Lake Wentworth and Crescent Lake Watershed Management Plan

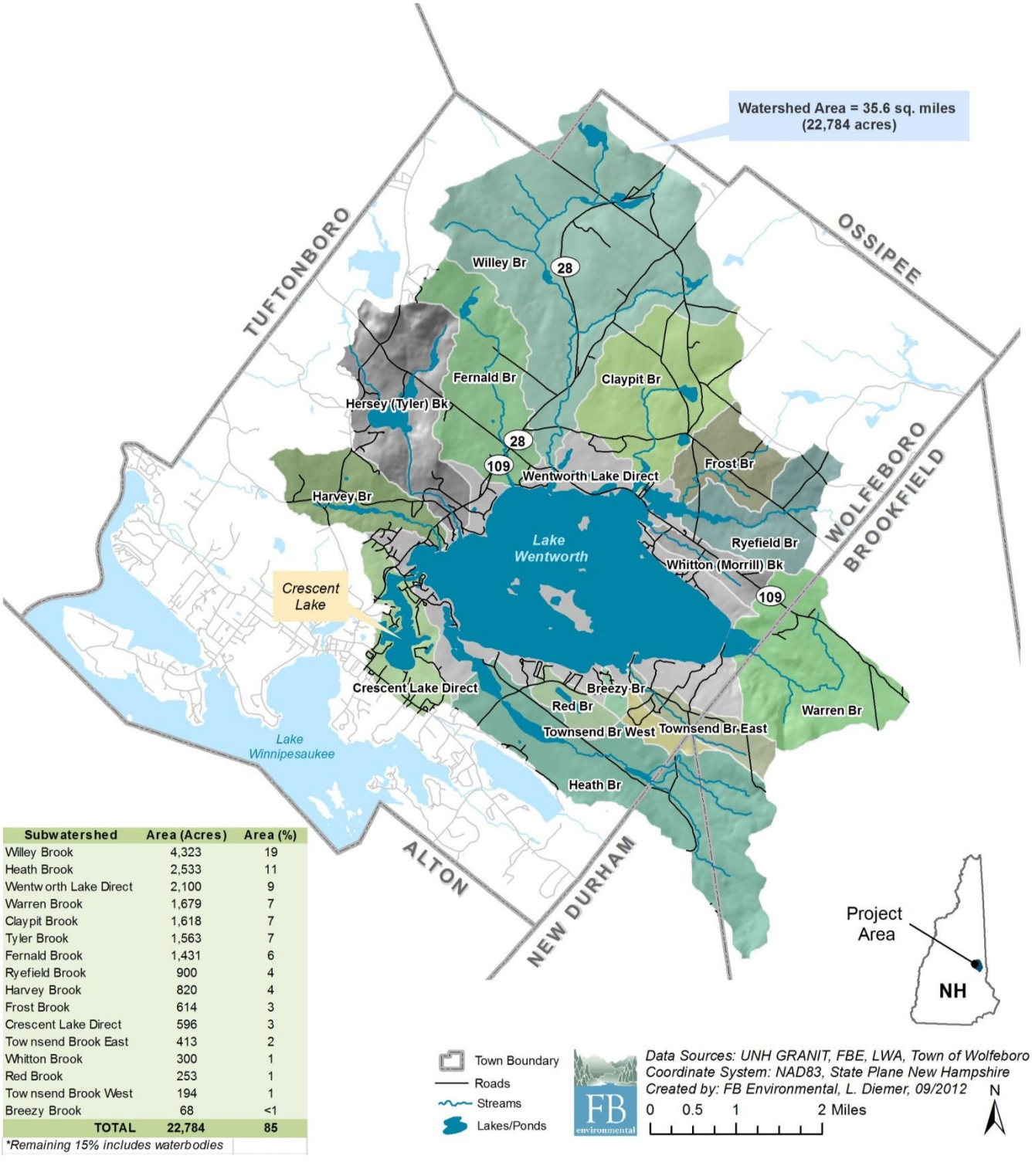
Carroll County, New Hampshire

In Partnership with:

December 2012

Subwatersheds

Lake Wentworth & Crescent Lake Watershed



Subwatershed	Area (Acres)	Area (%)
Willey Brook	4,323	19
Heath Brook	2,533	11
Wentworth Lake Direct	2,100	9
Warren Brook	1,679	7
Claypit Brook	1,618	7
Tyler Brook	1,563	7
Fernald Brook	1,431	6
Ryefield Brook	900	4
Harvey Brook	820	4
Frost Brook	614	3
Crescent Lake Direct	596	3
Townsend Brook East	413	2
Whitton Brook	300	1
Red Brook	253	1
Townsend Brook West	194	1
Breezy Brook	68	<1
TOTAL	**22,784**	**85**
**Remaining 15% includes waterbodies*		

Lake Wentworth and Crescent Lake Watershed Management Plan

Prepared by FB Environmental Associates, Inc
in cooperation with the Lake Wentworth Foundation, the Town of Wolfeboro, the New Hampshire Department of Environmental Services, and Comprehensive Environmental, Inc.

December 2012

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Cover photo: Aerial view of Lake Wentworth and Crescent Lake (Photo: LWF)

EXECUTIVE SUMMARY

Project Overview

Located in the Town of Wolfeboro in Carroll County, New Hampshire, Lake Wentworth and Crescent Lake serve as an attractive summer getaway for tourists who come to enjoy the scenic beauty and excellent water clarity of the lakes. Threats to the water quality of Lake Wentworth and Crescent Lake include inputs of excess sediment and nutrients from existing and future development, aging septic systems, and roads throughout the watershed.

The Lake Wentworth/Crescent Lake Watershed Management Plan is the culmination of a major effort by many individuals who really care about protecting the long-term water quality of these two lakes. The idea was initiated back in 2009 by two members of the Lake Wentworth Foundation, who saw the need to develop a scientifically-based plan to protect these lakes for future generations. A meeting was held to generate interest in the plan, and many enthusiastically jumped on board. From senior members of the Wolfeboro Town staff and Town Planning Board, to volunteer environmental scientists, to members of the University of New Hampshire (UNH) staff, to staff members from the New Hampshire Department of Environmental Services (NHDES), and stakeholders from the Lake Wentworth Foundation (LWF) – many committed to the formation of a Steering Committee to ensure that a strong watershed plan was developed for these two important New Hampshire lakes.

The Lake Wentworth/Crescent Lake Watershed Management Plan is a scientifically based plan created to protect the water quality of these lakes for future generations. The plan provides decision makers and local residents the tools needed to begin this commitment to the future.

This plan was partially funded by a Watershed Assistance Grant for High Quality Waters from NHDES, with additional financial and in-kind services provided by the LWF, the Town of Wolfeboro and UNH. Now, over three years later, a comprehensive watershed plan has been created which will provide guidance for the next phase of actions to preserve the water quality of these picturesque lakes. The water quality of these two lakes represent a core asset for the local economy as a premier tourist destination for playing on, in, and around these pristine waters. The efforts of the volunteers, who helped develop this plan, are dedicated to the future generations who will continue to enjoy these lakes, the same way we enjoy them today.

The Lake Wentworth/Crescent Lake Watershed

Within the Lakes Region of east central New Hampshire, the Lake Wentworth and Crescent Lake watershed (35.6 square miles) is located in the towns of Wolfeboro (86.1%), Brookfield (11.3%), and Ossipee (0.3%) in Carroll County, and New Durham (2.3%) in Strafford County. Lake Wentworth and Crescent Lake, at 534 ft above sea level, are encompassed by mountainous woodlands in all directions, topped at 1,868 feet above sea level by Copple Crown Mountain south of Lake Wentworth (NHDES, 1999). On a clear day, residents can enjoy the ghostly blue silhouettes of the Belknap Mountains to the south and the Ossipee Mountains to the north (Bowman, 1996).

Lake Wentworth and Crescent Lake provide a plethora of critical water resources for the surrounding landscape, including 1,128 acres of wetlands, 3,758 acres of open water, 54 miles of major streams, and 6,710 acres of associated riparian habitat. Crescent Lake and Lake Wentworth levels are controlled by a dam to the Smith River built in 1855 by the Lake Company at the outlet of Crescent Lake. This dam was originally built to control water flow to Wolfeboro Falls mills and, eventually, Lake Winnipesaukee and the Merrimack River. Lake Wentworth and Crescent Lake flow into Lake Winnipesaukee via the Smith River.

The watershed is characterized by non-developed land, including mixed forest, regenerating land, and wetlands. The large extent of wetlands and other riparian habitat in the Lake Wentworth/Crescent Lake watershed is home to a diverse community of fish, birds, mammals, and plants that are dependent on clean water for survival. Based on available data from the Maine Office of GIS, conservation land in the Lake Wentworth watershed covers 2.61 square miles (1,670 acres) or approximately 7.3% of the watershed. The conserved land is characterized by conservation easements (42%) and fee ownership (58%) properties.

Fourteen streams drain directly into Lake Wentworth: Fernald Brook, Heath Brook, Harvey Brook, Hersey (Tyler) Brook, Willey Brook, Warren Brook, Ryefield Brook, Breezy Brook, Claypit Brook, Frost Brook, Townsend Brook East and West, Whitton Brook, and Red Brook. These inlet streams account for 76% of the water entering Lake Wentworth, which makes these tributaries and their associated direct land use critical to the water quality of Lake Wentworth and ultimately Crescent Lake.

Why Develop a Management Plan?

Over the past several years, there has been an increase in the amount of algae in both Lake Wentworth and Crescent Lake, and low levels of oxygen (anoxia) at depths greater than 40 feet. Anoxia can release phosphorus bound to sediments to the water column, thereby making more phosphorus available to algae. Threats to the water quality of Lake Wentworth and Crescent Lake include excess sediment and nutrients from existing and future development, aging septic systems, and roads throughout the watershed. A decline in water quality is a signal that current land-use practices are impacting the health and function of the lake system.

The Lake Wentworth Watershed Management Plan Steering Committee has set a water quality goal that would reduce current in-lake phosphorus by 15% in both Lake Wentworth and Crescent Lake. Although Lake Wentworth is currently within acceptable in-lake median phosphorus capacity levels, discharge from Lake Wentworth accounts for 96% of the water load and 68% of the total phosphorus load to Crescent Lake. As a result, phosphorus levels in Crescent Lake can be improved only through a reduction in phosphorus levels in Lake Wentworth. Yet, reductions in the direct watershed of Crescent Lake are also necessary for long-term water quality preservation.

The Lake Wentworth/Crescent Lake Watershed Management Plan provides guidance for the next phase of actions to protect and improve the water quality of these picturesque lakes.

This plan is dedicated to the future generations who will continue to enjoy these lakes in the same way we enjoy them

This plan provides a roadmap for improving the water quality of Lake Wentworth and Crescent Lake, and provides a mechanism for acquiring grants and other funding to pay for the actions needed to achieve the water quality goal. In addition, it sets the stage for ongoing dialogue among key stakeholders in many facets of the community, and promotes coordinated municipal land use changes to address stormwater runoff. The success of this plan is dependent on the concerted effort of volunteers, and a strong and diverse steering committee that meets regularly to review progress and make any necessary adjustments to the plan.

In the process of plan development, a municipal ordinance review and buildout analysis, water quality analysis, and volunteer septic and stormwater survey were conducted. Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the current and projected amount of phosphorus being delivered to the lakes from the watershed. Since phosphorus is the limiting nutrient in freshwater systems (driving algal growth) phosphorus was used in setting water quality goals for Lake Wentworth and Crescent Lake to maintain or improve their High Quality Waters status.

An Action Plan (Section 5.2) with associated time frames, responsible parties and estimated costs was developed based on feedback from the sixty-two community members that attended the community forum in July 2012. Attendees represented a diverse subset of the community, including the LWF, the Town of Wolfeboro, the Lake Wentworth Association (LWA), community business members, and watershed citizens. The forum was designed

to provide local stakeholders with background information about the watersheds and water quality of Lake Wentworth and Crescent Lake, to solicit stakeholder concerns, and to discuss the timing and elements of the watershed management plan. The Steering 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 15% target reduction in phosphorus can be achieved through 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 development;*
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);*
3) *Institute greater controls on new and re-development, require low-impact development (LID) in site plans, and encourage regular septic system maintenance;*
4) *Continue to conserve land through conservation easement purchases;*
5) *Continue and/or expand the water quality monitoring and aquatic invasive plant control programs.*

Plan Components

The Lake Wentworth/Crescent Lake Watershed Management Plan includes nine key planning elements to address nonpoint source (NPS) pollution (Section 1.3). These guidelines, set forth by 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. 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 Lake Wentworth and Crescent Lake, and provides a summary of current 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 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)) to reduce phosphorus inputs to Lake Wentworth and Crescent 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 Lake Wentworth and Crescent Lake over the next 10 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.

Funding the Plan

Reducing phosphorus inputs from existing development in the Lake Wentworth and Crescent Lake watershed will require significant financial and technical resources on the order of $5 million - $6 million over the next 10 years, including the financial support of private, town, state, and federal partners. Section 5.4 lists the costs associated with successfully implementing this 10-year watershed plan, including both structural and non-structural management measures. A sustainable funding plan should be developed within the first year of this plan to ensure that the major planning objectives can be achieved over the long-term. This funding strategy would outline the financial responsibilities at all levels of the community (landowners, towns, community groups, and state and federal governments). The funding strategy should be incorporated into this plan within the first year, and be revisited on an annual basis.

Administering the Plan

Through the combined efforts of the Lake Wentworth Foundation (LWF) and the Town of Wolfeboro, this watershed management plan should be carried out by a committee similar to the Lake Wentworth Watershed Management Plan Steering Committee. Local participation is an integral part of the success of this plan, and should include the leadership of other local municipalities with land in the watershed (Brookfield, Ossipee, and New Durham). This task will also require the support of other stakeholders, including NHDES, schools and community groups, local businesses, and individual landowners. The primary stakeholder group will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce nonpoint source pollution in the Lake Wentworth and Crescent Lake watershed. Periodic updates to the plan will need to be made in order to maintain the action items and keep the plan relevant to current watershed activities. Measurable milestones (number of BMP sites, volunteers, funding received, etc) should be tracked by the Steering Committee and reported to NHDES on an annual basis.

Next Steps

The success of the plan can be measured in many ways, as outlined in Section 5.3, *Indicators to Measure Progress.* Much of this progress weighs heavily on the cooperation of local municipalities and key stakeholders to support the plan, and the ability of the Steering Committee to develop a sustainable funding strategy.

ACKNOWLEDGMENTS

Lake Wentworth Watershed Management Plan Steering Committee

Bob Craycraft, Center for Freshwater Biology, University of New Hampshire

Don Kretchmer, Lake Wentworth Association

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Mim & Bob Donovan, Landowners
Ann Calvert, Landowner
Leon Pechinsky, Landowner
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Jack Smith, Landowner
Mitch Kazter, Landowner
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Forrest Bell (Municipal Ordinance Review, Community Forum, Field &Technical Support)
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1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

Located in the Town of Wolfeboro in Carroll County, New Hampshire, Lake Wentworth and Crescent Lake serve as an attractive summer getaway for tourists who come to enjoy the scenic beauty and excellent water clarity of the lakes. Over the past several years, there has been an increase in the amount of algae in both Lake Wentworth and Crescent Lake, and low levels of oxygen (anoxia) at depths greater than 40 feet. Anoxia can release phosphorus bound to sediments to the water column, thereby making more phosphorus available to algae. Threats to the water quality of Lake Wentworth and Crescent Lake include sediment and nutrients from existing and future development, aging septic systems, and roads throughout the watershed.

Seasonal and year-round residents and tourists alike enjoy the excellent water quality and clarity in Lake Wentworth. (Photo: FB Environmental)

Lakes are highly valued natural resources that provide critical habitat for a diverse abundance of plants, wildlife, and aquatic life, and opportunities for recreation, scenic enjoyment, and drinking water. Because the water quality of lakes and streams can decline rapidly as a result of stormwater runoff from watershed development, taking proactive steps to properly manage and treat stormwater runoff to protect these important water resources is essential for continued ecosystem health, including resources valued by humans.

The Lake Wentworth/Crescent Lake Watershed Management Plan is the culmination of a major effort by many individuals who really care about protecting the long term water quality of these two lakes. The idea was initiated back in 2009 by two members of the Lake Wentworth Foundation, who saw the need to develop a scientifically-based plan to protect these lakes for future generations. A meeting was held to generate interest in the plan, and many enthusiastically jumped on board. From senior members of the Wolfeboro Town staff and Town Planning Board, to volunteer environmental scientists, to members of the University of New Hampshire staff, to staff members from the New Hampshire Department of Environmental Services, and stakeholders from the Lake Wentworth Foundation – many committed to the formation of a Steering Committee to ensure that a strong watershed plan was developed for these two important New Hampshire lakes.

The Plan was partially funded by a Watershed Assistance Grant for High Quality Waters from the NH Department of Environmental Services (NHDES), with additional financial and in-kind services provided by the Lake Wentworth Foundation, the Town of Wolfeboro and the University of New Hampshire (UNH). Now, over three years later, a comprehensive watershed plan has been created which will provide guidance for the next phase of actions to preserve the water quality of these picturesque lakes. The water quality of these two lakes represent a core asset for the local economy as a premier tourist destination for

playing on, in, and around these pristine waters. The efforts of the volunteers, who helped develop this plan are dedicated to the future generations who will continue to enjoy these lakes, the same way we enjoy them today.

As part of the watershed management plan, a build-out analysis, a water quality and assimilative capacity analysis, and a septic and stormwater survey were conducted, and results were incorporated in a land-use loading model to estimate the current and projected amount of phosphorus being delivered to the lakes from the watershed. Since phosphorus is the limiting nutrient in freshwater systems, driving algal growth, total phosphorus was used to set water quality goals for Lake Wentworth and Crescent Lake to maintain or improve their High Quality Waters status.

This watershed management plan includes nine key planning elements to restore waters impaired by ***nonpoint source (NPS) pollution***. These guidelines, set forth by EPA, highlight important steps in protecting water quality for waterbodies impacted by human activities, including recommendations for future development, and strategies for the reducing the cumulative impacts of NPS pollution on lake water quality in the Lake Wentworth/Crescent Lake watershed.

Nonpoint Source (NPS) Pollution *(a.k.a. stormwater runoff) cannot be traced back to a specific source- but comes from a number of diffuse sources throughout a watershed. One of the major constituents of NPS pollution is sediment, which contains a mixture of nutrients and inorganic and organic material that stimulate algal growth.*

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.*

1.2 STATEMENT OF GOAL

This plan provides short and long-term goals for improving the water quality of Lake Wentworth and Crescent Lake over the next ten years (2013-2023). The long-term goal is to protect the water quality of Lake Wentworth and Crescent Lake through a 15% reduction in median in-lake total phosphorus (TP). This target reduction in TP can be achieved through the following structural (typically engineered treatment options) and non-structural objectives:

- Utilize the BMP matrix to identify, prioritize, and implement ***best management practices (BMPs)*** throughout the watershed to reduce sediment and phosphorus runoff from existing development (Sections 3.6 and 4.2).
- Educate landowners through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a waterbody, and rarely pumped out) (Section 3.5).
- Institute greater controls on new and redevelopment, require ***low-impact development (LID)*** in site plans, and encourage regular septic system maintenance (Sections 3.3 and 3.5).
- Continue to conserve land through conservation easement purchases (Section 2.2.3).

- Continue and/or expand the water quality monitoring and aquatic invasive plant control programs (Section 3.2).

These objectives and more are discussed in greater detail in the Action Plan (Section 5.2).

