-Retaining-Walls-Cost*

Appendix D:
Towle Farm BMP Conceptual Design


TOWLE FARM ROAD
HILL ROAD
RIP RAP SWALE (6" STONE)
APPROX. 20' X 5'
NO WETLANDS IMPACT
5'Ø CATCH BASIN WITH GRATED
INLET MATCH EXISTING FRAME
ELEV = 100.27
5'Ø CATCH BASIN
WITH SOLID COVER
12" RCP INLET TO REPLACE
EXISTING 12" CMP
INV = 97.75
NO WETLANDS IMPACT
MAILBOXES
40' X 12" RCP
@ 3% SLOPE
12" HDPE STUB
50' X 12" RCP
@ 0.0% SLOPE
12" RCP OUTLET TO REPLACE EXISTING 8" PVC
INV = 97.64
OUTFALL AND INVERT AT SAME LOCATION
BONNYMAN ROAD
VEGETATIVE BUFFER
HOSTAS OR SIMILAR
RIP RAP OUTFALL (6" STONE)
APPROX. 3' X 5'
NO WETLANDS IMPACT
BOAT LAUNCH
15' TO WATERLINE
PROVINCE LAKE
The Contractor shall verify and be responsible for all dimensions. DO NOT scale the drawing - any errors or omissions shall be reported to UNHSC without delay. The Copyrights to all designs and drawings are the property of UNHSC. Reproduction or use for any purpose other than that authorized by UNHSC is forbidden.
SC
UNIVERSITY OF NEW HAMPSHIRE
STORMWATER CENTER
University of New Hampshire
35 Colovos Road
Durham, NH 03824
Phone (603) 862-2518
Fax: (603) 862-3957
http://www.unh.edu/unhsc
No. Date Revision
Designed: TAP
Checked: JJH
Approved: TPB
GRAPHIC SCALE
0 15 30
Original Drawing Size = 11 x 17 in.
N
Project:
TOWLE FARM ROAD DRAINAGE
PROPOSED LAYOUT
PROVINCE LAKE - BOAT LAUNCH
WAKEFIELD, NH
Date:
6/5/2014
Sheet No.
1 of 2


PLAN VIEW
5'Ø ID CATCH BASIN
LIFTING HOOKS (TYP.)
12" HDPE
INV = 97.52
12" RCP TO LAKE
INV = 97.52
PIPE SLOPE = 0.0%
12" RCP FROM STREAM
INV = 97.52
PIPE SLOPE = 3.0%
CROSS SECTION VIEW
INLET GRATE
2' X 2'
TF = 100.27
4.0"
12" HDPE WITH
RUBBER BOOTS
FOR EACH END
SOLID COVER 24"Ø
8"
6'
12" RCP
37" TYP.
12" RCP
5'
6'
6.0"
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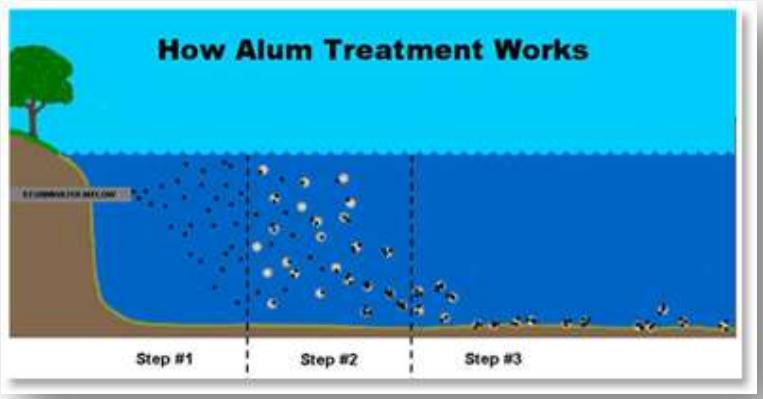
University of New Hampshire
35 Colovos Road
Durham, NH 03824
Phone (603) 862-2010
Fax (603) 862-3957
http://www.unh.edu/unhsc
No. Date Revision
Designed: TAP
Checked: JJH
Approved:
GRAPHIC SCALE
0 NOT TO SCALE
Original Drawing Size = 11 x 17 in.
N
Project:
SEDIMENTATION STRUCTURE
PROVINCE LAKE - BOAT LAUNCH
WAKEFIELD, NH
Date:
6/5/14
Sheet No.
2 of 2