1.3 INCORPORATING EPA'S NINE ELEMENTS

EPA Guidance lists nine components that are required within a Watershed-Based Management Plan to restore waters impaired by nonpoint source (NPS) pollution. Although Lake Wentworth and Crescent Lake are not currently defined as impaired waters, these guidelines highlight important steps in protecting water quality for any waterbody affected by human activities. The following locates and describes the nine required elements found within this plan:

A. **Identify Causes and Sources: Sections 1.5.1, 3.5, and 3.6** highlight known sources of NPS pollution in the Lake Wentworth/Crescent Lake watershed and describe the results of the watershed surveys conducted in 1999 and 2011. 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 4.3** describes how reductions in annual phosphorus loading to Lake Wentworth and Crescent Lake may be realized over a ten-year period, and describes the methods used to estimate phosphorus reductions. These reductions apply primarily to structural BMPs (e.g. installing vegetated buffers or rain gardens, mitigating runoff from roofs and driveways, improving and maintaining roads and managing fertilizer) for existing development, 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 LID designs for future development, and educating watershed citizens about activities to reduce phosphorus at home.

C. **Description of Management Measures: Section 5.2** identifies ways to achieve the estimated phosphorus load reduction and reach water quality targets described in (B) above. The Action Plan focuses on five major topic areas that address NPS pollution, including: Education and Outreach, Municipal Ordinances, Best Management Practices (BMPs), and Monitoring and Assessment. 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 Lake Wentworth and Crescent Lake is estimated at between $500,000 and $600,000 per year. Sources of funding need to be diverse, and should include state and federal granting agencies (US EPA and NHDES), local groups (watershed towns and lake associations), private donations, and landowner contributions for BMP implementation on private property. The Lake Wentworth Foundation (LWF) and its core stakeholders, led by a steering committee, should oversee the planning effort by meeting regularly and efficiently coordinating resources to achieve the goals set forth in this plan.

E. **Information & Education & Outreach: Sections 5.2.1 and 5.5** describe how the Education and Outreach component of the plan should be implemented to enhance public understanding of the project. This includes leadership from the LWF and the LWA to promote lake/watershed

stewardship. BMP demonstration sites, buffer tours, and outreach, particularly to road associations, are among 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 Lake Wentworth and Crescent 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 to measure progress makes the plan relevant and helps sustain the action items. The indicators are broken down into three different categories: Programmatic, Social, and Environmental Indicators. 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 number of new lake monitoring volunteers. Environmental indicators are a direct measure of environmental conditions, such as improvement in water clarity or reduced in-lake phosphorus concentration.

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

I. **Monitoring component: Section 5.6** describes the long-term water quality monitoring strategy for Lake Wentworth and Crescent 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 achieve a stable or decreasing trophic state. This means halting any current trends of declining water clarity, and reducing the probability of any near-future summer/early fall algal blooms and associated depletion of dissolved oxygen concentration in the deeper sections of Lake Wentworth. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

1.4 PLAN DEVELOPMENT AND COMMUNITY PARTICIPATION PROCESS

On July 9, 2011, Cayce Dalton of FB Environmental (FBE) and Rebecca Balke of Comprehensive Environmental, Inc. (CEI) presented information about the development of the Lake Wentworth and Crescent Lake Watershed Management Plan to members of the Lake Wentworth Association (LWA) at the LWA annual meeting. The presentation provided an overview of phosphorus pollution as the primary pollutant resulting in declining water quality in lakes.

A public meeting to kick off the watershed management project took place on August 8, 2011, at the Wolfeboro Public Library to give interested stakeholders an introduction to the main purpose of the plan and to explain how the town and residents can utilize this information to protect Lake Wentworth and Crescent Lake.

On July 9, 2012, the LWF and FBE sponsored a community forum at the Wolfeboro Inn. The forum was designed to provide local stakeholders with background information about the watersheds and water quality of Lake Wentworth and Crescent Lake, to solicit stakeholder concerns, and to discuss the timing

and elements of the watershed management plan. Outreach was geared toward local landowners, residents, business groups, town planners, and code enforcement officers. Presentations were given by Forrest Bell (FBE), Jennifer Jespersen (FBE), Cayce Dalton (FBE), and Ben Lunsted (CEI).

The 2012 Lake Wentworth/Crescent Lake Community Forum had over 70 watershed stakeholders in attendance. (Photo: FB Environmental)

Sixty-two people attended the community forum and provided valuable input for this plan. Ten additional individuals from FBE, CEI, LWF, and the New Hampshire Department of Environmental Services (NHDES) presented and/or coordinated forum efforts. Attendees represented a diverse stakeholder set, including the NHDES, the LWA, the LWF, FBE, the Town of Wolfeboro, community business members, and landowners. Attendees were asked to describe why Lake Wentworth and Crescent Lake are important to them, and to voice their primary concerns about lake health. The majority of people valued the lakes' clear waters, quiet beauty, simplicity, and abundant wildlife. Stakeholders were particularly interested in fostering stewardship ethics in future generations for the long-term protection of Lake Wentworth and Crescent Lake. The biggest threats to water quality identified were current and future development (particularly along Route 28), inadequate street drainage (particularly along Route 109), failing or improperly maintained septic systems, and general lack of environmental awareness. Recommendations from the forum are listed in the Action Plan (Section 5.2).

This plan was developed through the collaborative efforts of numerous steering committee meetings and conference calls between FBE and outside technical staff, including LWF, CEI, the Town of Wolfeboro and NHDES (see Acknowledgments). Subcommittees of the Lake Wentworth Watershed Management Plan Steering Committee served to review data and goals regarding water quality and priority BMP identification. Several subcommittees were formed over the course of the planning period including a water quality and goal setting committee, ordinance review committee, and BMP review committee.

1.5 CURRENT WATERSHED EFFORTS

The Lake Wentworth Association (LWA) was founded in 1930 by Lake Wentworth property owners concerned about water level control on the dam separating Crescent Lake and Lake Wentworth from the lower Smith River and ultimately, Lake Winnipesaukee. By 1954, the LWA had developed a water pollution committee to address cesspool, septic tank overflow, garbage dumping, and other illegal discharges to the lake. Later, a fishing committee was established to regulate fish catches through licensing and stocking. In 1977, the Clean Water Committee was formed and started its first water testing the following year. By 1984, the LWA had added Lake Wentworth to the University of New Hampshire (UNH) Lakes Lay Monitoring Program (LLMP). LLMP water quality testing included weekly summer monitoring of temperature profiles, Secchi disk transparency, chlorophyll-a, alkalinity, total phosphorus, and dissolved color. Four deep-hole sites were established by 1985, including Fuller's Deep, Trigg's, Governor's Deep, and Crescent Lake Center. The LWA also added phosphorus monitoring at eight major

tributaries to Lake Wentworth, which were sampled three times per year at the outlet to the lake. Additional tributary stations have since been added.

Today, the LWA aims to protect Lake Wentworth and Crescent Lake. The association has more than 1,000 members, with six executive officers and 12 members on the Board of Directors. The LWA has played an active role in education and outreach and water quality monitoring for several decades, and continues to foster an environmentally conscious lake community.

Bass Island. (Photo: LWF)

In concert with LWA activities, the Lake Wentworth Foundation (LWF) was founded in 1996 as a Section 501(c)(3) non-profit organization dedicated to the long-term protection and preservation of the water quality and environmental beauty of Lake Wentworth and Crescent Lake through the funding of many LWA projects, preserving environmentally sensitive property as a land trust, and sponsoring environmental projects within the watershed, including the development of this watershed plan. The LWF provides financial support for the UNH Lakes Lay Monitoring Program and milfoil eradication program, and it manages 175 acres of conservation properties in the watershed. The LWF is directed by 16 trustees and four officers. The LWF and LWA work together on water quality and invasive species issues, with the LWF serving as the primary funder of watershed activities and the LWA serving as the advocate for critical lake issues.

1.5.1 Watershed Surveys

A watershed survey is designed to locate potential sources of nonpoint source (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 watershed.

Bare, exposed soil, as shown in this photo from the 2011 survey, results in delivery of nutrients and sediments in the lakes. (Photo: FB Environmental)

A watershed survey for Lake Wentworth was conducted in 1999 by the New Hampshire Department of Environmental Services (NHDES, 1999). The study identified the following priority sources of pollutants to Lake Wentworth and Crescent Lake: stormwater runoff, timber harvesting, inadequate sand pit stabilization, beach erosion, improper wastewater management, inadequate shoreline buffering, and poor resident education.

In 2011, more than 21 volunteers assisted FB Environmental (FBE) with septic system and stormwater surveys that included 625 properties within 250 feet of Lake Wentworth and Crescent Lake and their tributaries. The purpose of these surveys was to determine critical areas contributing polluted runoff to the lakes. Trained staff spent several days looking at roads, residential areas, commercial areas, and other land uses that could contribute polluted runoff to the lakes. Areas with eroding soil were especially noted because soil contains phosphorus, the limiting nutrient of greatest concern for freshwater lakes. The survey identified 106 sites as sources of polluted runoff in the watershed. Two additional sites were added at the request of Wolfeboro's Director of Public Works, Dave Ford, bringing the total to 108 sites. The most problematic land use types observed involved residential properties (e.g. roofs, paths, inadequate shoreline buffers, etc.), beach access, and driveways; and 11% of identified sites were assessed as high impact to water quality. Commonly observed problems stemmed from surface erosion, bare soil, and lack of shoreline vegetation.

Stormwater surveys were sent to Comprehensive Environmental, Inc (CEI) for follow-up site visits and priority evaluations for BMP implementation. CEI conducted pollutant source evaluations at road crossings and commercial areas, with particular focus on high-priority sites identified by FBE. A two phase ranking system was applied to the 108 NPS sites identified, with prioritization of the top 30 sites for BMP implementation. Of those 30 sites, four were selected for development of conceptual design and cost estimates.

A list of all 108 sites, the 30 high priority sites, and the top six sites identified in the Stormwater/NPS surveys in 2011 by FBE and CEI are provided in Appendix E.3. Conceptual designs and stormwater design plans for the top four priority sites are provided in Appendix F and G. A more detailed description of the BMP priority matrix methodology can be found in Section 3.6 and Appendix E.1.

1.5.2 Land Conservation

Considerable effort has gone into the protection of land in the Lake Wentworth/Crescent Lake watershed not only to protect critical wildlife habitat and other environmentally sensitive land and water resources, but also to provide low-impact public recreational access to these natural resources. Land conservation is one of many tools for protecting lake water quality for future generations. Several local, state and federal organizations have a rich history of land conservation in the watershed. More information on the extent of land conservation efforts are described in Section 2.2.3.

Portions of Fernald Brook and its associated wetlands are protected within the Linda Baldwin Preserve. (Photo: LWF)

1.5.3 Public Outreach

Outreach efforts by the LWA and LWF are aimed at local and seasonal residents, school children, summer visitors, and community decision-makers. Through presentations, hands-on workshops, interactive classroom sessions, and print and electronic media, the mission of the LWA and LWF in protecting the water quality of Lake Wentworth and Crescent Lake has been widely distributed across the watershed. Both organizations have made an effort to educate lakefront residents on the use of non-phosphorus based products, such as detergents and fertilizers. Recent surveys have shown a significant increase in resident awareness of product selection on lake water quality.

The LWA and LWF work cooperatively to raise awareness among watershed residents about water quality issues, including fertilizer use, detergents and nonpoint source pollution. (Photo: LWF)

As part of the current watershed management plan project, the LWF developed three brochures (*Landscaping by the Water, Preventing Nonpoint Source Pollution*, and *Septic Systems: How Do They Work? How Do You Maintain Them?*), which were distributed to landowners within 250 feet of shorelines and tributaries, and is available to all interested residents on the foundation's website (http://lakewentworth.org).

2. WATERSHED CHARACTERIZATION

2.1 LOCATION & CLIMATE

Located in the Lakes Region of east central New Hampshire, south of the White Mountains, Lake Wentworth has been long treasured as a recreational haven for summer vacationers and year-round residents, many of whom have passed down their shoreland properties for several generations. The 35.6 square-mile watershed of Lake Wentworth and Crescent Lake is one of the oldest summer vacation spots in New Hampshire and offers fishing, hiking, boating, sailing, canoeing, kayaking, swimming, golf and tennis in the summer, and ice fishing, cross-country skiing, and snowmobiling in the winter. While Lake Wentworth and Crescent Lake are located entirely within the Town of Wolfeboro, 86.1% of the watershed is situated within the town's borders and extends into Brookfield (11.3%), Ossipee (0.3%), and New Durham (2.3%) in Carroll and Strafford Counties.

Lake Wentworth is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as severe thunder and lightning storms, hurricanes, heavy snowfalls, and tornados. The largest tornado in New England was recorded on July 24, 2008, as it mowed down a 50-mile swath, cutting across Wolfeboro and Lake Wentworth. The area experiences moderate rainfall and snowfall, averaging 40.6 inches of precipitation annually. Temperature ranges from minus 35 °F to 102 °F with an average of 20.6 °F in January and 70 °F in July (U.S. National Weather Service, 2011). The growing season extends from May to September over a 120 day period. Winter extends from December to March with ice-out in mid-April to early May (Bowman, 1996).

2.2 POPULATION, GROWTH TRENDS, AND LAND USE

2.2.1 Population and Growth Trends

Much has changed within the Lake Wentworth watershed since its initial emergence as a resort vacation spot as early as the 1880's. Today, most residents are seasonal, enjoying the natural beauty of the landscape from Independence Day to Labor Day. These seasonal residents and visitors utilize various property types around the lake shore, including private camps, private rental camps, group rental cottages, family resorts, children's camps, and overnight cabins. There are two public beaches, one of which is Clow's Beach located within Wentworth State Park. Two children's camps are also located along the shoreline of Lake Wentworth: Pierce Camp Birchmont is a 247-acre camp established in 1950, and Camp Bernadette is a 23-acre camp established in 1953.

Development in the watershed changes the natural land cover that protects lake water quality. All new development should be managed carefully to mimic natural conditions by infiltrating stormwater runoff during storm events. (Photo: FB Environmental)

Understanding population growth and demographics, and ultimately development patterns, provides critical insight into watershed management, particularly as it pertains to lake water quality. The Lake Wentworth watershed is characterized by 83.3% undeveloped land, the majority of which is found in the northern headwaters. The 6.6% of the watershed considered developed consists largely of low to mid-density residential areas along major roadways and the lake shores of Crescent Lake and Lake Wentworth. Higher density, commercial development is concentrated in downtown Wolfeboro, most of which is outside of the Lake Wentworth/Crescent Lake watershed boundary.

According to the U.S. Census Bureau, the population of Carroll County in 2010 was 47,698, representing a 9.4% increase in population since the 2000 census (NHOEP, 2011). There is limited public transportation in the area, and most people use personal vehicles in their daily commute. Residents are attracted to Wolfeboro and the Lake Wentworth/Crescent Lake area for its small town character and easy commute to I-95, which can be accessed by vacationers in northern and southern New England. Route 28 is a significant route into Wolfeboro from the south.

From 2000 to 2010, the populations of Wolfeboro, Brookfield, Ossipee, and New Durham increased by 3.1%, 17.9%, 3.2%, and 18.8%, respectively (NHOEP, 2011). Based on census data, it appears that Wolfeboro experienced the lowest percentage change in population among the towns in the watershed. The Town of Wolfeboro indicates that the most recent census data was low based on town population data (Wolfeboro, 2007) and an internal review of other data (Rob Houseman, personal communication). The Town's Master Plan indicates that over the past 25 years, Wolfeboro has exceeded the growth rates in the State of New Hampshire and the Lakes region, and since 1990 has exceeded the growth rate of Carroll County. This growth has been in the form of second homes and has resulted in an increasing percentage of retirement age (55-65+) seasonal residents. In fact, the seasonal population is more than double the year-round population. A review of the last 30 years showed a compounded annual growth rate of 2.3%, closer to the rate used by the Town of Wolfeboro for long-range planning purposes (Wolfeboro, 2007).

Table 2.1: *2010 population demographics for Lake Wentworth watershed communities.*

Town/County	Total Population	Population Aged 0-19	Population Aged 20-64	Population Aged 65+
Carroll County	**47818**	**9798**	**28182**	**9838**
Brookfield	712	156	423	133
Ossipee	4345	924	2578	843
Wolfeboro	6269	1233	3280	1756
New Durham	2638	672	1648	318

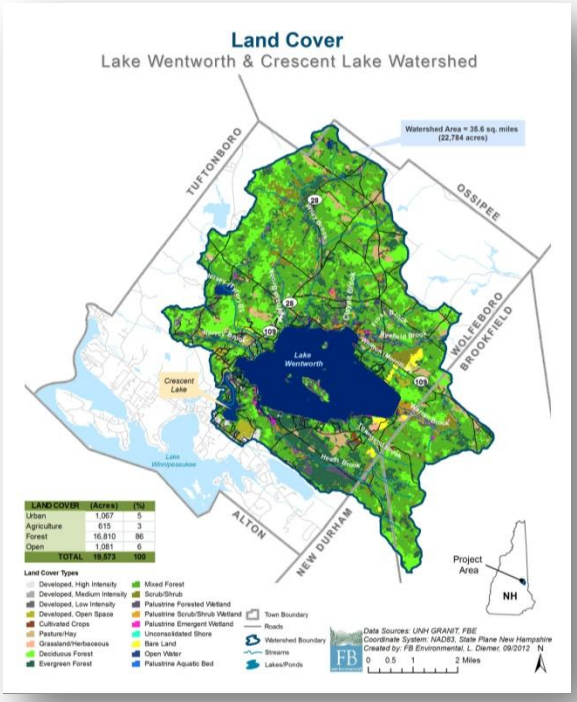
Total Houses	Total Occ Houses	Owner Occ Houses	Seasonal Houses	Vacant Houses	Renter Occ Houses	Median Hhold Income
39813	**53%**	**23%**	**42%**	**42%**	**11%**	
338	86%	92%	10%	14%	7%	$55,833
3057	42%	48%	34%	40%	12%	$44,967
4443	64%	50%	30%	36%	14%	$55,667
1523	67%	61%	29%	33%	6%	$70,568

Median household income ranges from $44,967 in Ossipee to $70,568 in New Durham, with Wolfeboro falling in the middle at $55,833 (Table 2.1). Family occupied residences represent 65% of the occupied housing in Wolfeboro, and most residents are married with young children (<18 years old). Wolfeboro residences consist of a high percentage of seasonal (30%) and renter occupied (14%) homes; while 42% of residences in Carroll County are seasonal. These statistics illustrate the well-known fact that the Lakes Region is an attractive tourist destination for those seeking a tranquil summer retreat, particularly along the shores of Lake Winnipesaukee and Lake Wentworth.

The desirability of Lake Wentworth as a recreational destination will likely stimulate continued population growth in the future. 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 for NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams.



Land use within the Lake Wentworth and Crescent Lake watershed is dominated by mixed forest (see Appendix C for larger map).

Comparing land use within a watershed on a temporal scale can also highlight significant changes over time. According to the diagnostic study completed in the late 1990's (NHDES, 1999), the Lake Wentworth watershed was primarily forested (80%) with some wetlands (17%), open land (2.7%), and agriculture (0.3%). Within the last ten years (2000-2010), the Lake Wentworth watershed has experienced some changes in land use. Today, development accounts for 6.6% of the watershed. Forested areas have remained stable since 1999 at 83.3%, particularly along critical headwater streams in the northern half of the watershed. Wetlands and open water (aside from the surface areas of Lake Wentworth and Crescent Lake) represent 6.7% of the watershed, a decrease from 17% within the last ten years. Agriculture has increased from 0.3% to 3.3%, and includes cover crops, row crops, pastures, and hayfields. These trends coupled with the recent water quality analysis (Section 3) may suggest that new development of residential, commercial, and agricultural land may be affecting the quality of wetlands, lakes and ponds in the watershed (Appendix C; Figure 2.1).