Appendix E:
Alternative BMPs for Province Lake

Types of Alternative BMPs to Control Phosphorus Levels and Cyanobacteria Blooms

Author's Note: *The primary authors of this report have included the following information as a guide to stakeholders in order to present what types of alternative treatments have been used in other areas of the United States to address water quality issues. We do not endorse or recommend these measures. Many of the measures listed here are expensive and can have a negative impact on the ecology of the lake system. We strongly encourage the residents of the Province Lake Watershed to focus on addressing the issues in the watershed outlined in detail in this report. Addressing issues on the land that impact the water will likely have short and long-term benefits for the health of Province Lake.*

1) Aluminum Sulfate Treatment (Alum)



Aluminum sulfate (alum) can be added to lakes to reduce the amount of phosphorus by controlling the internal recycling of phosphorus from the sediments on the lake bottom. Alum is added to the lake and on contact with water, forms an aluminum hydroxide precipitate called floc. As the floc settles to the bottom, it binds with phosphorus in the water column to form an aluminum phosphate compound. This insoluble compound cannot be consumed by algae and other organisms. During the settling process, floc also collects other particulates from the water column, leaving the lake noticeably clearer. As the floc reaches the sediment, it forms a layer on the bottom that acts as a barrier to internal loading as it combines with phosphorus as it is released from the sediment. This decrease in the internal input of phosphorus into the water column reduces the outbreak of algae blooms.

The effectiveness of the alum treatment varies with the length of treatment and the depth/size of the water body. In general, the treatment tends to last longer in smaller and deeper lakes, with less success in shallow lakes. When the treatment is added and in what amount varies and is dependent on the lake. Successful treatments have been observed on both large and small scale projects throughout the country. It should be noted that an alum treatment for Province Lake would likely cost in excess of $500,000 and would last less than ten years (Jeff Dennis, Maine DEP, personal communication).
(http://www.ecy.wa.gov/programs/wq/plants/algae/lakes/lakerestoration.html)

Example Projects:

- *An experimental alum research project was performed on Lake Leba in eastern Nebraska and results published in the Journal of Lake and Reservoir Management. The results illustrate the success of alum in reducing phosphorus loading and levels in the water column, as well as reducing chlorophyll levels and increasing water quality in general. (http://habaquatics.com/node/13)*
- *Alum treatment projects in New England have been implemented at Cochnewagon Lake, Maine & Kezar Lake, NH & Lake Morey, Vermont (http://aquaticcontroltech.com/services/nutrient-management-phosphorus-removal/)*
- *Another use of alum treatment was conducted at Green Lake in Seattle, Washington (http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/aquatic_plants/03-02489-000_greenlake_alum_study_techrpt.pdf)*

2) Artificial Circulation or Aeration

Artificial circulation (or aeration) is a process that provides increased oxygen to a lake by circulating the water to expose more of it to the atmosphere. These systems are most commonly used in shallow water bodies. There are numerous systems that provide aeration including surface spray (fountains), paddlewheels, and air diffusers. Artificial circulation disrupts and prevents stratification while increasing aerobic habitat. Fountains and paddlewheels are located on the water's surface, while air diffusers are often located at the bottom of the water column. There are also mid-depth bubblers that can be located throughout the water column.