Developed areas within the Lake Wentworth and Crescent Lake watershed are characterized by impervious surfaces including areas with asphalt, concrete, and rooftops that force rain and snow that would otherwise soak into the ground to runoff as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals. Studies have shown a link between the amount of impervious area in a watershed and water quality conditions (CWP, 2003). In one study, researchers correlated the amount of pathogens in a waterbody to the percentage of land with impervious cover in a watershed (Mallin *et al.*, 2000).

The total impervious cover is relatively low in the Lake Wentworth watershed, and is limited primarily to areas along major routes and in downtown Wolfeboro. The buildout analysis conducted for the watershed, coupled with projected population growth trends, indicates that the percentage of impervious cover will continue to increase. Therefore, it is imperative that watershed communities incorporate low-impact development (LID) techniques into new development projects. More information on LID strategies and BMP implementation can be found in the Action Plan in Section 5.2. A map detailing impervious cover in the Lake Wentworth and Crescent Lake watershed can be found in Appendix C.

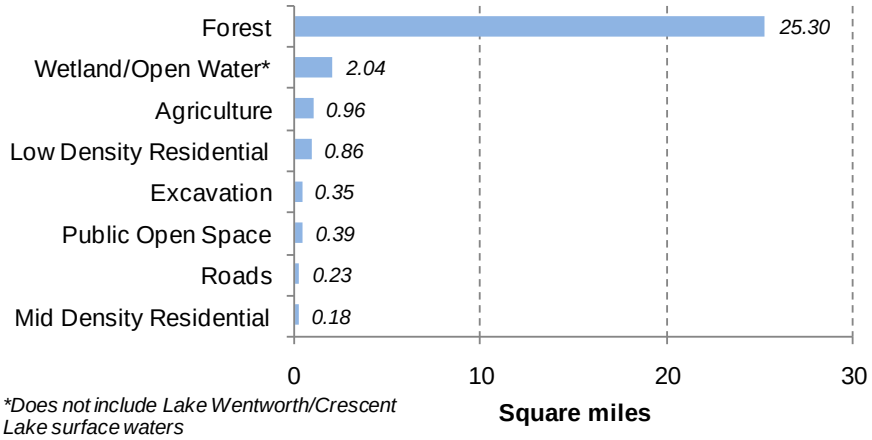
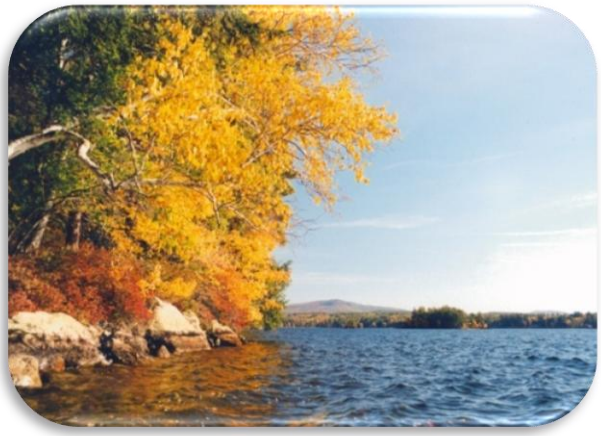


Figure 2.1: *Land use in the Lake Wentworth and Crescent Lake watershed.*

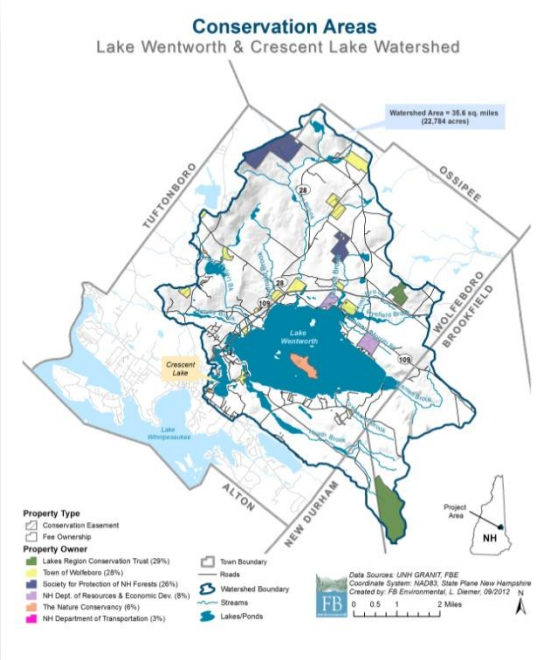
2.2.3 Protected and Public Lands

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Based on available data from the Maine Office of GIS, conservation land in the Lake Wentworth watershed covers 2.61 square miles (1,670 acres) or approximately 7.3% of the watershed (Appendix C). The conserved land is characterized by conservation easements (42%) and fee ownership (58%). The conservation easements are owned by the Lakes Region Conservation Trust



Stamp Act Island. (Photo: LWF)

(61.4%), the Town of Wolfeboro (26.6%), and the Society for Protection of NH Forests (12.0%). The fee ownership properties are owned by the Lakes Region Conservation Trust (40.6%), the Town of Wolfeboro (28.8%), the NH Department of Resources & Economic Development (14.8%), the Nature Conservancy (10.9%), and the NH Department of Transportation (4.9%). Many of the fee ownership properties are town-managed woodlots or recreational areas. The more well-known conserved lands in the watershed include:



Conservation land within the Lake Wentworth/ Crescent Lake watershed (see Appendix C for larger map).

Governor Wentworth State Park: (50 acres) Located on the northeastern shore of Lake Wentworth along Route 109 (Governor Wentworth Highway). The land was purchased by the State of New Hampshire in 1932, and the state park was created by the Civilian Conservation Corps from 1933 to 1942.

Stamp Act Island: (100 acres) Located in the middle of Lake Wentworth, Stamp Act Island is approximately 4,000 feet long at its widest, and 1,200 feet wide, with 12,000 feet of shoreline. The island was purchased as protected land by The Nature Conservancy in 1977 through the impressive fundraising efforts of the Lake Wentworth Association and community residents.

The LWF also acts as a land trust with considerable land holdings totaling 175 acres of sensitive land in the Lake Wentworth and Crescent Lake watershed. These parcels were inherited by the LWF in 2001 from Linda Baldwin, a summer resident of Wentworth Park. The LWF purchased the 2.2 acre Allen Stevens Preserve on Pleasant Valley Road in 2012. The following properties are the main LWF land holdings:

- **Allen 'A' Preserve:** 13 acres includes portions of both Harvey and Hersey (Tyler) brooks, as well as frontage on route 28, Moose Point Road, Albee Beach Road, and the TRAC Cotton Valley Trail.
- **Hersey Point Preserve:** 15 acres located on Hersey Point Road, protecting Hersey (Tyler) Brook and part of the Cotton Valley Trail. Part of this preserve is in conservation easement.
- **Linda Baldwin Preserve:** 35 acres along Route 28, protecting Fernald Brook and several wetlands. Part of this preserve is in conservation easement.
- **Square Hill Preserve:** 67.3 acres on Square Hill off Allen Road, protecting Hersey (Tyler) Brook and tributaries to Sargent's Pond.
- **Square Hill Lot 6:** 23.5 acres located near Square Hill.

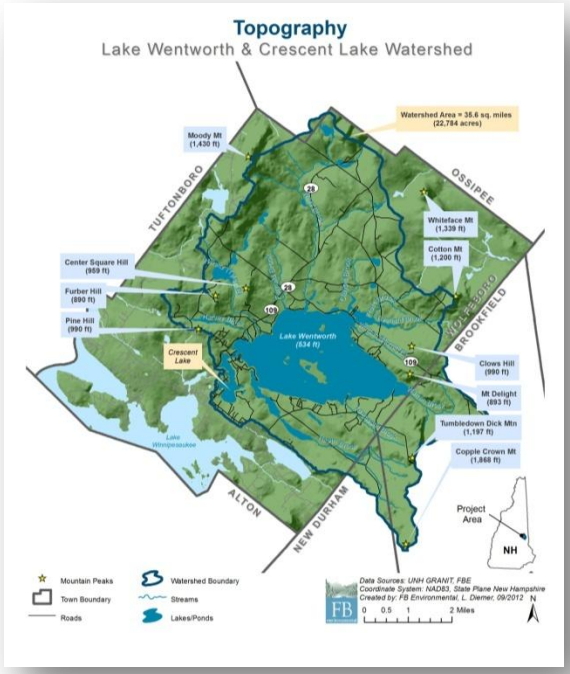
These land holdings are not included in the conservation land data file from UNH GRANIT (Appendix C) but are important to include in future development scenarios since these lands will most likely be kept in conservation by the LWF. With 83.3% of the watershed undeveloped, there is opportunity for the expansion of conserved land in the region. Protection of headwater streams, in

particular, will help reduce total phosphorus runoff to tributaries and ultimately to Lake Wentworth and Crescent Lake.

2.3 PHYSICAL FEATURES

2.3.1 Topography

Lake Wentworth and Crescent Lake, at 534 feet above sea level, are encompassed by mountainous woodlands in all directions with Copple Crown Mountain rising to the south of Lake Wentworth to 1,868 feet above sea level (NHDES, 1999). Peaks within or near the Lake Wentworth watershed include Moody Mountain (1,430 feet), Center Square Hill (959 feet), and Whiteface Mountain (1,339 feet) to the north; Cotton Mountain (1,200 feet), Clow's Hill (990 feet), and Mount Delight (893 feet) to the east; Tumbledown Dick (1,197 feet) to the south; and Pine Hill (990 feet) and Furber Hill (890 feet) to the west (Appendix C). On a clear day, residents may get a glimpse of the Belknap Mountains to the south and the Ossipee Mountains to the north.



The Lake Wentworth watershed is characterized by varying topography just south of the White Mountain National Forest (see Appendix C for larger map).

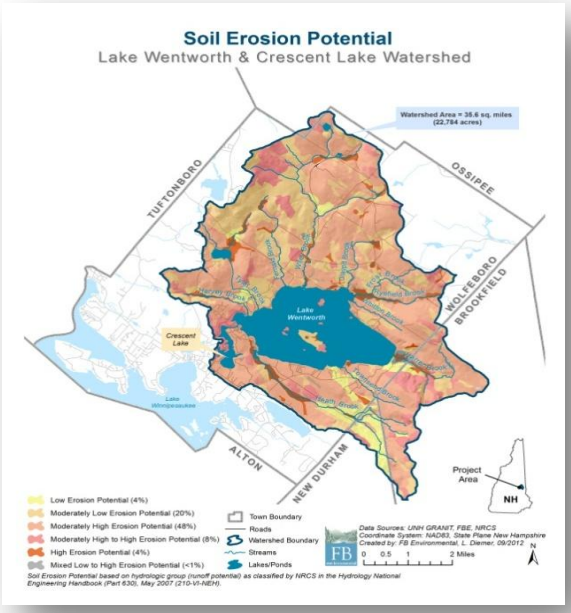
2.3.2 Soils and Geology

The composition of soils surrounding Lake Wentworth 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).

View of Lake Wentworth from Square Hill. (Photo: LWF)

The current landscape formed 12,000 years ago at the end of the Great Ice Age as the mile-thick glacier over half of North America melted and retreated, scouring bed rock and depositing glacial till to create the deeply scoured basin of Lake Wentworth and Crescent Lake (NHDES, 1999). 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 invading vegetation and meandering streams as the depression basins throughout the region began to fill with water (Goldthwait, 1968). The Lake Wentworth watershed is characterized by fertile soils of coarse granite and clays with a large alluvial deposit located near Warren Brook (known as Warren Sands) (NHDES, 1999). The region continues to be modified by tributary streams, wave action, lake ice formation, frost, and wetting/drying till (Goldthwait, 1968).



Areas of high erosion potential are concentrated around tributaries and pose a threat to Lake Wentworth (see Appendix C for larger map).

The Lake Wentworth/Crescent Lake watershed is characterized by multiple soil associations (groups of soils with similar characteristics) and can be organized by their origin of formation. The Hinckley-Windsor-Deerfield and Greenwood - Chocorua-Naumburg soil associations were formed from water-deposited material along floodplains, eskers, kames, or other glacial outwash features (USDA, 1977). In the southern part of Carroll County near Lake Wentworth, the Hinckley-Windsor-Deerfield soil association can be found along glacial drainages and lakes and is characterized by nearly level to very steep, excessively to moderately well drained, gravelly and sandy soils. The Greenwood-Chocorua-Naumburg soil association can be found along lake or stream drainages and wet depressions and is characterized by nearly level, very poorly to somewhat poorly drained, organic and sandy soils.

Four additional soil associations found in the Lake Wentworth watershed were formed on glacial till where rocky bedrock outcrops and woodlands are common: Paxton-Woodbridge-Ridgebury, Millis-Scituate-Ridgebury, Gloucester-Acton-Leicester, and Hollis-Gloucester-Charlton soil associations (USDA, 1977). The Paxton-Woodbridge-Ridgebury soil association can be found in upland areas, and is characterized by nearly level to moderately steep, well, moderately, somewhat, and poorly drained, loamy soils. The Millis-Scituate-Ridgebury soil association can also be found in glacial upland areas, and is characterized by nearly level to moderately steep, well to moderately drained with sandy pan layer or poorly to somewhat poorly drained with a loamy pan layer. The Gloucester-Acton-Leicester soil association can be found on irregular, very stony, glacial uplands, and is characterized by nearly level to steep, somewhat excessively to moderately well drained, sandy soils or somewhat poorly to poorly drained, loamy soils. The Hollis-Gloucester-Charlton soil association can be found along ridges and hills where rocky outcrops are common, and is characterized by gently sloping to very steep, somewhat excessively to well drained, loamy and sandy soils.

Minor soil series found within the Lake Wentworth watershed include the poorly drained Raynham variant series in freshwater marshes in the Greenwood-Chocorua-Naumburg soil association, the moderately well drained Sutton soil series along lower hillsides in the Hollis-Gloucester-Charlton soil association, and the very poorly drained Whitman soil series in depressions or drainages in the Millis-Scituate-Ridgebury and Paxton-Woodbridge-Ridgebury soil associations (USDA, 1977).

Steep, unvegetated paths leading down to the lake can result in delivery of nutrients and sediments into the water. (Photo: FB Environmental)

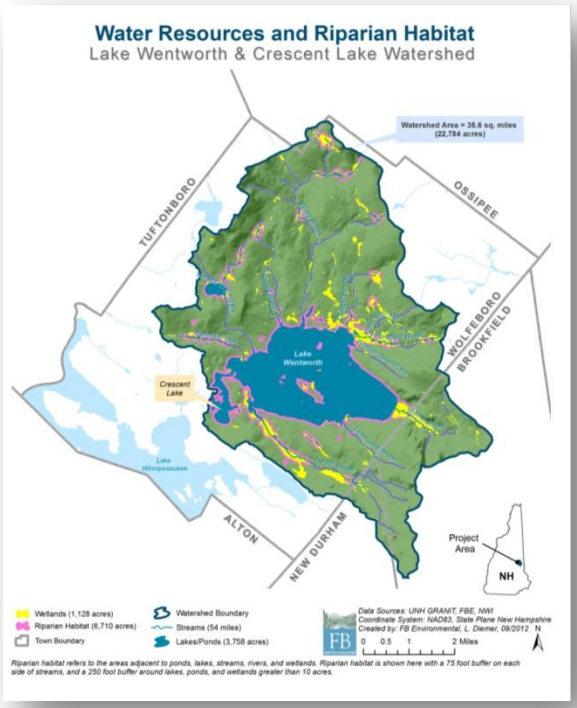
Soil erosion potential is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al. 2006). Soil erosion potential should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion potential are primarily low lying wetland areas near abutting streams. The soil erosion potential for the Lake Wentworth 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 are concentrated in major wetlands and along tributaries, particularly on sloping areas. Low erosion potential areas are found primarily in the flatter, intact forests throughout the watershed. Development should be restricted in areas with highly erodible soils due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment 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

Lake Wentworth and Crescent Lake provide a plethora of critical water resources for the surrounding landscape, including 1,128 acres of wetlands, 3,758 acres of open water (including Lake Wentworth and Crescent Lake), 54 miles of major streams, and 6,710 acres of associated riparian habitat. The ***riparian habitat*** of these waterbodies is home to a diverse community of fish, birds, mammals, and plants that are dependent on clean water quality conditions to flourish. Wetlands can maintain this necessary water quality by acting as a filter of nutrients and sediments from incoming stormwater runoff. Any decrease in the extent of wetlands as a consequence of development will limit this natural filtration and cause detrimental long-term effects on water quality and diversity of inhabiting species.

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.*

New Hampshire Fish & Game ranks habitat based on value to the state, biological region, and supporting landscape. According to this schema, Lake Wentworth, the wetland complex along Warren Brook, and the Copple Crown Mountain area extending from Brookfield into New Durham are considered Tier 1 for highest ranked habitat in the State of New Hampshire. This area includes the Brewster Heath area (Heath Brook) and its substantial wetland complex immediately upstream of the lake. Crescent Lake and all major streams within the watershed are considered Tier 2 for highest ranked habitat in the biological region. All other land in the watershed is considered Tier 3 for the supporting landscape. A map detailing priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix C.



Wetlands, tributaries, lakes, ponds, and riparian habitat are critical components of a healthy watershed (see Appendix C for larger map).

The Lake Wentworth/Crescent 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, 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, cormorants, 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. Fish species present in Lake Wentworth include smallmouth and largemouth bass, rainbow trout, chain pickerel, white perch, yellow perch, crappie, smelt, hornpout, cusk, sunfish, suckers, fallfish, American eel, and golden shiners (Bowman, 1996; NHDES, 1999; Jack O'Connell and Don Kretchmer, personal communication). Smallmouth bass were introduced in 1878, and have been restocked annually from 1938 to 1949 and from 1951 to 1954. Golden shiners were restocked in 1941 and 1942. Introductions of lake trout in 1928 and land-locked salmon in 1879 were unsuccessful. Rainbow trout were introduced in 1991 and are stocked annually.

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.

Lake Wentworth is nearly four miles long from east to west and 2.5 miles wide from north to south. The average depth is 21 feet (6.4 m), and maximum depth is 83 feet (25.3 m) (Figure 2.2). The surface area of Lake Wentworth is approximately 3,018 acres (1,221 ha) (not including the islands), while the total

watershed area is 35.6 square miles (22,784 acres). There are 13 miles of shoreline and 73,997,266 cubic meters of water in Lake Wentworth (as calculated by NHDES 2011 bathymetry provided by Scott Ashley) (NHDES, 1999). The ***areal water load*** is 3.45 m/yr, and the lake water volume flushes completely approximately every other year (0.74 times per year as calculated by FB Environmental). Lake Wentworth is also influenced by 19 islands scattered throughout the waterbody, including eight currently inhabited islands (Bass, Cate, Loon, Mink, Poplar, Sister, Trigg's, and Turtle), two previously inhabited islands (Brummitt and Stamp Act), seven uninhabited islands (Flo, Goose, Joe, two Jockey Caps, Min, and Wal), and two unnamed islands with unknown human impact.

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

Crescent Lake is hydrologically connected to Lake Wentworth, by a narrow stream channel known as the Smith River (Figure 2.2). The surface area of Crescent Lake is 0.23 square miles (147 acres) with a mean depth of 9.9 feet (3 m) and maximum depth of 21 feet (6.4 m). There are 20,013 feet (6,100 m) of shoreline and 1,814,665 cubic meters of water volume in Crescent Lake [1]. The areal water load is 35.62 m/yr, and the lake water volume flushes 31 times each year (previously calculated at 11.9 times per year[1]). Approximately 13.2% of Crescent Lake is considered ponded as a result of the dam along the Smith River. The water from Lake Wentworth flows into Crescent Lake, which flows southwest into New Hampshire's largest waterbody, Lake Winnipesaukee, via the lower Smith River.