Artificial mixing was used for algae control at Province Lake between 1975-1976. The mixing occurred over two time periods (July 24, 1975 through October 14, 1975 and July 20, 1976 through October 12, 1976). Researchers compared results of the two mixing periods and the results of the mixing vs. non-mixing periods. Results indicate that there were no obvious changes in values of the water quality parameters measured, although greater ranges in temperature, and phosphorus were recorded at 4.5 meters during mixing. Turbidity was much higher during the mixing period which affects Secchi disk transparency. There were no reported algal blooms during the study period (NHWSPCC, 1979).

3) Biomanipulation of Fish Populations

Biomanipulation is the alteration of a lake's current food web with the overall goal of restoring ecosystem health. In nutrient-rich, eutrophic lakes, biomanipulation of fish populations have been conducted to restore the water body and improve water quality. Large nutrient influxes into lakes cause major changes in lake dynamics including an increase in planktivores, a reduction of dominance and size of zooplankton species, and the ratio of planktivores to

piscivores increases. As a result, the ability to control phytoplankton populations becomes difficult and algal blooms become frequent. The general approach to biomanipulation is to increase zooplankton communities through the removal of planktivores by fish kill/removal or the direct stocking of piscivores.

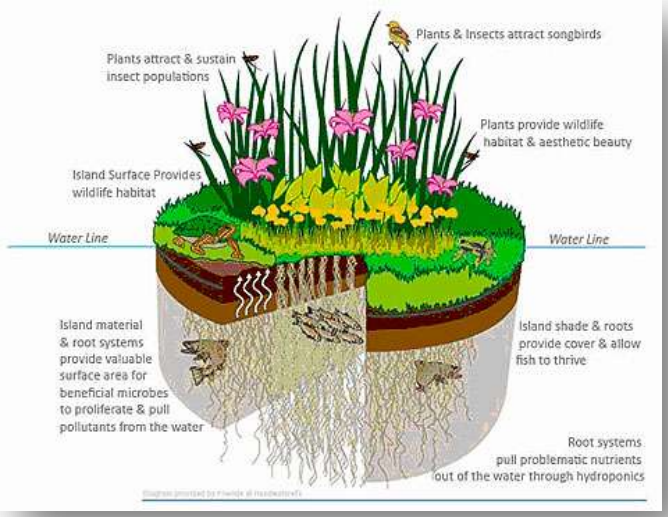
Biomanipulation of fish populations has limited success and reliability, and is often costly and labor intensive. Success of this technique is largely dependent on the specific lake ecosystem, and is typically only used in small, shallow lakes that are closed systems. (http://conservancy.umn.edu/bitstream/58747/1/2.2.Riedel-Lehrke.pdf).

Example Projects:

- An example of biomanipulation of fish populations in a small eutrophic lake is Moe Pond in New York. Largemouth and small mouth bass were added to the lake system and shifted the fish population and in turn the zooplankton and phytoplankton communities. Lake transparency increased, mean chlorophyll decreased, with algal blooms becoming "practically non-existent." (http://www.esf.edu/efb/schulz/Seminars/Albright.pdf)
- Another local effort of biomanipulation occurred in East Pond of Central Maine is described in the link below. Planktivorous fish were reduced in the lake system through fish removal with the goal of increased clarity and water quality in the water body. The hypothesis is that by favoring large-bodies cladocerans and other zooplankton species, there is an increased grazing pressure on nuisance cyanobacteria. (http://www.gulfofmaine.org/kb/files/9202/Halliiwell%20&%20Evers%2009.pdf)
- A biomanipulation project was implemented in 2013 on Nokomis Lake in the City of Minneapolis. In this project, bottom feeding fish that were dominant in the lake system were controlled and removed by the city with the intent to control the phosphorus levels in the lake. (http://www.minnehahacreek.org/project/lake-nokomis-biomanipulation-project)

4) Floating Wetland Islands

Floating wetland islands are artificial floats that mimic naturally occurring wetland ecosystems. Although anchored to the specific point in the pond or lake, they are not stationary and can rise and fall as the water level changes. Peat moss, soil, and native plants are added to the float to create similar soil and root interactions that would be found in natural wetlands, and harbor



Example of a floating island.

microorganisms beneficial to water quality. Specifically, floating wetlands reduce nitrate, TN, ammonia, TP, dissolved phosphorus, copper, zinc, and fine particulates. By acting as a wetland, these floating islands will help improve water quality in the body of water, along with providing ever-declining wetland wildlife habitat.

- Floating Island International's website provides a section on case studies that lists numerous projects that have been implemented with great success across the county as well as internationally. Project locations include Louisiana, North Carolina, New Jersey, Pennsylvania, and Montana as well as many others

  (http://www.floatingislandinternational.com/research/case-studies/).

5) Barley Straw

The use of barley straw to reduce algae levels in ponds and lakes has been implemented in England for many years. Dry barley is amended to the surface of the water in large nets that are anchored to floats that keep the straw in the top three to four feet of water. It should be added when the water temperature is high to promote decomposition, which may last 1-3 months. Replicate additions may be made depending on the severity of the algal blooms.

Example of barley straw application.

The specific process that controls the algae is unknown. However, it is thought to be a result of a compound from the fungi on the barley straw that is released as the barley decomposes in the water that may inhibit algae growth, or perhaps as a result of the bacteria and/or rotifers that are released from the straw that decompose or outcompete algae cells in the water. The success of the straw is dependent on the algae species and water/climate conditions. Limited research and use in the United States shows inconsistent results with varied success rates. (http://www.dec.ny.gov/docs/water_pdf/dietlakech7.pdf)

Example Projects/Research:

- Purdue University developed an informational report on the use of barley straw to control algae growth, research that has been performed in the US, EPA's view on the use, and how to use it/general considerations to be considered before using. This document provides a good overview on the use of the barley straw technique. (http://www.btny.purdue.edu/pubs/apm/apm-1-w.pdf)

6) Dilution or Flushing

Dilution or flushing of lakes may be used as a hydraulic control for high nutrient levels and algae growth in specific situations and conditions. Dilution is achieved by adding amounts of nutrient-poor water from an outside source to reduce the concentration of nutrients in the lake. By adding large amounts of additional water that is, the lake may be flushed of all algae before they are able to reproduce. The flushing of an entire lake is virtually impossible; however, this technique has been successful in small linear impoundments. The feasibility of dilution or flushing is usually low and the cost is often high because it is difficult to find an outside water source. Outlets and downstream channels must also be able to handle the influx of water/discharge and resulting effects must be considered before dilution or flushing is performed.
(http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/downloads/practical-guide.pdf)

There are few documented case studies or research performed on dilution or flushing because of stringent requirements on ecology of the lake and the presence of an outside water source. Despite this, there have been successful uses of these techniques.
(http://projects.geosyntec.com/NPSManual/Fact%20Sheets/Dilution%20and%20Flushing.pdf)

Example Projects/Research:

- Dilution and flushing have been documented as an effective restoration technique for Moses and Green Lakes in Washington State.
  (http://nepis.epa.gov/Adobe/PDF/2000I8RO.PDF)
- Flushing was successful in Lake Veluwe, the Netherlands in reducing phosphorus levels.
  (http://link.springer.com/article/10.1007/BF02291162)

7) Sonication

Sonication is the process of emitting sounds waves into a water medium. Sonication has been used in a lab setting to break up algae in water samples for more detailed analysis. This technique is only recently being used on a lake management scale. Commercial sonicators float on the surface of the water and emit sound waves that break up algae and allow them to settle to the bottom of the lake/pond. This is a relatively new technology and not many examples of successful systems are available in the lake management literature

Example of a commercial sonicator .

(http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/downloads/practical-guide.pdf).