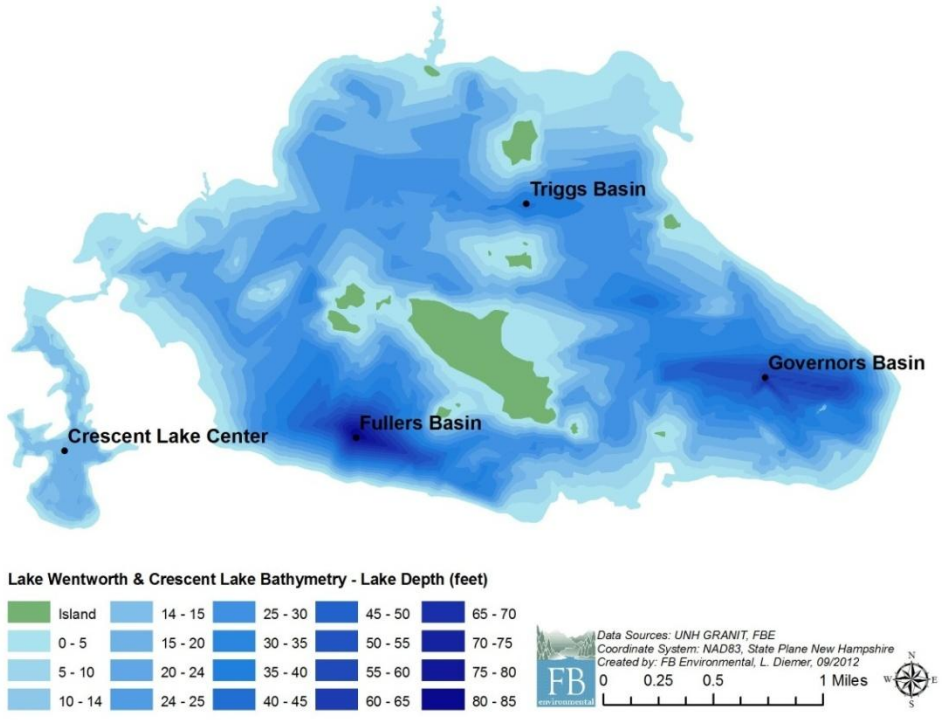


Figure 2.2: *Bathymetry of Lake Wentworth and Crescent Lake (UNH GRANIT).*

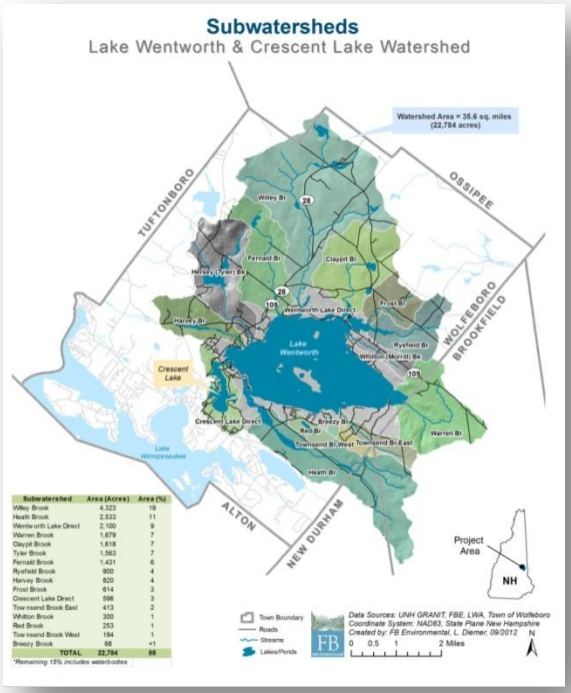
[1] *Lake volume was calculated for both lakes based on the most recent bathymetry data provided by NHDES in October 2011. Using the hydrologic budget determined by the land use model, new flushing rates were calculated for both lakes. These results were reviewed and approved for use in the land use runoff model by NHDES.*

[2] There is currently only one town in New Hampshire with a septic system inspection ordinance in Place (Town of

2.3.5 Direct and Indirect Drainage Areas

Fourteen streams drain directly into Lake Wentworth: Fernald Brook, Heath Brook, Harvey Brook, Hersey (Tyler) Brook, Willey Brook, Warren Brook, Ryefield Brook, Breezy Brook, Claypit Brook, Frost Brook, Townsend Brook East and West, Whitton Brook, and Red Brook (Appendix C). Lily Brook was transformed into a bog in the early 1940's through the construction of the state park. Hersey Brook is the outlet for Sargent's Pond, and Willey Brook (the largest subwatershed) is the outlet for Batson's Pond. Warren, Ryefield, and Heath Brooks are deep enough for small watercraft navigation.

There are also small drainages to Crescent Lake, including one from Kingswood High School and Middle School through the golf course and holding pond to the lake. Two streams flow through the golf course where steep slopes may be causing erosion during major rain events.



Subwatersheds include the land area around major tributaries draining to Lake Wentworth and Crescent Lake (see Appendix C for larger map).

Flow from inlet streams accounts for 76% of the water entering Lake Wentworth, which makes these tributaries and associated land uses critical to the water quality of Lake Wentworth and ultimately Crescent Lake. Additional inputs to Lake Wentworth are from rainfall (25.3%) and direct runoff (0.3%) (NHDES, 1999). It is estimated that 82.5% of the water entering Lake Wentworth flows directly into Crescent Lake with 7.5% evaporating and 10% entering groundwater.

Excess sediment delivered to Lake Wentworth via major tributaries like Fernald Brook, seen here in 2008, has resulted the formation of deltas in the lake. (Photo: Jack O'Connell)

Crescent Lake and Lake Wentworth are also controlled by a dam built in 1855 by the Lake Company at the outlet of Crescent Lake. This dam was originally built to control water flow to Wolfeboro Falls mills, and consequently, Lake Winnipesaukee and the Merrimack River. The Smith River was also dredged which allowed the water level of Lake Wentworth to be manipulated three to four feet by operation of the Crescent Lake dam.

Concern about sedimentation from road sanding and streambank erosion, caused by higher flows in the streams as a result of development, has been raised by members of the Lake Wentworth/Crescent Lake Watershed Plan Steering Committee. Buildup of excess sediment at the mouths of major tributaries,

including Fernald Brook has resulted in the formation of deltas that are visible in recent aerial photographs. The Fernald Brook delta extends 350-400 feet into the lake. From the mouth of the brook, it extends approximately 300 feet east, and in the other direction it extends approximately 200 feet west. The water depth 400 feet from the shore is estimated to have decreased from approximately four feet to two feet in the past 50 years. The deltas are considered a navigational hazard, since many recreationists water ski 300 feet off shore and often churn up sand from the delta. This is especially true later in the summer as the lake often drops almost a foot in elevation. In late summer residents may have difficulty powering their boats to and from their docks.

The large volume of water entering these lakes directly or indirectly via tributary streams makes phosphorus loading from these subwatersheds of major importance for lake management. High phosphorus inputs can result in nuisance algal blooms that damage the ecology and aesthetics of a lake. As a result, reducing phosphorus inputs to Lake Wentworth and Crescent Lake from tributaries should be a high management priority. A detailed summary of the recent nutrient loading analysis for Lake Wentworth and Crescent Lake is provided in Section 3.2.3.

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: NHDES)

Variable milfoil (*Myriophyllum heterophyllum*) arrived in Lake Winnipesaukee in 1979 and found its way to Mast Landing at Crescent Lake the following year. A Weed Watch Committee was formed in 1983 in response to this unwanted aquatic invader. The State of New Hampshire helped the Town of Wolfeboro and Lake Wentworth Association pay for placement of chemically treated mats in an attempt to eliminate the milfoil. In 1991 1995, 1999, and 2003, large areas of Crescent Lake were treated with Diquat, a contact herbicide. In 1991, milfoil was discovered between Allen Albee Beach and Hersey Brook in Lake Wentworth. Mats were laid out immediately, which seemed to stem the spread of milfoil. NHDES introduced new treatment procedures in 1994 to include chemical treatments, manual weed pulling, chemical mats, and plant surveys. A NHDES plant survey in 2006 found milfoil common in Heath Brook, Hersey Brook, and Willey Brook tributary coves in Lake Wentworth. These infestations have been managed in recent years by chemical treatment with 2, 4 D, a systemic herbicide and hand-pulling by divers. The LWA has supported a Lake Host at the Mast Landing boat launch to provide voluntary boat and trailer inspections and to inform the public about invasive species. Continuing to monitor and control variable milfoil and other invasive species will help preserve the water quality of Lake Wentworth and Crescent Lake for the future.

3. ASSESSMENT OF WATER QUALITY

This section provides an overview of the water quality standards that apply to Lake Wentworth and Crescent Lake, the methodology used to assess water quality, and recommendations for managing these lakes to prevent future decline in water quality. Lake Wentworth is already listed as impaired on the 2010 303(d) list of impaired or threatened waters due to low levels dissolved oxygen, low pH and non-native aquatic plants (variable milfoil). 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 blooms, fish kills, decreased water clarity, loss of aesthetic values, and beach closures.

3.1 APPLICABLE WATER QUALITY STANDARDS AND CRITERIA

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

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. The Federal Clean Water Act, New Hampshire *RSA 485-A Water Pollution and Waste Control*, and the NH Surface Water Quality Regulations (Env-Wq 1700) are the regulatory bases for governing water quality protection in New Hampshire. These regulations form the basis for New Hampshire's regulatory and permitting programs related to surface water. States are required to submit biennial water quality status reports to Congress via EPA. The reports provide an inventory of all waters assessed by the state and indicate which waterbodies exceed the state's water quality standards.

3.1.1 Designated Uses & Water Quality Classification

The CWA requires states to determine designated uses for all surface waters in the state's jurisdiction. Designated uses for surface waters include aquatic life, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming) and fishing (aquatic life) and secondary contact recreation (boating) and wildlife. Lakes can have multiple designated uses.


Photo: LWF

In New Hampshire, all surface waters are legislatively classified as Class A or Class B; most of which are Class B. A brief description is provided in Table 3.1 (NHDES, 2012); however, a more detailed discussion of these classifications can be found in the State statute RSA 485-A:8. Further review and interpretation of the regulations (Env-Wq 1700) reveals that the general rules can be expanded and refined to include the seven specific designated criteria (Table 3.2). Lake Wentworth, after initially being classified by the NH Legislature as Class B was changed to Class A in Chapter Law 189:1 in 1988.

Table 3.1. *New Hampshire Surface Water Classifications (Adapted from NHDES, 2012).*

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

These general use classifications can be expanded to include additional designated uses specific to human and wildlife needs (Table 3.2).

Table 3.2. *Designated Uses for New Hampshire Surface Waters (Adapted from NHDES, 2012).*

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

3.1.2 Water Quality Standards and Criteria

New Hampshire's water quality standards provide a baseline measure of water quality that surface waters must meet to support designated uses. Water quality standards are the "yardstick" for identifying water quality exceedences 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.

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 (NHDES, 2008). New Hampshire recently developed thresholds for the narrative criteria based on trophic classes. The previous aquatic life use phosphorus threshold for New Hampshire lakes of 15 ppb was based on a one size fits all standard. While the 15 ppb phosphorus threshold remains for the primary contact recreation designated use, the draft water quality threshold for aquatic life use was set by analyzing 233 New Hampshire lakes (or about one-fourth of all lake 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). 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 phosphorus levels exceed the identified thresholds.

Water Quality Parameters

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

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.*

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).*

Table 3.3. *Aquatic life nutrient criteria ranges by trophic class in New Hampshire.*

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

3.1.3 Antidegradation

The Antidegradation Provision (Env-Wq 1708) in New Hampshire's water quality regulations serves to protect or improve the quality of the State's waters. The provision outlines limitations or reductions for future pollutant loading. Certain development projects (e.g. projects that require Alteration of Terrain Permit or 401 Water Quality Certification) may be subject to an Antidegradation Review to ensure compliance with the State's water quality regulations. The Antidegradation Provision is often invoked during the permit review process for projects adjacent to waters that are designated impaired, high quality

and outstanding resource waters. High quality waters is a special designation that NHDES assigns to waters of significantly better quality than set forth by water quality standards. Currently, New Hampshire does not have and has not tried to designate any of its surface waters as high quality.

3.1.4 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 (see section 3.1.2), consisting of a "nutrient indicator" (for example, phosphorus) and a "response indicator" (in this case, chlorophyll-a) (See also: Env-Wq 1703.03 Env-Wq 1703.04 Env-Wq 1703.14 Env-Wq 1703.19). Sampling results from both the nutrient indicator and the response indicator are used to assess aquatic life uses (ALU) in New Hampshire Lakes (Table 3.3). 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 quality, and possibly changes in aquatic species composition.

Primary Contact Recreation

The narrative criteria for primary contact recreation (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. *E. coli* is the primary indicator for "fully supporting" designations. 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 3.4. The Chl-a concentration will dictate the assessment if both Chl-a and TP data are available and the assessments differ.

Table 3.4. *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	Insufficient Info	Insufficient Info	Insufficient Info

From 1974 through 2010, NHDES 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. Oligotrophic lakes typically have low productivity, low levels of phosphorus and Chl-a, few rooted aquatic plants and algae, deep transparency readings (8.0 m or greater), and high dissolved oxygen levels throughout the water column. Both Lake Wentworth and Crescent Lake are considered oligotrophic.

Trophic State *is 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.*

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

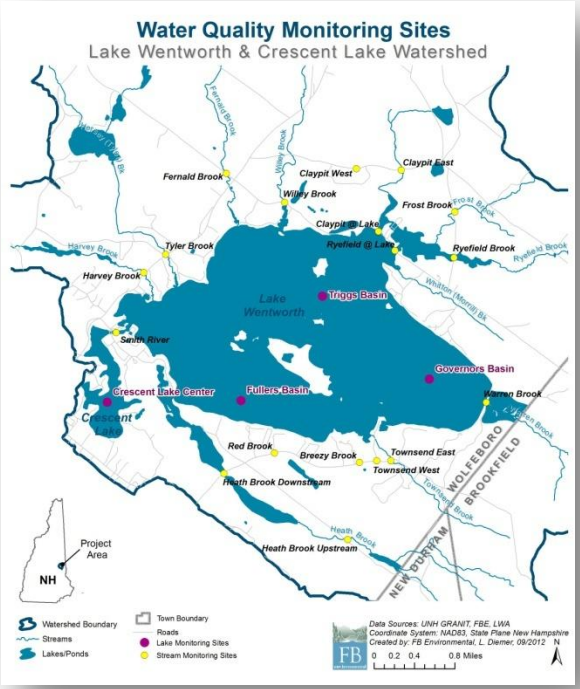
3.2 ASSIMILATIVE CAPACITY ANALYSIS

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 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 its water quality will decline over time as algal blooms become more frequent.

Over the past several years, there has been an increase in the amount of algae in both Lake Wentworth and Crescent Lake, and historical Lake Wentworth profiling data indicate anoxic conditions below 40 feet. Anoxia is a concern because it can release sediment-bound phosphorus into the water column, thereby making more phosphorus available to algae. Reducing the amount of nonpoint source pollution entering Lake Wentworth and Crescent Lake will help reverse the trend towards increasing productivity.

3.2.1 Study Design and Data Acquisition

Historical water quality monitoring data was analyzed by FB Environmental to determine the median phosphorus value and the assimilative capacity for Lake Wentworth and Crescent Lake. The New Hampshire Lake Survey Program and Volunteer Lake Assessment Program (VLAP) and the New Hampshire Lakes Lay Monitoring Program (LLMP) are the primary groups for collecting water quality data on lakes in New Hampshire. The LLMP is administered jointly by the UNH Center for Freshwater Biology (CFB) and UNH Cooperative Extension (UNHCE). All NHDES and UNH data is available through the NHDES Environmental Monitoring Database (EMD).



The water quality analysis for Lake Wentworth and Crescent Lake included five major sampling locations (see Appendix C for larger map).

Data acquisition and analysis for Lake Wentworth and Crescent Lake followed protocols set forth in the Site Specific Project Plan (SSPP) in Appendix B. Historical water quality monitoring data was used for determining the median phosphorus values and the assimilative capacity of both lakes (as well as trends in several additional key water quality parameters, including water clarity, chlorophyll-a, color, and dissolved oxygen), and for determining the phosphorus water quality goal for each lake. The analysis (FBE, 2012c) includes a comparison of historical (2001 and earlier) and recent (2002-2011) total phosphorus monitoring results, and a seasonal analysis (samples collected between May 15 and September 30), as well as a summary of available data and sources of this data (Table 3.5).

Grab Samples *are water samples taken just below the surface, or with a depth sampler collected at a specified depth or location in the water column.*

Epilimnetic Core (EC) samples *represent a vertical sample of the water column obtained within the lake's epilimnion using flexible plastic tubing, usually ½ inch in diameter. The tubing is lowered to a desired depth, clamped at the water's surface, raised, and decanted into a collection jug. This integrated sample is tested for multiple water quality parameters.*

Water quality data from multiple sources were combined into a common spreadsheet for each waterbody and then sorted by date and station for Quality Assurance/Quality Control (QA/QC) in order to avoid duplicating data sets. All duplicates were removed. An initial analysis was conducted to determine median total phosphorus (TP) based on all samples regardless of whether they were ***grab or epilimnetic core (EC) samples***. Minimum, maximum, and median TP values were determined for each station on both lakes, and were sorted by depth of sample (epilimnetic core samples vs. grab samples from the epilimnion, metalimnion, and hypolimnion). Data were further refined using only EC data to calculate the median TP concentration.

The seasonal (May 15- Sept 30), median EC value represents the 'Existing Median Water Quality' applied to the NHDES Assimilative Capacity Analysis for determining if a waterbody is Impaired, Tier 1 or Tier 2. See Figure 3-1 in the 2012 Consolidated Assessment and Listing Methodology for a conceptual diagram of Tier 1 and Tier 2 waters. Similar methodology was used to calculate average Chlorophyll-a, Secchi disk transparency (SDT), and color.

Table 3.5. *Available water quality data for Lake Wentworth and Crescent Lake.*

Data Source	Agency/Org	Lake Wentworth		Crescent Lake	
		Years Sampled	# Years Sampled	Years Sampled	# Years Sampled
Trophic Reports & Surveys	NHDES	1975, 1978, 1988, 1989, 2006, 2007	6	1984, 2002	2
VLAP	NHDES	1984 - 1997	14	NA	NA
CFB/LLMP	UNH	1994 - 2011	18	1984, 1986 - 2011	27

Water quality monitoring data for Lake Wentworth has been collected since 1975. This includes 29 years of Secchi disk transparencies, 26 years of phosphorus data (including 19 years of epicore samples), 29 years of chlorophyll-a data, 22 years of color data, and seven years of dissolved oxygen profiles. Water quality data has been collected at three in-lake locations known as Fuller's (Station 1-deep hole), Governor's (Station 12), and Trigg's (Station 2), as well as at the Smith River where Lake Wentworth flows into Crescent Lake (refer to Appendix C for monitoring stations map).

Water quality monitoring data for Crescent Lake has been collected since 1984. This includes 27 years of Secchi disk transparencies, 22 years of phosphorus data, 27 years of chlorophyll-a, data 25 years of color data, and 7 years of dissolved oxygen profiles. Water quality data has been collected at one in-lake location known as Center (Station 1 – deep hole).

NHDES calculates ***Trophic State Index (TSI)*** from summer bottom dissolved oxygen, summer Secchi disk transparency (SDT), aquatic vascular plant abundance, and summer epilimnetic Chlorophyll-a. This trophic classification system also accounts for lake stratification. Stratified lakes with TSI values greater than 6 may support algal blooms (for unstratified lakes this value is 4), while TSI values over 12 indicate extreme productivity and annual algae blooms (for unstratified lakes this value is 9).