Example Projects/Research:

- LG Sounds is a company that has used this technology in two lakes; one in Poland and one in Malaysia. They had positive results in both. (http://www.lgsonic.com/algae-control-in-lakes/)

8) Aquatic Dyes and Shades

Dyes and shades do not kill algae directly, but limit their growth by reducing the amount of light that is able to penetrate through the water. The dyes are generally non-toxic and will color the water slightly. In order for these techniques to be effective, they must be added early in the growing period before plants and algae have started growing rapidly and the dye concentration should be maintained throughout the summer. These techniques have been successful in small golf ponds but have not shown consistently acceptable control in larger systems (http://ohioline.osu.edu/a-fact/0016.html).

- The Army Corps of Engineers provides an informational report on the use and effectiveness of light attenuating dyes. They mention that these dyes can be effective in controlling the growth of certain species of algae as well as some vascular plants. They are not effective on floating or emergent aquatic plants. Dyes are seldom effective enough for treatment alone, and are often added in conjunction with herbicides. (http://glmris.anl.gov/documents/docs/anscontrol/LightAttenuatingDyes.pdf)

Table E.1: Comparative table describing potential in-lake treatments with associated efficacy and approximate cost.

Treatment	**Efficacy/Longevity**	**Approximate Cost**
Alum	Low	Very High
Artificial Circulation or Aeration	Variable	High
Biomanipulation of Fish Population	Variable	High
Floating Wetlands	Unknown	Medium/High
Barley Straw	Variable	Medium
Dilution or Flushing	Variable	High
Sonication	Variable	High
Aquatic Dyes and Shades	Low	High

Appendix F:
Province Lake Q & A

Province Lake Watershed Plan Project

Response to Public Questions

April 14, 2014

The Province Lake Association (PLA) hosted a public meeting on January 18, 2014 for the purpose of developing a draft Action Plan to include in the Province Lake Watershed Management Plan. Because the meeting was held during the "off season" the PLA and their watershed plan partners decided to offer a public comment period for those who could not attend the meeting. Responses to comments and questions received during the public comment period are provided in this document. These questions and comments will also be taken into consideration during the development of the final Action Plan and Watershed Plan.

(Note: This is intended to be a working document and will be periodically updated to include additional questions that come up during the remainder of the watershed planning process.)

Septic Systems and Outhouses	
Question	**Response**
SS.1 Green Toilets: What about exploring the possibility of replacing outhouses with "green" toilets?	The watershed plan will include recommendations for improvements to on-site waste water treatment (including outhouses). Information about green systems such as composting toilets and other methods will be included.
SS.2 Public Bathrooms: Where do people go to the bathroom when they are at the Route 153 beach all day? Should the town provide toilets for the beach on route 153? Submitted 04.23.2014	The Route 153 beach is privately owned; therefore, coordination with the landowner would be needed to implement toilet facilities.

Roads	
Question	**Response**
R. 1 Route 153: Is the culvert at Shore Acres too small & contributing to flooding?	The watershed plan will include a recommendation to work with Maine DOT to evaluate culvert size relative to the drainage area. If culverts are discovered to be undersized, the recommendation will include a suggestion that the culverts be replaced and sized to accommodate flow.
R.2 Route 153: Guardrails will not control erosion; is there a better way to control runoff from the road?	A comprehensive, multi-solution approach will be needed to address all aspects of the road runoff and beach erosion problem. Several options for controlling road runoff and addressing beach erosion will be recommended in the plan: installing stabilization measures such as geogrid, rip rap or vegetation along the road shoulder, shimming and re-crowning the road so that stormwater drains away from the lake and managing foot traffic and parking to minimize erosion. Foot traffic and parking on the road shoulder exacerbate erosion by breaking down the road shoulder and killing shoreline vegetation. A guardrail has been proposed as one way to address the parking and foot traffic aspect of the overall problem. (Also see question R.3)
R.3 Route 153: Installing a guardrail on route 153 will prevent beach access.	The intent for recommending a guardrail is to provide better management of access to the lake and alleviate issues related to parking on the road shoulder. With the guardrail, beach access would still be available; however, the access points would be reduced and concentrated, which would prevent broad-scale erosion arising from access over the length of the beach.
R.4 Route 153: Concerns about aesthetics of guardrails.	If a guardrail is proposed, aesthetic concerns would be discussed and incorporated into any recommendations.
R.5 Private Roads: Education is needed for people who maintain private roads; especially about proper materials and how to grade the road.	The watershed plan will include a recommendation for private road maintenance education programs.