NHDES's most recent (2006) trophic state index (TSI) determination numerically scored the trophic state of Lake Wentworth as 4 (Oligotrophic). NHDES considers the water quality of Lake Wentworth to be high based on measures of SDT, aquatic plant abundance, and chlorophyll-a (Chl-a). The potential for nuisance algal blooms on Lake Wentworth is therefore low. However, NHDES has listed Lake

TSI Index

Stratified Lakes (Lake Wentworth)
TSI > 6 *may support algal blooms*
TSI > 12 *indicates extreme productivity & annual algal blooms.*

Unstratified Lakes (Crescent Lake)
TSI > 4 *may support algal blooms*
TSI > 9 *indicates extreme productivity & annual algal blooms.*

Wentworth as impaired due to low pH (less than the minimum standard of 6.5), low dissolved oxygen, and presence of exotic milfoil (variable milfoil) in the bays near Heath, Hersey, and Willey Brooks.

The NHDES's most recent (2002) trophic state index (TSI) determination numerically ranked the trophic state of Crescent Lake as 3 (Oligotrophic). NHDES considers the water quality of Crescent Lake to be high based on measures of SDT, aquatic plant abundance, and chlorophyll-a (Chl-a). The potential for nuisance algal blooms on Crescent Lake is therefore low. However, the presence of exotic milfoil (variable milfoil), first found in Crescent Lake at Mast Landing in 1980, continues to plague this lake. Herbicides have been used in combination with hand-pulling to help control this species.

3.2.2 Water Chemistry Assessment

Existing and future development pose a major threat to water quality as stormwater runoff exports excess sediment and nutrients to streams and lakes in the watershed. A water quality assessment is a key component to assessing the health of a lake and determining impacts from watershed activities. The water quality analysis for Lake Wentworth and Crescent 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***.

> ***Dissolved Oxygen (DO)*** *is a measure of the amount of oxygen dissolved in water. Most living organisms need oxygen to survive. Low oxygen can directly kill or stress organisms and release phosphorus from bottom sediments.*
>
> ***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 Chloropatinate Units (CPU). Naturally colored lakes with > 25 CPU may exhibit reduced transparency.*

A full analysis of water quality parameters for Lake Wentworth and Crescent Lake can be found in the Lake Wentworth and Crescent Lake Water Quality Report (FBE, 2012c). A brief summary of water quality, particularly for the deep holes of Lake Wentworth (Station 1 – Fuller's) and Crescent Lake (Station 6 – Center), is provided here. Water clarity (measured using Secchi disk transparency) ranged from 3.7 to 9.5 m, with an average of 6.7 m at Fuller's in Lake Wentworth (Figure 3.1). Governor's and Trigg's, follow similar trends.

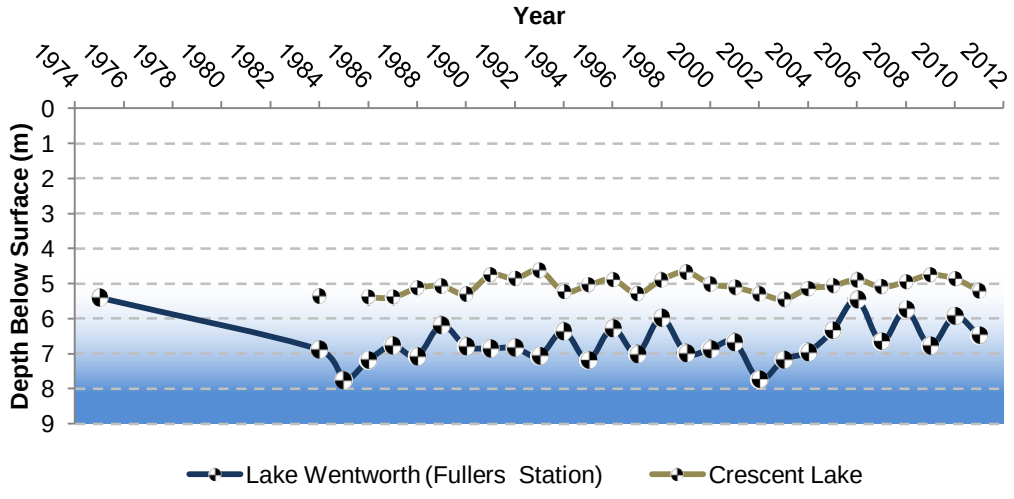


Figure 3.1. *Summary of water clarity for Lake Wentworth and Crescent Lake.*

Between 1991 and 2011, epilimnetic TP ranged from 3.2 to 11.5 ppb, with a median of 6.5 ppb at Station 1 – Fuller's. Median TP for Station 12 – Governor's (1994-2011) and Station 2 – Trigg's (1995-2011) is slightly less at 6.2 ppb. When comparing historical (1991-2001) to recent (2002-2011) analyses, median TP has increased slightly (0.3 ppb) at Station 1 – Fuller's. In contrast, Station 12 – Governor's and Station 2 – Trigg's have decreased in median TP by 0.3 ppb and 0.5 ppb, respectively. Maximum TP results have also decreased, while minimum TP values for all three stations have increased by 1 ppb (Table 3.6). However, it should be noted that differences in UNH and NHDES sampling methodology may have an impact on the apparent trends. Of particular note, TP grab samples collected at the outlet of Lake Wentworth at the Smith River (Whitten Neck) monitoring station indicate that this station has one of the highest median TP values at 7.6 ppb. Station 6 – Crescent Lake (1986-2011) ranged from 1.1 to 20.7 ppb with a median of 7.6 ppb. When comparing the historical (1986-2001) to recent (2002-2011) analyses, median TP has increased by 1 ppb in Crescent Lake. These results, coupled with the increasing annual TP trend, indicate that TP is increasing in Crescent Lake over time.

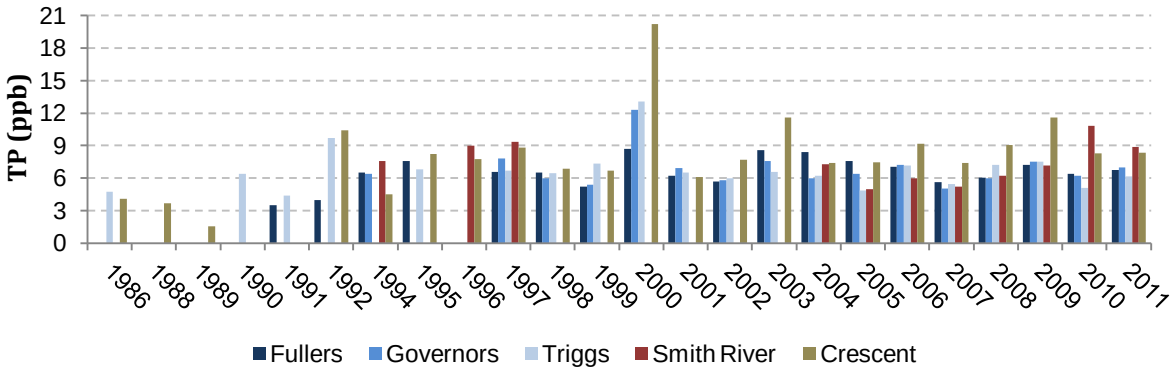


Figure 3.2. *Median annual (seasonal), epilimnetic total phosphorus (TP) results for all lake monitoring stations in Lake Wentworth and Crescent Lake, including the Smith River outlet, from 1986-2011.*

Chl-a ranged from 0.4 to 12.6 ppb with an annual average of 1.9 ppb at Station 1 – Fuller's. Chl-a ranged from 0.5 to 19.4 ppb with an annual average of 2.3 ppb at Station 6 – Crescent. As shown in Table 3.6, Station 1 – Fuller's and Station 2 – Trigg's show an increase in Chl-a over time. Overall, Chl-a levels seem to be relatively stable in Lake Wentworth and Crescent Lake, typically falling below 3.3 ppb.

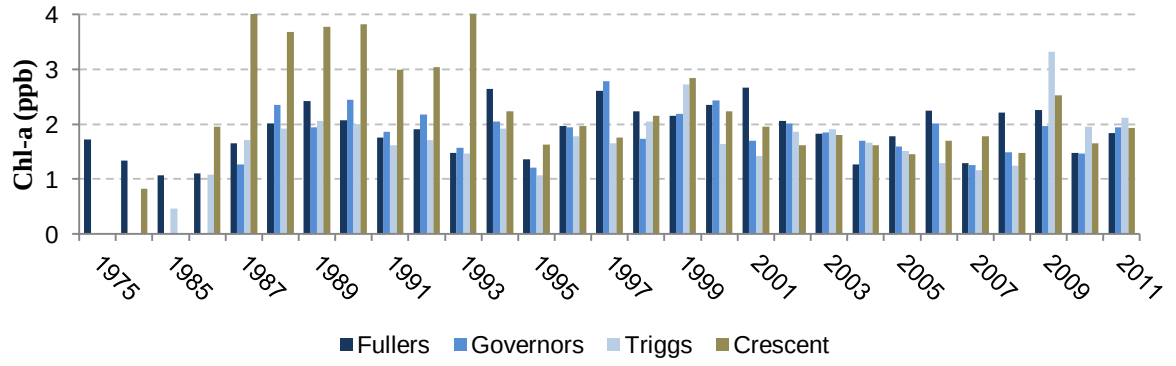


Figure 3.3. *Mean annual (seasonal) chlorophyll-a (Chl-a) results for all lake monitoring stations in Lake Wentworth and Crescent Lake from 1975-2011.*

Historic profiles show DO depletion in deep areas of Lake Wentworth (Station 1 – Fuller's), beginning in late July through early October. Anoxia is a concern because it can release phosphorus bound to sediments (internal P loading) to the water column, thereby making more phosphorus available to algae. However, a 2011 study by the NHDES Clean Lakes Program indicated that the lake did not experience significant internal loading during the 2011 summer season (Andy Chapman, personal communication).

In addition, oxygen levels below 5 ppm stress certain cold water fish, and a persistent loss of oxygen may eliminate or reduce habitat for sensitive cold water species. Profiles also show temperature stratification during the summer months. Formation of the metalimnion has generally occurred between 5 and 10 meters below the surface (see FBE, 2012c). DO profiles for Station 6 – Crescent show very little stratification and no DO depletion. Consequently, the potential for TP release from bottom sediments (internal loading) is low in Crescent Lake.

Station 1 – Fuller's shows declining trends for four of the major water quality parameters (SDT, Chl-a, color, and TP). However, historical trends indicate that the decline may be gradual and therefore, not cause for immediate alarm. The deep holes of both Lake Wentworth (Station 1) and Crescent Lake (Station 6) show declining trends, in that total phosphorus has increased at both stations in the past ten years (2002-2011). The result is most pronounced at Crescent Lake, where the TP increase is more than 1 ppb (Table 3.6).

Table 3.6. *Summary of water quality parameters for lake monitoring stations.*

Lake	Station	Mean Annual Secchi (m)	Mean Annual Chl-a (ppb)	Mean Annual Color (CPU)	Median TP (ppb)	Historical (1991-2001) Median TP (ppb)	Recent (2002-2011) Median TP (ppb)
Lake Wentworth	1 - Fuller's	*6.7	*1.9	*13.9	6.5	6.4	*6.7
Lake Wentworth	12 - Governor's	*6.8	1.9	14.8	6.2	6.5	6.2
Lake Wentworth	2 - Trigg's	6.8	*1.7	14.8	6.2	6.6	6.1
Lake Wentworth	1 & 12 Combined	na	na	na	na	6.5	*6.7
Crescent Lake	6 - Crescent	5.1	2.3	15.8	7.6	6.8	*7.9

**Indicates trend toward declining water quality over time (2002-2011).*

These trends will only be exacerbated by increasing population and resulting future development in the watershed. Proactive measures should be taken to mitigate these declining trends by maintaining or improving water quality through established water quality goals, as described in the following section.

In addition to the water quality parameters discussed above, the Lake Wentworth Foundation (LWF) was tasked with executing a series of conductivity readings around Lake Wentworth and Crescent Lake, as part of the High Quality Waters Assistance Grant. Unusual spikes in conductivity readings can be a sign of failing septic systems or intensive road salting. LWF volunteers, Rich Masse and Jack O'Connell used a YSI 85 conductivity meter, collecting conductivity readings along the shoreline with the sensor just below the surface 5-15 feet from shore. Testing for Lake Wentworth was conducted on 8/22/2011 and 8/27/2012 and readings averaged 50 µS/cm. Testing for Crescent Lake was conducted on 8/28/2012 and readings averaged 15% higher than Lake Wentworth at 57 µS/cm. Minor spikes were observed at the mouths of Harvey, Hersey, Fernald, and Willey Brooks, ranging from 78 to 108 µS/cm. While the

readings may be inconclusive as to whether septic systems and road salt are having an impact on Lake Wentworth and Crescent Lake water quality, they do indicate that NPS pollution is impacting the lakes.

3.2.3 Assimilative Capacity Analysis and Lakes Loading Response Modeling

As stated previously, 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 water quality in Lake Wentworth and Crescent Lake. The median total phosphorus concentration from each lake (by station) was used to calculate the total, reserve, and remaining assimilative capacity for each lake using procedures described in the Standard Operating Procedures for Assimilative Capacity Analysis for New Hampshire Waters (Table 3.7; NHDES, 2008). Tier 2 waters, or high quality waterbodies, have one or more water quality parameters that exceed the water quality standard and that also exhibit a reserve capacity of at least 10% of the waterbody's total assimilative capacity. Tier 2 waters have some assimilative capacity remaining, whereas Tier 1 and Impaired Waters do not.

Table 3.7. *Assimilative capacity analysis results for Lake Wentworth and Crescent Lake.*

Lake	WQ Monitoring Station	Existing Median TP (ppb)	TP WQ Threshold (ppb)	AC Threshold (ppb)	Remaining AC (ppb)*	Analysis Results	Impaired (Y/N)
Lake Wentworth	Station 1 - Fuller's	6.7	8.0	7.2	0.5	Tier 2	N
Crescent Lake	Station 1 - Center	7.9	8.0	7.2	-0.7	Tier 1	N

The Assimilative Capacity Analysis for Lake Wentworth demonstrates that Lake Wentworth is a ***Tier 2 or High Quality Water*** because the existing median water quality value for total phosphorus is 6.7 ppb with 0.5 ppb remaining assimilative capacity. These results are based on the results of the water quality analysis for Station 1(Fuller's), the deepest location in the lake. A similar analysis was conducted for the other two stations (Governor's and Trigg's) which exhibited even higher remaining assimilative capacity's (1.0 ppb for both stations) than at Fuller's. The Assimilative Capacity Analysis for Crescent Lake classifies the waterbody as ***Tier 1***, since the remaining assimilative capacity falls within the reserve capacity. Lakes with no remaining assimilative capacity or reserve capacity may be considered ***impaired***. Based on these thresholds, Crescent Lake is not considered "High Quality Water." Acceptable TP increase was set to zero for both lakes (see Section 3.2.4 for rationale).

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 Lake Wentworth and Crescent 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

Tier 2 or High Quality Waters *exhibit water quality that is better than the standard + reserve capacity.*

Tier 1 *waters exhibit water quality that is better than the standard but is within the reserve capacity.*

Impaired *waters exhibit water quality that is worse than the standard, has no remaining assimilative capacity, and is not within the reserve.*

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.

As shown in Table 3.8, the results of this model indicate that the greatest phosphorus load comes from watershed runoff, which accounts for 65% of the total loading for Lake Wentworth and 70% for Crescent Lake. Atmospheric deposition to the lakes account for about one-fifth of the P loading, septic systems account for less than 10%, and waterfowl are assigned just 2% of the P entering Lake Wentworth and 1% in Crescent Lake. Internal loading was set at zero in the model but may contribute about 1% in some years due to anoxic zones.

Table 3.8. *Total phosphorus and water loading summary for Lake Wentworth and Crescent Lake.*

Loads to Lake Wentworth	**TP** *(kg/year)*	**TP** *(%)*	**Water** *(m^3/year)*	**Water** *(%)*
Atmospheric Deposition	244	25%	7,664,541	14%
Internal Loading	0	0%	NA	NA
Waterfowl	20	2%	NA	NA
Septic Systems	79	8%	67,009	>0.2%
Watershed Runoff	643	65%	46,728,516	86%
Total Load To Lake Wentworth	**986**	**100%**	**54,460,066**	**100%**

Loads to Crescent Lake	**TP** *(kg/year)*	**TP** *(%)*	**Water** *(m^3/year)*	**Water** *(%)*
Atmospheric Deposition	12	2%	373,066	1%
Internal Loading	0	0%	0	0%
Waterfowl	4	1%	0	0%
Septic Systems	13	3%	11,185	0%
Load From Lake Wentworth via Smith River Inflow	365	71%	54,461,988	96%
Watershed Runoff (Crescent Lake)	124	24%	1,903,818	3%
Total Load To Crescent Lake	**517**	**100%**	**56,750,056**	**100%**

The model estimates that 76% of the water load to Lake Wentworth comes from tributaries and 56% of P loading comes from the upper watershed via tributaries. Consequently, examining the P concentration and attenuation factors for each contributing tributary to Lake Wentworth is important for nutrient management. Based on high P concentrations and low attenuation, the model determined that the following streams should be considered for future pollution reductions: Whitton Brook, Breezy Brook, Townsend East, Shoreline and Islands, and Townsend West.

Approximately 96% of the water load entering Crescent Lake comes directly from Lake Wentworth via the Smith River along with 71% of the P load. The model estimated that 2.9 times more P enters Crescent Lake from Lake Wentworth than from the direct Crescent Lake watershed. However, the high flushing

rate (31 times per year) that Crescent Lake experiences leaves it less susceptible to watershed nutrient loading, despite its more intense development and nutrient loading per acre compared to Lake Wentworth.

A more detailed discussion of watershed modeling results can be found in the Lake Wentworth and Crescent Lake Nutrient Modeling Report (FBE, 2012a) with a breakdown of loading by subwatershed in Appendix D.

3.2.4 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 of each waterbody is greater than the reserve assimilative capacity. In the event that the median total phosphorus value was greater than the reserve assimilative capacity (e.g. Lake Wentworth -Tier 2), then the water quality goal was based on a comparison between the current median TP value and the historic water quality data with consideration to the TP loading to the downstream waterbody. If the median water quality values fell within the reserve capacity (e.g. Crescent Lake- Tier 1), then the water quality goal was based on historical water quality and potential reductions needed to achieve high quality water designation.

The over-arching goal for the watershed is to improve water quality conditions to achieve Tier 2 designation for both Lake Wentworth and Crescent Lake and to protect the lakes from future, unaccounted-for inputs of TP from new development in the watershed over the next 10-20 years. This means reducing the TP concentration in Crescent Lake by a minimum of 0.8 ppb to reach 7.2 ppb, so that the lake would meet the Tier 2- High Quality Water designation. Because 71% of the TP load in Crescent Lake comes from the water flowing in from Lake Wentworth, minimum reductions on the order of 0.5 ppb were needed in Lake Wentworth to reduce the TP load delivered to Crescent Lake.

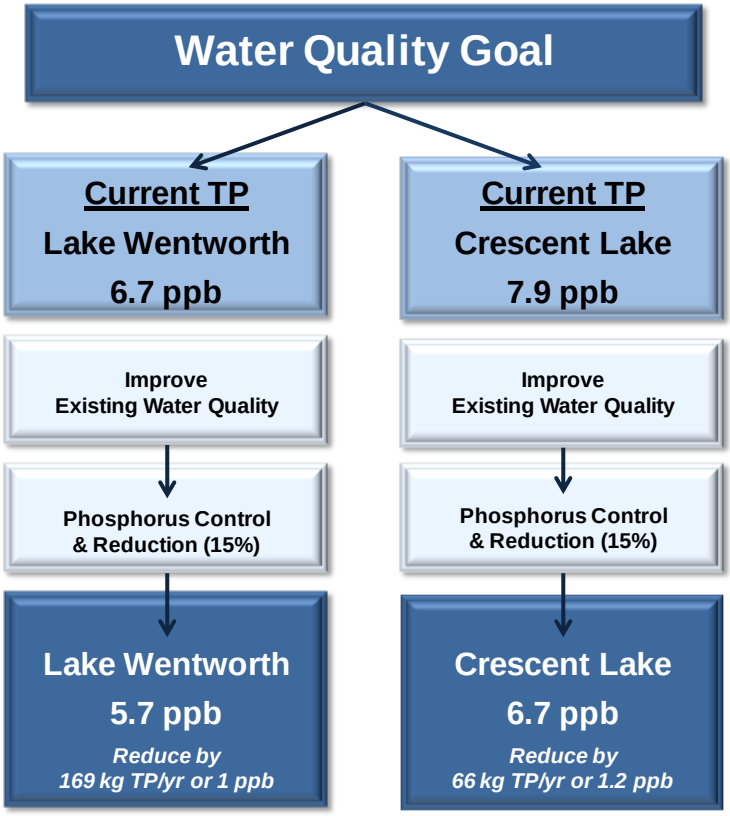


Figure 3.4. *Water quality goal diagram for Lake Wentworth and Crescent Lake.*

In August 2012, the Lake Wentworth Watershed Steering Committee set a water quality goal that would reduce current in-lake phosphorus by 15% in both Lake Wentworth and Crescent Lake. Although Lake Wentworth is currently within acceptable in-lake median P capacity levels, discharge from Lake Wentworth accounts for 96% of incoming water (and thus, sediment-bound nutrients) and 71% of incoming P loading to Crescent Lake. Consequently, Crescent Lake median P concentrations can be improved only through a reduction in

median TP concentrations in Lake Wentworth. The large projected increase in phosphorus from the buildout analysis indicates that new development in the Lake Wentworth/Crescent Lake watershed needs to be carefully managed to reach this goal. The subcommittee agreed that the conservative target of 15% would account for an additional 0.5 ppb increase in TP from new development in the watershed in the next 10-20 years. The Town of Wolfeboro should focus efforts to implement Low Impact Development (LID) techniques for future development as well as to install BMPs that address existing sources of phosphorus throughout the watershed. These goals will be discussed further in Section 5.2.

3.3 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 seasonal blue-green algal 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.

Municipal ordinances are just one tool that can be designed and implemented to protect lake water quality from the effects of watershed development. (Photo: FB Environmental)

FB Environmental (FBE) conducted a Municipal Ordinance Review as a supplement to this plan, reviewing the Town of Wolfeboro's existing and proposed land use and zoning regulations. Benchmark standards were analyzed for ordinances relating to shorefront protection, wetlands, riparian buffers, stormwater runoff, sediment and erosion control, subdivisions, low impact development (LID), and septic systems.

The review suggests that the watershed communities of Lake Wentworth and Crescent Lake have considerable room for improvement in order to protect water quality in the future. The primary areas where changes to ordinances should be considered are: stormwater runoff, erosion and sediment control, and LID. Specific suggestions for new or revised ordinances include:

1) Wetland Conservation Overlay District Ordinance – approve proposed changes and consider extending wetlands setback to 100 feet for very poorly drained soils.
2) Steep Slope Ordinance – consider requiring pre and post-construction BMPs for areas with greater than 15% slope.
3) Stormwater Management Ordinance – consider mandating BMP installation for construction site runoff regulation, establishing pollutant reduction goals for post-construction sites, and restricting impervious cover on lots.
4) Septic System Ordinance [2]– consider requiring routine maintenance and inspection of septic systems within 150 feet of a waterbody and 100 feet of a wetland.

[2] There is currently only one town in New Hampshire with a septic system inspection ordinance in Place (Town of Meredith, 2012). This is largely due to lack of local authority to enforce septic ordinances. Alternatively, a septic system management plan could be developed and include landowner incentives for regular pumping.

5) Road Ordinance – consider requiring more stringent drainage standards and long-term erosion control using LID techniques, especially for private roads and subdivisions.

In addition, the ordinance review recommended incorporation of specific language pertaining to erosion and sediment control, riparian buffers, and conservation subdivisions. The review also suggested mandating a 75-foot setback, enhancing buffers where applicable, and restricting impervious cover to a maximum of 20% per lot. These concepts have been recommended for the Center Street Rezoning effort. For more specific details relating to recommended municipal ordinances, refer to the Action Plan in Section 5.2.

3.4 FUTURE LAND USE PROJECTIONS: BUILD-OUT ANALYSIS

A Buildout Analysis was conducted by FB Environmental for the Lake Wentworth and Crescent 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 (Figure 3.5). The analysis determined that 44% of the watershed (9,802 acres) is buildable and can house up to 2,264 more buildings (a 98% increase from current conditions); most of the new development would be contained in the Residential-Agriculture and Rural Residential zones (Figure 3.6).

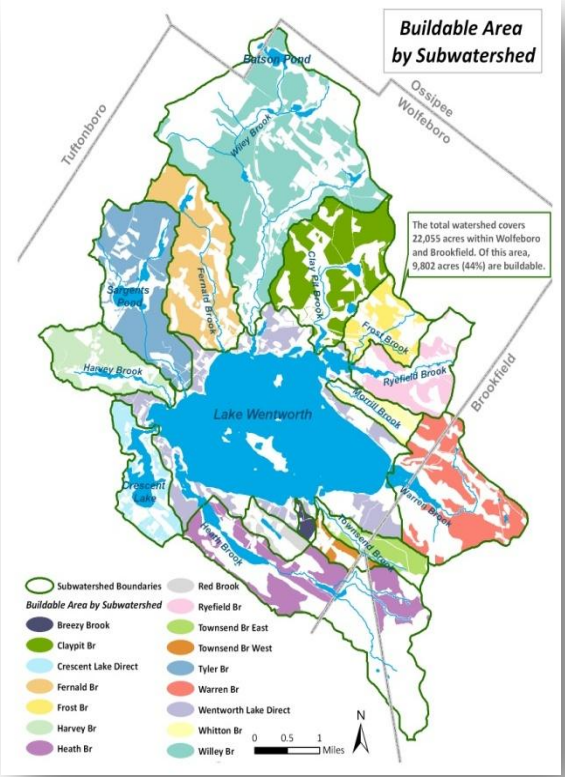


Figure 3.5: *Map of buildable area by sub-watershed (see Appendix C for larger map).*

At the rate of population growth that Wolfeboro experienced from 1990 to 2010, full buildout could occur as early as 2043, while full buildout is projected to occur in Brookfield by 2110. Full buildout refers to the time and circumstances in which, based on a set of restrictions (e.g. environmental constraints and current zoning), no more building growth can occur, or the point at which lots have been subdivided to the minimum size allowed. A conservative annual growth rate of 2% was used for estimating buildout scenarios for Wolfeboro, although, it is likely that this rate of growth will be variable each year, with a chance that it will increase on an annual basis. It is recommended that town officials recognize this population pressure in future watershed management planning.

Within the next 20 years, in-lake concentrations of phosphorus could be as high as 9.6 and 11.1 ppb in Lake Wentworth and Crescent Lake, respectively, based on 2012 zoning standards.

Results of this analysis reinforce the concept of comprehensive planning at the watershed level in order to address future development and its effect on the water quality of the region. Phosphorus load analyses were conducted for two scenarios based on the year 2032 (20-year buildout) at 3,440 watershed buildings and on the year 2110 (full buildout) at 4,580 watershed buildings. A 20-year buildout would result in a 41% increase in P loading to Lake Wentworth and a 44% increase to Crescent Lake. At full buildout, it's estimated that there would be a 93% increase in P loading to Lake Wentworth and an 84% increase to Crescent Lake. The LLRM estimates that, within 20 years, in-lake concentrations of P could be as high as 9.6 ppb in Lake Wentworth and 11.1 ppb in Crescent Lake. Note that these predicted phosphorus levels do not include the potential for internal phosphorus loading, which could result in further declines in water quality. These increases exceed the standards set by NHDES for oligotrophic lakes (currently 8 ppb). At full buildout, in-lake concentrations of P could increase to 13 ppb in Lake Wentworth. Based on conservative population growth trends and current zoning regulations, Lake Wentworth and Crescent Lake are at risk for impairment listing within the next 20 years.

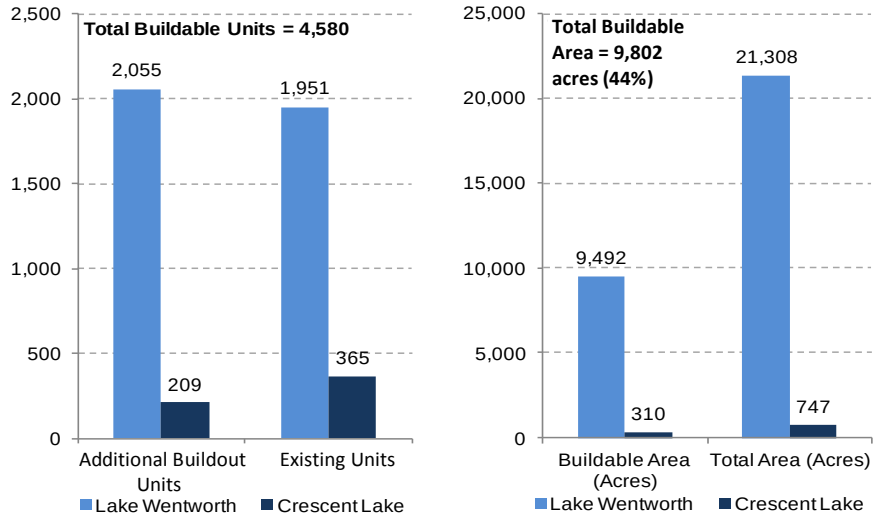


Figure 3.6: *Summary of buildout analysis results.*

3.5 WATERSHED SEPTIC SYSTEM SURVEY ASSESSMENT

Understanding the role of septic systems in maintaining water quality is important because a failing septic system can be detrimental to human health, aquatic life, and water resources. A poorly designed, installed, or maintained septic system has the potential to contribute excessive phosphorus to lakes and streams via groundwater. Excess phosphorus stimulates plant growth in lakes, which can result in algal blooms that are eventually consumed by decomposers, leaving an oxygen-stressed environment for fish and other aquatic species.

The door-to-door septic survey in 2011 resulted in a 54% response rate from shoreline residents in the Lake Wentworth/Crescent Lake watershed. (Photo: FB Environmental)

In August and September of 2011, FB Environmental (FBE) conducted a watershed survey in coordination with Comprehensive Environmental, Inc. (CEI), with guidance from

the Lake Wentworth/Crescent Lake Watershed Plan Steering Committee and assistance from 21 resident volunteers. Properties within 250 feet of all streams, ponds, and lakes in the watershed were identified and mapped using available Geographic Information Systems (GIS) shapefiles. Of the 625 total properties within the shorezone, 552 properties had willing participants regularly using the property. Information on current septic system practices was gathered from each of these properties during a door-to-door survey. The questionnaire included information about type of system, age of system, pumping frequency, property use (year round or seasonal), number of occupants, distance to the waterbody and types of water-using machines in use (Figure 3.7). Of the 552 properties, 296 septic surveys were completed, resulting in a 54% survey success rate. Results indicate that there are a number of septic systems in the watershed that need attention and, unknowingly, may be contributing excess phosphorus to a nearby stream or lake.

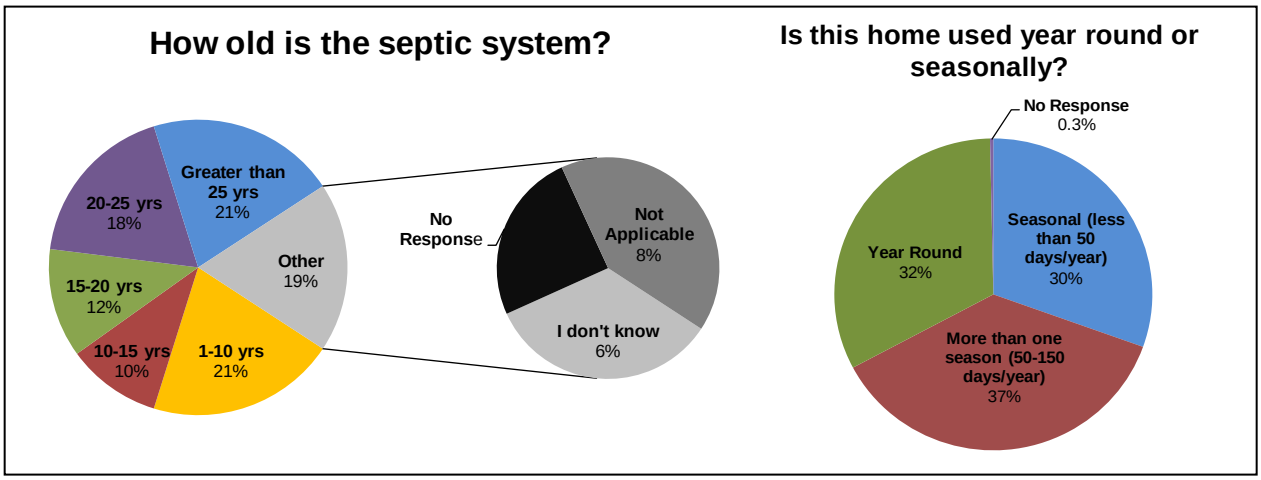


Figure 3.7: *Examples of results from the 2011 septic survey for Lake Wentworth and Crescent Lake.*

Results of the septic survey were used to estimate total phosphorus loading to the lakes from septic systems in the shorezone using septic system loading models. According to these models, the lakes could be receiving between 92 kg P per year to 180 kg P per year from septic systems. By addressing concerns identified with older systems, systems within 50 feet of the shoreline, and systems that are rarely pumped out, watershed stakeholders can work to help alleviate these nutrient loadings to the lake.

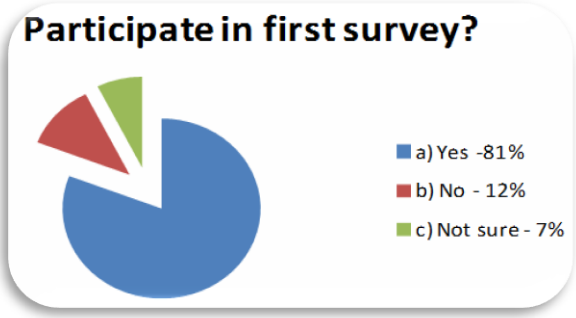
Recommendations from the 2011 Septic Survey include:

1) Prioritize outreach activities to target older systems (39% of those surveyed), septic systems within 50 feet of the shorefront (6%), and landowners who rarely, if ever, pump their systems (3%).
2) Educate residents on proper septic system maintenance (every 2-3 years for year-round residents; 4-5 years for seasonal).
3) Develop a septic system management plan and/or septic system pump-out schedule/record for the Town of Wolfeboro.

A more detailed discussion of results and recommendations can be found in the Septic and Stormwater Survey Report (FBE, 2011).

Following on the successful door-to-door canvass of shoreline and other properties conducted in August 2011, watershed plan organizers sent out a follow-up survey in the late summer of 2012. The intention

was to determine how effective education and outreach activities had been over the course of the watershed project. Questionnaires consisting of 17 questions were distributed by Lake Wentworth Association volunteers to several hundred households, while property owners living along tributaries to Lake Wentworth were mailed postcards pointing them to an online version of the survey. About 10% (68) of the forms were filled out, either on paper or online.



Eighty-one percent of property owners surveyed in 2012 had participated in the 2011 septic and stormwater survey. Property owners showed a good understanding of water quality issues in the follow-up survey (Source: Rich Masse, LWF).

A fair amount of the data from the limited follow-up survey seems to indicate that, on some issues, watershed residents have an appreciable understanding of water quality issues. For example, they know the role of phosphorus in deteriorating water quality, and they appreciate the need to maintain their septic systems. On the other hand, some seem to have a limited understanding of the role of native plants in protecting shorelines, and a significant number are vague on the nature of the threat from invasive species. The challenge for the lake organizations and the town is to translate goodwill into action, particularly in terms of mitigating stormwater runoff and maintaining septic systems.

3.6 WATERSHED STORMWATER SURVEY ASSESSMENT

During large precipitation events in forested areas, it is natural for approximately 10% of rain or snowmelt to flow as runoff. In developed areas, however, runoff volumes increase five-fold due to impervious surfaces, including packed dirt or paved roads, parking lots, and rooftops. Stormwater pollutants can have negative consequences for fish and wildlife, native vegetation, public drinking water sites, and public recreational water usage. Landowners, municipal officials, and developers should consider alternatives such as low impact development (LID) for mitigating impacts from any new development. Stormwater retrofits (BMPs) can be utilized for existing development where stormwater issues are prevalent.

The 2011 stormwater survey identified 108 sites where stormwater improvements are needed within 250 ft. of the shoreline. (Photo: FB Environmental)

In conjunction with the septic survey described above, a stormwater survey was also conducted to document sources of pollution on residential sites within the 250-foot shorezone. 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. Of the 625 properties within the shorezone, 481 parcels were surveyed for stormwater issues and 106 of those parcels

had observed stormwater issues. There were 13 artificially created beaches documented with stormwater issues, but that is only a fraction of the total number of artificial beaches found within the watershed. 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, and 11% of identified sites were assessed as having a high impact on water quality. Commonly observed problems stemmed from surface erosion, bare soil, and lack of shoreline vegetation (Figure 3.8).

Stormwater surveys were sent to Comprehensive Environmental (CEI) for follow-up site visits and priority evaluations for BMP implementation. CEI conducted pollutant source evaluations at over 50 road crossings and several commercial areas with particular focus on high priority sites identified by FBE.

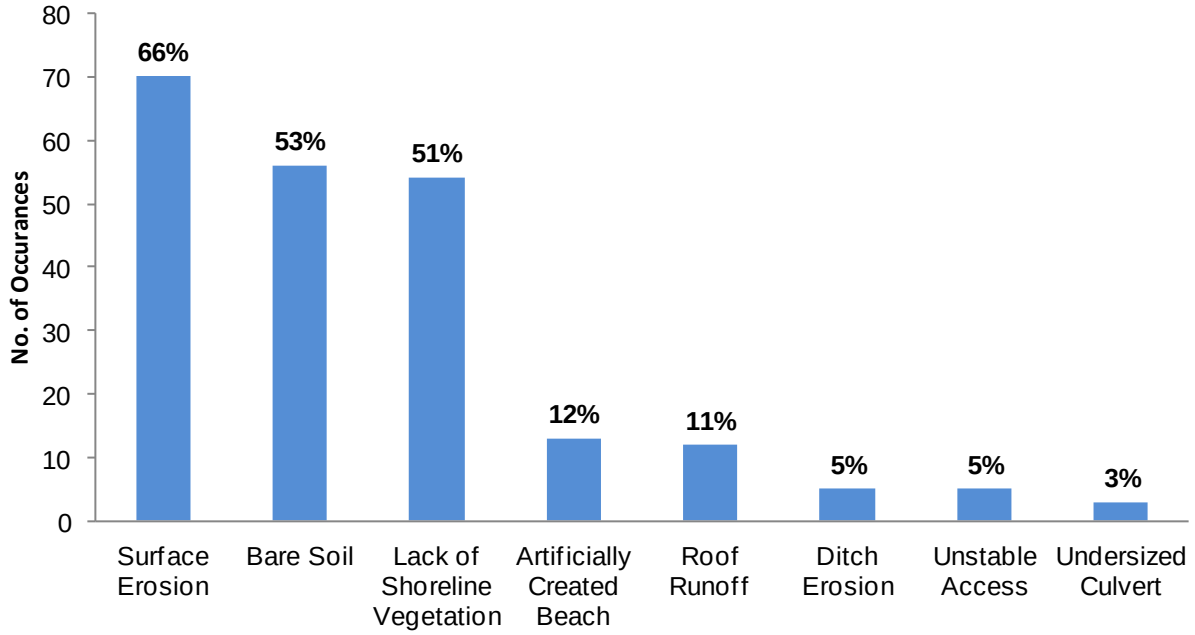


Figure 3.8: *Frequency and percentage of polluted runoff problems by type.*

Additional information was provided by the watershed plan steering committee members and Town of Wolfeboro officials. A two-phase ranking system was applied to the 108 NPS sites identified (2 sites were added after the initial FBE survey), with prioritization of the top 30 sites for BMP implementation. Of those 30 sites, four were eventually selected for development of conceptual design and cost estimates.