Municipal Ordinances & Other Regulations	
Question	**Response**
MO.1 Fireworks: Would it be possible to explore a ban on fireworks?	The towns are aware of water quality concerns related to fireworks. Some towns have discussed regulating fireworks, but no action has been taken. (Also see question REC.1)
MO.2 Shoreline Regulations: Interested in seeing if NH's shoreline regulations could be modified to be similar to Maine's where rip rap or stone reinforcement of the shoreline is allowed in certain circumstances.	While New Hampshire does not currently permit the use of rip rap or rock walls to stabilize lake shoreline (in most cases), the plan will include a recommendation that officials from New Hampshire and Maine evaluate ways to streamline and coordinate regulations between the states to promote better water quality.

Recreation and Boating	
Question	**Response**
REC.1 Fireworks: Increased use of fireworks is a concern. What can be done?	Education is the best way to inform people about the negative impacts of fireworks on water quality. The watershed plan will include a recommendation that a fireworks education program be developed and implemented to help reduce impacts from fireworks.
REC.2 Boating: Do jet skis stir up the water? Would a ban on jet skis help improve water quality?	Some studies show that boating and personal water craft use contributes to erosion and turbidity in lakes; particularly in shallow areas. Addressing this issue will require many steps including research, public outreach, and education. The watershed plan will include recommendations to evaluate boating impacts.

Water Quality	
Question	**Response**
WQ.1 Aeration: Would installation of a mechanical aerator or water "bubbler" improve water quality?	Artificial mixing was conducted in the mid- 70s as part of a study to evaluate whether mechanical aeration would improve lake water quality. The results from the study were inconclusive; however, the watershed plan will include recommendations for evaluating the effectiveness and feasibility of various water quality improvement approaches.
WQ.2 Water Level: Would dropping the water level during the summer improve water quality? How does the dam affect water quality & flushing rate?	To the best of our knowledge, watershed sources of pollution have a greater impact on water quality than the dam. Additionally, previous studies indicate that water quality concerns existed well before the dam was built. Therefore, it is critical to focus management efforts on identifying and reducing watershed sources of pollution & preventing polluted runoff from getting into the lake. The Maine Department of Environmental Protection provides some excellent answers to questions about dam impacts to lakes: http://www.maine.gov/dep/water/lakes/waterlevel.htm
WQ.3 Fertilizer: Has anyone discussed fertilizer use near the water? Submitted 04.23.2014	Education is the best way to inform people of proper lawn care practices. The watershed plan will include recommendations for outreach to provide information about proper lawn care practices near the water.

Appendix G:
Route 153 Correspondence

Province Lake Association
P.O. Box 24
Effingham, NH 03882-0024
(207) 200-3234

27 March 2014

John Maclaine
Maine DOT

Dear Mr. Maclaine,

On behalf of the Province Lake watershed planning team, I would like to thank you for the opportunity to provide comments on the upcoming work Maine DOT proposes to conduct along Route 153 in Parsonsfield. As you are aware, the Province Lake Association (PLA) along with its project partners is developing a watershed management plan for the lake. Province Lake is currently on the New Hampshire 303(d) list of impaired waters due to high phosphorus levels, high chlorophyll a, and frequent cyanobacteria blooms.