BMPs for the top four sites emerging from the ranking process would treat approximately 29 acres of the watershed, preventing approximately 16.6 kg of phosphorus per year from entering Lake Wentworth and Crescent Lake. It will cost an estimated $5,500 per acre of treated area, and approximately $19,000 per kg of phosphorus removed. The top four conceptualized BMPs will reduce the total phosphorus loading to Lake Wentworth by 16 kg/year (see Section 4.2).

A list of the total 108 sites, the top 30 priority sites by waterbody, and the top six priority sites identified in the Stormwater/NPS surveys in 2011 by FBE and CEI are provided in Appendix E. Conceptual designs and stormwater design plans for the top four priority sites are provided in Appendix F and G.

Since phosphorus is often attached to soil particles, erosion serves as a fertilizer for lakes. Implementing erosion control and stormwater runoff control improvements at these sites will require efforts by individual property owners, the Lake Wentworth Foundation, road associations, and municipal officials.

Recommendations from the 2011 Stormwater Survey include:

1) Track erosion sites as they are identified for BMP installation.
2) Organize educational workshops for residents to start fixing identified erosion problems on their properties.
3) Enforce shoreland zoning and establish watershed protection ordinances, including LID, buffer, steep slope, and sediment and erosion control.

A more detailed discussion of results and recommendations can be found in Appendix E, and including a BMP Ranking Map (Appendix E.5) and the Septic and Stormwater Survey Report (FBE, 2011).

4. MANAGEMENT STRATEGIES

4.1 GOALS FOR LONG-TERM PROTECTION

The ultimate vision of the Lake Wentworth/Crescent Lake Watershed Management Plan is to protect critical watershed characteristics sufficiently to maintain or improve current water quality status. This ambitious effort is supported by the idea that existing and new development can be conducted in a manner that sustains environmental values, and that citizens, businesses, government, and other stakeholder groups can be responsible stewards of the Lake Wentworth and Crescent Lake watershed. The long-term goal is to protect the watershed and water quality of Lake Wentworth and Crescent Lake through a 15% reduction in median in-lake total phosphorus (TP). This target reduction in TP can be achieved through the following ***structural and non-structural*** objectives:

- Utilize the BMP matrix to identify, prioritize, and implement ***best management practices (BMPs)*** throughout the watershed to reduce sediment and phosphorus runoff from existing development (Sections 3.6 and 4.2).
- Educate landowners through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a waterbody, and rarely pumped out) (Section 3.5).
- Institute greater controls on new and re-development, require ***low-impact development (LID)*** in site plans, and incentivize regular septic system maintenance (Sections 3.3 and 3.5).
- Continue to conserve land through conservation easement purchases (Section 2.2.3).
- Continue and/or expand the water quality monitoring and aquatic invasive plant control programs (Section 3.2).

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

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.*

4.2 ADDRESSING NONPOINT SOURCE POLLUTION (NPS)

4.2.1 Structural NPS Restoration

FB Environmental Associates (FBE), Comprehensive Environmental, Inc (CEI) and local volunteers documented 108 sites that impact water quality directly through the delivery of phosphorus-laden sediment. Consequently, structural BMPs are a necessary and important component for the improvement and protection of water quality in Lake Wentworth and Crescent Lake. The best methods for treating these sites are to:

If not properly installed or maintained, perched beaches, like the one above, will add to the sediment and nutrient load to Lake Wentworth and Crescent Lake. (Photo: FB Environmental)

1) Address the highest priority sites with an emphasis on low-cost fixes. High impact sites were sent to CEI for follow-up field work, and a BMP priority matrix methodology was used to identify the top 30 sites for BMP implementation (Appendix E.3). Conceptual designs and cost estimates were generated for the top four sites (Appendix F).

2) Work with landowners to get commitments for treating and maintaining sites. Tours of demonstration sites and workshops can help encourage landowners to utilize BMPs on their own property.

3) Work with experienced professionals on sites that require a high technical level of knowledge (engineering) to install, and ensure proper functioning of the BMP.

4) Measure the pollutant load reduction for each BMP installed (see below).

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 Stormwater Survey Report (FBE, 2011), and Section 3.6 for continued discussion of BMP implementation strategies.

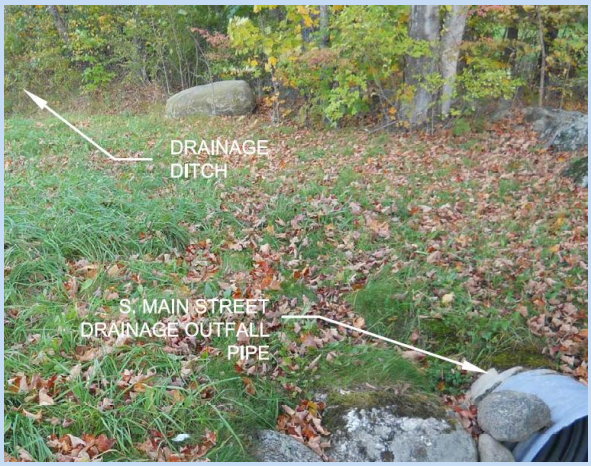
The top four BMP sites were identified using the BMP priority matrix methodology (Appendix E.1). These sites are described in greater detail in Appendix F, but a brief summary is provided below. In total, these four sites will treat 56.64 acres (including 27.85 acres of impervious cover) of land near or directly adjacent to Lake Wentworth and Crescent Lake (Table 4.1). CEI estimated a 68% removal rate (or 16.58 kg/yr) of annual total phosphorus (TP) and an 85% removal rate (or 45.96 kg/yr) of annual total suspended sediments (TSS) from the current estimated loading rates of TP and TSS from these sites. Approximately $315,000 would need to be raised in order to successfully implement these BMPs (see Section 5.4).

Site 1: Wentworth State Park

Stabilization and infiltration techniques are needed at this site to limit runoff from the parking lot to the public beach area. CEI suggests using erosion control fabrics, vegetative buffers, erosion control mulch, filter socks to protect bare soil, pervious pavement for lot and footpaths, rain gardens, and infiltration trenches. Some maintenance of the vegetation and sediment catchment cleaning will be needed.

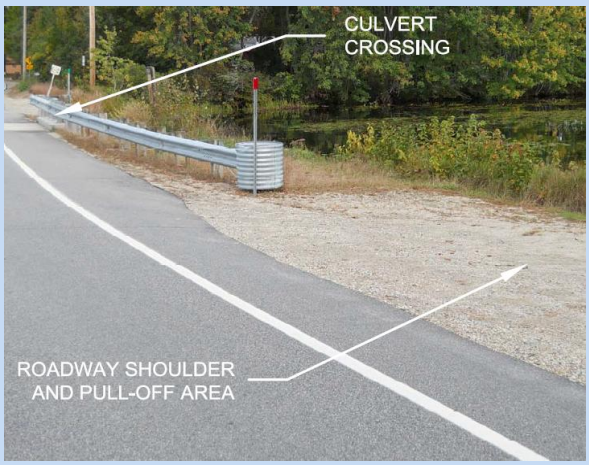
Site 2: South Main Street Drainage

Stabilization and infiltration techniques are needed at this site to limit runoff from the wooded area to Crescent Lake. CEI suggests using swales fitted with check dams, plunge pools, and erosion control, a forebay, a lined treatment pond, and gravel filters. Some maintenance of the vegetation and sediment catchment cleaning will be needed.



Site 3: Governor Wentworth Highway

Stabilization and infiltration techniques are needed at this site to limit runoff from the road to Lake Wentworth. CEI suggests using erosion controls and rip-rap to protect bare soil along the shoreline, as well as media filter strips, drainage swales, and plunge pools. Some maintenance of the vegetation and sediment/woody debris catchment cleaning will be needed.



Note: *Design details for the top four BMP sites and additional photos are located in Appendix E.*

Site 4: Camp Bernadette

Stabilization and infiltration techniques are needed at this site to limit runoff from the paved areas to the beach along Lake Wentworth. CEI suggests using erosion control fabrics, vegetative buffers, porous pavers, erosion control mulch, rain gardens, and infiltration trenches. Some maintenance of the vegetation and sediment catchment cleaning will be needed.

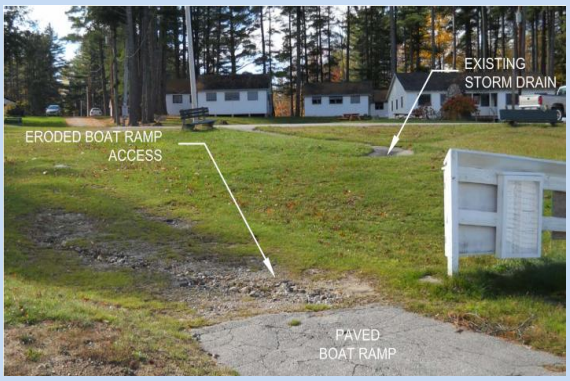


Table 4.1: *Summary of estimated cost and TP/TSS loading removal rates for top four BMP sites.*

Site	Site	Treated Area	Treated IC	Total Estimated Cost	Annual TP Load Removal		Annual TSS Load Removal	
#	Name	Acres	Acres	$USD	kg/yr	%	kg/yr	%
1	Wentworth State Park	5.70	0.86	$21,000	1.29	60%	9.82	90%
2	South Main Street Drainage	30.83	17.82	$205,000	10.68	55%	22.82	85%
3	Governor Wentworth Highway	5.33	2.86	$48,500	2.15	60%	7.94	90%
4	Camp Bernadette	14.78	6.31	$40,500	2.46	35%	5.38	40%
TOTAL		**56.64**	**27.85**	**$315,000**	**16.58**	**68%**	**45.96**	**85%**

BMP implementation at Albee Beach by LWF, Town of Wolfeboro, and Kingswood High School. (Photo: Rich Masse, LWF)

In an effort to provide guidance to residents on ways to mitigate runoff caused by stormwater and snowmelt, the LWF has already taken action in implementing BMPs in the watershed. In the spring of 2011, the LWF and the Town of Wolfeboro Parks and Recreation Department employed a team of nine students from the Region 9 Vocational/Technical Program at Kingswood High School to replace a failing erosion control structure on Albee Beach with native plants, including high bush blueberry, low bush blueberry, sweet fern, and silky dogwood. This site will serve to demonstrate appropriate BMP implementation that local landowners can use to control stormwater runoff and erosion from their own properties.

In 2012, the LWF began collaborating with the Kingswood Acres Condominium Association on Crescent Lake to install a rain garden intended to infiltrate runoff before it reaches the lake. The 1,000 square foot installation is located at the edge of a large waterside lawn area situated at the base of a long slope. The slope gathers significant volumes of water and deposits it on the lawn, which can, in very wet conditions, become spongy. Under extreme conditions, pooled water can begin to migrate from the lawn towards the

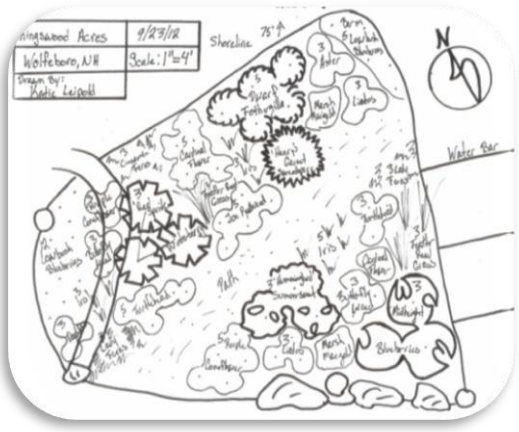


Illustration of the rain garden design for Kingswood Acres Condominium Assn. (Source: Rich Masse, LWF)

community's sand beach, resulting in erosion into the lake. The rain garden is expected to intercept runoff from some 12,500 square feet of property leading down to the lawn.

The design of the garden was created by landscaper Katie Leipold of Katie's Landscape Design. The actual installation work was carried out by students in Bruce Farr's agricultural science program from Kingswood Regional High School's vocational/technical program. The same group implemented the demonstration site at Albee Beach.

In preparation for installation of the garden, the turf covering the area was removed and a ten-foot diameter depression dug into the center to act as a sink for water entering the garden. A loam/compost mix was then laid. A number of native plants that are capable of thriving in wet environments were then installed.

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 surfaces. 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 can not only improve water quality but can also enhance watershed aesthetic (e.g. through shade tree planting, landscaping, and trash reduction), streamline the permitting process (e.g. by removing conflicting design or stormwater codes), and reduce development costs (e.g. by minimizing impervious area development).

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

1) Planning, design, and construction 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, it is critical for municipal staff and 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 Lake Wentworth watershed presents considerable opportunity for continued development (see Buildout Analysis or Section 3.4) and, by extension, increased threats to aquatic habitat and recreational use of the lakes. In watersheds with significant development potential (44% for Lake Wentworth watershed), the Center for Watershed Protection identifies BMP/LID implementation requirements for development projects 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:

1) Review current zoning ordinances for regulatory barriers and improvements (see Municipal Ordinance Review or Section 3.3).
2) Set performance based standards.
3) Take additional measures to reduce impervious surfaces.
4) Promote the use of specific LID designs.
5) Use overlay districts to add new requirements to existing zoning districts.
6) Establish standards or incentives to improve stormwater management in developed areas.
7) Address storage/use of pollutants that contact stormwater.

4.3 CURRENT AND FUTURE POLLUTANT SOURCES

Example of an unstable gravel road leading directly to Crescent Lake. (Photo: CEI)

The NHDES (1999) diagnostic study identified the following priority sources of pollutants to Lake Wentworth and Crescent Lake: stormwater runoff, timber harvesting, inadequate sand pit stabilization, beach erosion, improper wastewater management, inadequate shoreline buffers, and poor resident education. While some of these issues have been addressed by local stakeholders since the study, the stormwater survey found that most of these issues persist today within the watershed (refer to Section 3.6). The Lake Wentworth Foundation has taken great measures in educating residents about the potential adverse effects of phosphorus detergents. In 2009, New Hampshire revised its Prohibited Products Statutes to prohibit the distribution, sale or offering for sale, any household cleansing products containing phosphorus (485-A:56). In 2010, sixteen other states followed suit and enacted a phosphate ban for dishwasher detergent including Massachusetts, Vermont and Michigan, while many other states, including Maine, have banned the use of high-phosphate laundry detergents.

These surveys indicate that a significant amount of phosphorus is delivered to the lakes as a result of soil erosion. 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, 930 kg of P enters Lake Wentworth annually and 495 kg/year enters Crescent Lake. According to the Buildout Analysis, Lake Wentworth will experience a 63% and 143% increase in P loading at the 20-year and full buildout marks, respectively, and Crescent Lake will experience 46% and 87%. In 20 years, 1,516 kg of P will enter Lake Wentworth annually, and 723 kg/year will enter Crescent Lake. At full buildout, 2,260 kg of P will enter Lake Wentworth annually, and 926 kg/year will enter Crescent Lake.

Ideally, if all 108 problem sites identified in the 2011 watershed survey were treated with BMPs, and all new development contained proper phosphorus controls, these annual P loadings would be significantly reduced. The top six BMP sites identified would treat 84 acres of the watershed (including 37 acres of impervious surfaces), removing approximately 19.5 kg of phosphorus per year from entering Lake Wentworth and Crescent Lake. This would account for 17% of the total estimated removal for the top 30 priority BMP sites. It will cost an estimated $2,100 per kg of phosphorus removed. The top four

conceptualized BMPs would reduce the total phosphorus loading to Lake Wentworth by 16 kg/year (refer to Appendix E and F).

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:

1) Nutrients (e.g. nitrogen)
2) Bacteria
3) Heavy metals (cadmium, nickel, zinc)
4) Petroleum products
5) 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 watersheds. Adaptive management enables stakeholders to conduct restoration activities in an iterative manner. 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, a cooperating group representing all towns and associations should be established for the implementation of future efforts in the watershed and to help coordinate the implementation of restoration activities. In addition to municipal officials, this collaborative should involve the various business interests 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 Lake Wentworth Foundation, the Town of Wolfeboro, technical consultants (FBE or CEI), and NHDES in collaboration with the project stakeholder group. 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 Lake Wentworth/Crescent 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 lakes. Indeed, the overall goal of the watershed management planning process is the protection of the long-term health of these lakes. For more information on future monitoring see Section 5.6.


Photo: FBE

- ***Establishing Measurable Milestones.*** A restoration schedule that includes milestones for measuring the restoration actions and monitoring activities in the Lake Wentworth and Crescent Lake watershed is critically important to the success of the plan. In addition to monitoring, twenty-seven environmental, social, and programmatic indicators have been identified to measure the progress of the Lake Wentworth/Crescent Lake Watershed Management Plan. These indicators are listed in Section 5.3, and are intricately tied to the action items identified in the Action Plan in Section 5.

5. PLAN IMPLEMENTATION

5.1 PLAN OVERSIGHT

Through the combined efforts of the Lake Wentworth Foundation (LWF) and the Town of Wolfeboro, this watershed management plan should be carried out by a steering committee similar to the Lake Wentworth/Crescent Lake Watershed Management Plan Steering Committee. Local participation is an integral part of the success of this plan, and should include the leadership of other local municipalities, such as Brookfield, Ossipee, and New Durham. This task will also require the support of other stakeholders, including NHDES, schools and community groups, local businesses, and individual landowners. The primary stakeholder group will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce nonpoint source pollution in the Lake Wentworth and Crescent Lake watershed.

The formation of smaller action committees would result in more efficient implementation of the Action Plan. Suggested action committees include:

1) Funding: form a new subcommittee to focus on obtaining funding for the above subcommittees.
2) Education and Outreach: form a new subcommittee to focus on education action items.
3) Municipal Ordinances: redirect existing subcommittee to focus on ordinance action items.
4) BMP Implementation: redirect existing subcommittee to focus on BMP action items.
5) Water Quality Monitoring and Assessment: continue existing subcommittee to focus on monitoring action items, including development of a long-term monitoring program.

These action committees will be charged with implementing projects and actions within the Action Plan with the support and assistance of state and local natural resource agencies and groups.

5.2 ACTION PLAN

The Lake Wentworth/Crescent Lake Watershed Management Plan Steering Committee should work toward improving and implementing an Action Plan that consists of action items within four major categories: 1) education and outreach, 2) municipal ordinances, 3) best management practices, and 4) monitoring and assessment. This Action Plan was developed from feedback provided during the 2012 community forum, as well as from results of previous watershed surveys. Preliminary action items are presented here as ideas to foster further thinking about long-term strategies for protecting the high quality waters and related natural resources within the Lake Wentworth/Crescent Lake watershed, and to promote communication between citizens, municipalities, and state agencies. The Action Plan outlines responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each of the four categories. Current cost estimates for each action item will need to be adjusted based on further research and site design considerations.