The PLA and its project partners seek to identify opportunities to reduce pollution to the lake and improve water quality. Route 153 is an important area of concern for the planning project because of stormwater runoff, erosion, and proximity to the lake. Addressing concerns related to Route 153 is a high priority for the project.

The information attached contains a list of recommendations for improvements that could help address runoff from Route 153. We believe several of these options are fairly low cost, would provide water quality benefits to the lake, and could be implemented over the next few years during the proposed road work.

Please take a look and then let me know if you have questions or would like clarification on any of the information presented. We appreciate the opportunity to provide input and look forward to working with you.

Sincerely,

Jon Samuelson

Jon Samuelson
President, Province Lake Association

Sent via e-mail.
CC via e-mail: Wendy Garland, Sally Soule, Linda Schier, Forrest Bell, Carl & Donna Davis, Peter Dinger, Sam Wilson

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Route 153 Improvement Recommendations

General Recommendations:

- Would it be possible to coordinate the re-paving project so that the timing aligns more closely with watershed planning efforts and potential grant opportunities that could provide funding that would enhance and improve the overall road improvement project.

- Ensure that the proposed road work does not disturb the east side of the roadway (especially vegetation; leave vegetation intact because it is functioning well as a wetland buffer).

Table 1. Site Specific Recommendations

Location	Problem	Recommendation	Cost	Water quality benefit
Culvert outlet; west side of road at bottom of hill; see Figure 1., Location A.	Erosion at culvert outlet	Install plunge pool or energy dissipator at culvert outlet to reduce erosion & improve stormwater treatment	Low	Moderate
Golf club pond culvert outlets; see Figure 1., Location B.	Beach erosion at culvert outlet	Stabilize culvert outlet areas to reduce beach erosion & lake sedimentation	Low	High
Golf club pond culverts; see Figure 1., Location B.	Culverts appear undersized and are perched at outlet	Replace culverts and install at correct elevation to eliminate perched condition	High	High
West side of road along beach	Beach erosion	Install guardrail designed with occasional openings to allow foot traffic to pass through openings	High	High
West side of road along beach	Beach erosion and stormwater runoff	Road is crowned in middle and sheet flows off the road cause beach erosion. Shim the road on the lake side and then re-crown road so that drainage flows to the east side of road – away from the lake	Moderate	High

West side of road along beach	Beach erosion and stormwater runoff	Stabilize road edge where it meets the beach. If it can be designed to withstand plow blades, install geogrid along the length of the road edge. If it is not possible to install geogrid, consider stabilizing with reclaim or rip rap (but leave openings for foot traffic)	High	High for geogrid Moderate for reclaim or rip rap
West side of road along beach	Beach erosion and stormwater runoff	Install vegetation (grass) along road edge to minimize erosion from foot traffic	Low	Moderate

Figure 1. Proposed locations for culvert improvements

Appendix H:
Commonly Used Acronyms

List of Commonly Used Acronyms

Province Lake Watershed Management Plan

ALU	Aquatic Life Use
AWWA	Acton Wakefield Watersheds Alliance
BMPs	Best Management Practices
CALM	Consolidated Assessment and Listing Methodology
Chl-a	Chlorophyll-a
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DOT	Department of Transportation
EPA	Environmental Protection Agency
FBE	FB Environmental Associates
LID	Low Impact Development
LLRM	Lake Loading Response Model
Maine DEP	Maine Department of Environmental Protection
NH DES	New Hampshire Department of Environmental Services
NPS	Nonpoint Source Pollution
PCR	Primary Contact Recreation
PCU	Platinum Cobalt Units
PLA	Province Lake Association
ppb	parts per billion
ppm	parts per million
SDT	Secchi Disk Transparency
SSPP	Site Specific Project Plan
UNH	University of New Hampshire
UNH SC	University of New Hampshire Stormwater Center
TP	Total Phosphorus
VLAP	Volunteer Lake Assessment Program
YCC	Youth Conservation Corps