5.2.1 Education and Outreach

Education and outreach are vital components to watershed protection and improvement. Fortunately, the Lake Wentworth Foundation (LWF) has already established an exceptional capacity and reputation in this regard. The organization has served as a critical community resource for protecting the natural resources of the Lake Wentworth watershed and should continue to play a central role in helping to coordinate

efforts among various stakeholders and interest groups in the region. The organization is also instrumental in efforts to communicate with seasonal residents and work closely with the Lake Wentworth Association (LWA) to communicate with watershed residents.

Identified Threats from Inadequate Awareness: *Lack of knowledge of rules and laws and the impact of human activities; lack of understanding about how water quality is important for the entire community; inadequate awareness for non-shorefront property owners and visitors about how their activities can adversely affect water quality.*

EDUCATION AND OUTREACH					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Demonstration Sites	Work with partners to sponsor BMP demonstration sites throughout the watershed. Currently planning a partnership with local schools for 2013.	LWF LWA Town of Wolfeboro	Public and private grants	ASAP and Ongoing	$10,000
Site Tours	Conduct boat and foot tours to showcase BMP sites at properties around the lake.	LWF, LWA	Volunteers, Donations	2013 and Ongoing	$500
BMP and Phosphorus Brochures	Develop and distribute brochures at workshops, demonstration tours, etc and explain ways in which residents can easily and cost effectively implement BMPs or reduce P on their own property.	LWF, LWA	Donations	ASAP	$1,000
Lake Shore Rep Training	Train Lake Shore Reps annually in outreach strategies to bring back to their neighbors.	LWA, LWF	Volunteers, Donations	2013 and Ongoing	$250
Lake Wentworth Day	Sponsor an end-of-summer Lake Wentworth Day with educational booths, donations, raffles, food, and awards for most improved property. Include free-boat tours.	LWA, LWF, Town of Wolfeboro	Volunteers, Donations	2013 and Ongoing	$2,500
Stakeholder Workshops	Sponsor annual educational seminars/workshops for contractors, landscapers, and homeowners in the watershed.	LWF, LWA, Town of Wolfeboro	Volunteers, Donations, Grants	2013 and Ongoing	$1,000
Interest Group Surveys	Conduct brief surveys of resident values to better target interest groups in future outreach campaigns. This can be done at trainings, tours, workshops, etc.	LWF, LWA	Volunteers, Donations	2013 and Ongoing	$500
Newspapers and Newsletters	Publicize events and lake quality updates through local newspapers and LWA/LWF newsletters.	LWF, LWA	Volunteers, Donations	2013 and Ongoing	$500
Website	Keep Wentworth and Crescent Websites current and make connection to Winnipesaukee Gateway website. Possibly work with Lake Winnipesaukee Watershed Association to highlight work done by Wentworth and Crescent.	LWA, LWF	Section 319 Grant, volunteers, donations	2013 and Ongoing	$1,500

EDUCATION AND OUTREACH					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Sponsor Youth Conservation Corps Program	Host an annual crew from the Youth Conservation Corps Program to help with BMP implementation and outreach activities around the watershed.	LWF, LWA, Town of Wolfeboro	Volunteers, Donations	2013 and Ongoing	$10,000-$15,000
Shore Meeting Presentations	Host a speaker to present on BMP implementation for landowners around the lake shores.	LWF, LWA	Volunteers, Donations	2013 and Ongoing	$100 - $500

5.2.2 Municipal Ordinances

Municipal land use regulations are a guiding force for where and what type of development can occur in the Lake Wentworth and Crescent Lake watershed, and therefore, how water quality is impacted as a result of this development. The Municipal Ordinance Review conducted by FB Environmental indicates that there is considerable room for improvement in protecting water quality through non-structural BMPs such as municipal ordinance adoption or revisions. Action items related to this element have been divided into those relating to the shoreland zone (direct impact to lakes), the adoption of new ordinances or incorporation of new language (watershed-wide), and the integration of low impact development (LID) strategy (watershed-wide).

Identified Municipal Ordinance Threats: *Zoning lacks environmental controls; imbalance between individual rights and responsibilities; the cost of required year round maintenance and repair of BMPs; pressure to rezone; potential development impacts on water quality; sand and salt from roads.*

MUNICIPAL ORDINANCES					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Shoreland Zoning (SZ)					
SZ Awareness	Make SZ more user-friendly and explain the rules to owners in advance of projects. Distribute NHDES SZ materials [3] at outreach events.	Town of Wolfeboro, Planning Board	Permits	2013 and Ongoing	$500
SZ BMP Implementation	Require stormwater BMPs in the Shoreland Zone for permits and property transfers. Must be integrated with Town's Master Plan.	Town of Wolfeboro, Planning Board	Owners, Section 319 Grant	2013	TBD
SZ Compliance	Improve compliance of existing ordinances by increasing the working hours of the Code Enforcement Officer.	Town of Wolfeboro, Planning Board	Taxes, Permit Fees	ASAP and Ongoing	$30,000-$50,000
Shorefront Protection	Mandate 75' setbacks from lakes and ponds for primary structures, buffers between development and waterbodies, and impervious cover restrictions of 20% maximum per lot.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
New or Revised Ordinances					

[3] Includes: A Shoreland Homeowner's Guide to Stormwater Management, Summary of Minimum Standards, Native Shoreland and Riparian Buffer plantings for NH, NH Stormwater Manual, and Shoreland Protection Fact Sheets, available on the DES website: http://des.nh.gov/organization/divisions/water/wetlands/cspa/index.htm

MUNICIPAL ORDINANCES					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Center Street Rezoning	Institute a maximum percent impervious cover per lot with mandatory LID implementation on lots with more than 20% impervious cover. Consider including mandatory septic system setbacks and stormwater pollutant reduction goals.	Town of Wolfeboro, Planning Board	Taxes, Permit Fees	ASAP	TBD
Wetland Conservation Overlay District Ordinance	Consider extending the wetlands setback to 100' for very poorly drained soils and 50' for poorly drained soils.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Steep Slope Ordinance	Ensure compliance with the new Steep Slope Ordinance. Consider requiring pre and post-construction BMPs within the steep slope overlay district (>15% slope), and reduction of disturbance sites from 20,000 to 10,000 square feet.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Stormwater Management Ordinance	Adopt a stormwater management ordinance or require specific standards within existing ordinances that mandate BMP installation for construction site runoff regulation, establish pollutant reduction goals for post-construction sites, and restrict impervious cover on lots. Use NHDES *Innovative Land Use Planning Techniques* as model.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Septic System Management Plan	Develop a septic system management plan with incentives for routine maintenance and inspection of septic systems within 250' of a waterbody and 100' of a wetland.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Road Ordinance	Develop a Road Ordinance for all new roads requiring drainage standards and ongoing erosion control.	Town of Wolfeboro, Selectmen, Planning Board	Permit Fees, Construction Costs	ASAP and Ongoing	TBD
Farm/Agriculture Ordinance	Address fertilizer use, pesticide use, and animal waste in regards to water quality protection.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Erosion and Sediment Control Language	Adopt benchmark erosion control standards within existing ordinances for site plan review and land subdivision. Language should also require BMP installation for runoff control and development of a sediment control plan for disturbances on slopes >15%.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Riparian Buffers Language	Clearly define Riparian Buffer, and increase the mandatory buffer width for perennial streams, rivers, lakes, and ponds with slope consideration.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD

MUNICIPAL ORDINANCES					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Conservation Subdivisions Language	Consider increasing the mandatory open spaces for conservation subdivisions above 50%.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD
Private BMP Implementation	Require driveway BMPs, septic system upgrades, etc for all new permits and property transfers. Must be integrated with the Master Plan.	Town of Wolfeboro, Planning Board	Private, Section 319 Grant	2013 and Ongoing	$5,000
Contractor Licensing	Require certified contractors for all permit work. These contractors will have adequate training in the installation and maintenance of LID and BMPs.	Town of Wolfeboro, NHDES	NHDES Training Workshops	2013-2014	N/A
Private/Public Roadways					
Road Awareness	Educate town officials, contractors, and landowners about road maintenance through outreach workshops. Collaborate with LWF.	Town of Wolfeboro, Road Associations, LWF, LWA	Section 319 Grant, Private	2013 and Ongoing	$500
Private Road Upgrades	Upgrade private roads annually using recommended BMPs from watershed survey, UNH Roads Scholar references and Maine Camp Road Manual. The survey identified road shoulder erosion, poor crown, inadequate culverts, and unstable access as reasons for roads with high impact sites.	Town of Wolfeboro, Road Associations	FEMA, Section 319 Grant	2013-2015 and Ongoing	$50,000-$75,000
Low Impact Development (LID)					
Developer Incentives	Offer good behavior incentives to developers with multiple ways to meet standards for density/lot size and green space. Must be performance-based.	Town of Wolfeboro, Planning Board	Grants, Permit Fees	2013-2014	TBD
LID Encouragement	Develop language within the Shorefront Residential District and Wetland Conservation Overlay District that requires LID techniques in new construction projects.	Town of Wolfeboro, Planning Board	Permit Fees	2013-2014	TBD

5.2.3 Best Management Practices (BMPs)

BMP action items place a strong emphasis on improving protection of shoreland vegetated buffers, promoting and understanding LID techniques to address future development, improving private and public roadways for stormwater runoff, treating runoff from existing development, encouraging proper operation and maintenance of septic systems, and conserving open space. Coordination with landowners is crucial for structural BMPs identified in this Action Plan because mitigation measures will need to be implemented on private land and roads, in most cases.

Identified BMP Threats: *stormwater runoff from roads, roofs, and steep sites without buffers; inadequately maintained and malfunctioning septic systems; sand and salt and salt runoff from roads; lack of vegetated shoreline buffers.*

BEST MANAGEMENT PRACTICES (BMPs)					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
		General BMPs			
Target BMPs	Implement BMPs for high priority sites identified in the 2011 survey utilizing the BMP Matrix. The Stormwater Survey identified residential areas, beach access sites, and roads/driveways as accounting for the majority of soil erosion and stormwater runoff in the watershed.	LWA, LWF, Town of Wolfeboro	Section 319 Grant	ASAP and Ongoing	$25,000
Track BMP Schedule	Track BMPs as sites are identified and BMPs implemented.	LWA, LWF, Town of Wolfeboro	Section 319 Grant	ASAP and Ongoing	$1,000
Private BMP Implementation	Encourage existing property owners to retrofit their properties with BMPs. Focus on driveway BMPs, septic system upgrades, etc for all new permits and property transfers. Must be integrated with Master Plan.	Town of Wolfeboro, Planning Board	Private, Section 319 Grant	2013 and Ongoing	TBD
Contractor Licensing	Require DES certified contractors for all permit work. These contractors will have adequate LID and BMP use ethics.	Town of Wolfeboro, NH DES	DES Training Workshops	2013-2014	N/A
		Private/Public Roadways			
Road Awareness	Educate town officials, contractors, and landowners about road maintenance through outreach workshops. Collaborate with LWF.	Town of Wolfeboro, Road Associations, LWF, LWA	Section 319 Grant, Private	2013 and Ongoing	$500
Tributary Crossing Evaluation	Identify stream crossings that do not meet specifications according to the NH Stream Crossings Guidelines and replace non-conforming stream crossings.	NH DOT, NHDES, Town of Wolfeboro, NH Fish & Game, Road Commissioners	FEMA, Section 319 Grant, NH Fish & Game	2013-2015 and Ongoing	$75,000-150,000
Private Road Upgrades	Upgrade private roads annually using recommended BMPs from watershed survey, UNH Roads Scholar references and Maine Camp Road Manual. The survey identified road shoulder erosion, poor crown, inadequate culverts, and unstable access as reasons for roads having some of the highest impact sites.	Town of Wolfeboro, Road Associations	FEMA, Section 319 Grant	2013-2015 and Ongoing	$50,000-$75,000

BEST MANAGEMENT PRACTICES (BMPs)					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
Public Road Upgrades	Upgrade public roads annually using recommended BMPs from watershed survey, UNH Roads Scholar references and Maine Camp Road Manual. The survey identified road shoulder erosion, poor crown, inadequate culverts, and unstable access as reasons for roads having some of the highest impact sites.	Town of Wolfeboro, Road Commissioners, NH DOT	FEMA, Section 319 Grant	2013-2015 and Ongoing	$150,000-$200,000
Sand/Salt Management Plan	Develop a winter sanding management plan for the reduction of excessive sand & salt on roads.	Town of Wolfeboro, NH DOT	DOT	2013 and Ongoing	$1,000
		Septic Systems			
Target Outreach	Based on the Septic Survey Report, outreach should concentrate on older systems (39%) within 50' of the shorefront (6%) that rarely pump (3%). Distribute the report to residents and encourage them to make improvements.	Town of Wolfeboro, LWF, LWA	Private, Fees	2013 and Ongoing	$1,500
Maintenance & Inspection Requirements	Encourage regular pumping of septic systems and repair through homeowner education for property transfers and permits.	Town of Wolfeboro, LWF, LWA	Private, Fees	2013 and Ongoing	$50,000
Pumping Incentives	Organize multiple pump-outs in close vicinity for inspection and pump-out cost-shares.	Contractors, Town of Wolfeboro, LWF, LWA	Private, Section 319 Grant	2013 and Ongoing	$2,000
Onsite Waste Management Program	Compile survey and GPS information of septic systems in shoreland area. Update annually with required pump-outs and inspections.	Town of Wolfeboro, LWF	Section 319 Grant	2013 and Ongoing	$9,000
Voluntary Dye Testing	Provide dye testing services to homeowner volunteers to encourage septic system maintenance.	Town of Wolfeboro, LWF	Private, Donations	2013 and Ongoing	$250 per system
Phosphorus-Based Products	Continue to educate watershed residents and businesses on using low or non-phosphate products.	LWF, LWA	Private	2005 and Ongoing	$100
Community Septic Systems	Install community septic systems for new subdivisions to help achieve proper maintenance procedures, and upgrade individual septic systems.	Town of Wolfeboro, LWF, LWA	Private, 319 Grant	2014 and Ongoing	$20-30,000 per household for initial installation

BEST MANAGEMENT PRACTICES (BMPs)					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
		Land Conservation			
Land Conservation	Conserve land through conservation easement purchases or direct ownership.	Town of Wolfeboro, LWF, Local Conservation Groups	Taxes, Donations	Ongoing	Variable

5.2.4 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, particularly during storm events, and expansion of the aquatic invasive species screening program. Since volunteers typically conduct many different monitoring activities, it will be critical to continue building on the success of LWA and LWF's ongoing education and outreach programs.

Identified Monitoring and Assessment Issues: *Declining water quality; climate change impacts to lake quality parameters; effects from extreme storm events; invasive species threats such as milfoil.*

MONITORING & ASSESSMENT					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
		Monitoring			
Baseline Land Use Standards	Document and assess baseline standards for land use practices around the shoreline using modern GPS technology.	Volunteers, LWF, LWA	Donations	2013	$15,000
Water Quality Monitoring	Continue to collect water quality samples on a bi-weekly basis through the summer season as well as during spring and fall mix on an annual basis.	LLMP, Volunteers, UNH CFB, LWA, LWF	Donations	Ongoing	$8,000
Invasive Aquatic Plant Control	Continue to control invasive species like Milfoil from entering Lake Wentworth. Conduct frequent routine surveys of dams, tributaries, and shallows during summer months.	Volunteers, LWA, LWF, NHDES	Donations	Ongoing	$2,500
Water Quality Awareness	Develop annual water quality report from the UNH LLMP yearly publications and distribute to shoreline residents. The report should focus on water quality issues specific to Lake Wentworth and Crescent Lake.	Volunteers, LWA, LWF	Donations	Ongoing	$2,500
Storm Event Surveys	Train volunteers to monitor during storm events at road crossings and culverts near the shorelines. Use information to identify problem areas and recommend solutions.	Volunteers, LWA, LWF	Donations	Ongoing	$1,000

MONITORING & ASSESSMENT					
ACTION ITEMS	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**SUGGESTED ANNUAL COST**
		Assessment			
Camp Road Conditions	Assess the condition of camp roads and make recommendations for improvements.	Town of Wolfeboro, LWF, LWA	Section 319 Grant	2013	$10,000
Target Sites	Resurvey documented NPS sites identified in this plan for BMP implementation and develop a tracking system to document long-term functionality.	Town of Wolfeboro, LWF, LWA	Section 319 Grant	2016 and every 5 years	$4,500
Land Use Nutrient Reductions	Determine pollutant reduction goals based on land -use types and incorporate into future development.	Town of Wolfeboro, LWF, LWA	Section 319 Grant	2013-2014	$500

5.3 INDICATORS TO MEASURE PROGRESS

Environmental, social, and programmatic indictors will help measure progress of the Lake Wentworth/ Crescent Lake Watershed Management Plan.

Establishing indicators to measure progress provides short-term input on how successful the plan has been in meeting the established goals and objectives for the watershed. It allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. In addition to water quality monitoring, the following environmental, social, and programmatic indicators should be used to measure the progress of the Lake Wentworth and Crescent Lake Watershed Management Plan. These indicators are intricately tied to the action items identified in the Action Plan.

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:

- Amount of funding secured for plan implementation
- Number of LID practices implemented
- Number of high and medium priority NPS sites remediated
- Number of residential BMPs installed
- Number of residential BMP demonstration projects completed
- Linear feet of buffers installed in the shoreland zone
- Number of BMPs installed on private and public roads
- Number of feet of roadside ditches stabilized
- Number of culverts stabilized or enlarged
- Number of stream crossings that meet the guidelines in *New Hampshire Stream Crossings Guidelines* (UNH, 2009)
- Number of new road associations formed
- Number of septic system assessments and septic system upgrades
- Number of acres of protected critical lands
- Number of watershed-based educational materials distributed

Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement. They include:

- Number of new LWA or LWF members or stakeholders on the Steering Committee
- Number of homeowners who participate in residential demonstration projects
- Number of people who sign Technical Assistance Pledge sheets
- Number of homeowners who participate in residential stormwater educational programs
- Number of contractors completing a training and certification program
- Citizen support as evidenced by the number of ordinances amended to support the plan
- Decrease in number of ordinance violations
- Number of volunteers participating in monitoring programs

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:

- Improvement in water clarity
- Reduction in the in-lake phosphorus concentration
- Improvement in the dissolved oxygen levels in deep areas of Lake Wentworth
- Reduction in the frequency of peak flows through use of LID technology
- Reduction of visual NPS pollution during storm events

5.4 ESTIMATED COSTS AND TECHNICAL ASSISTANCE NEEDED

The cost of successfully implementing this watershed plan for Lake Wentworth and Crescent Lake is estimated at close to $6 million (Table 5.1). 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.

Table 5.1: *Estimated annual and 10-year costs for watershed restoration.*

Category	Estimated Annual Costs	10-year Total
Education & Outreach	$32,850	$328,500
Ordinances	$50,500	$505,000
BMPs	$462,500	$4,625,000
Monitoring	$44,000	$440,000
Total Cost	**$ 589,850**	**$5,898,500**

Particular attention should be given to Crescent Lake, which no longer meets the criteria for a High Quality Water. However, since Lake Wentworth accounts for 71% of the incoming phosphorus load to Crescent Lake, efforts to reduce phosphorus loading to Lake Wentworth by 15% will by default reduce the in-lake phosphorus concentration in Crescent Lake. However, direct efforts are still needed in the Crescent Lake direct watershed to address existing and future sources of pollution to reduce phosphorus inputs over the long-term. 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.), and the Lake Wentworth Foundation (LWF) and Lake Wentworth Association (LWA). Funding for education and outreach might also be expected to come from the LWF and LWA. Funding to improve septic systems, gravel roads, and shoreland zone buffers could be expected from property owners most affected by the improvements.

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 Lake Wentworth Foundation is the primary entity to implement this portion of the Plan. Efforts should be made to encourage understanding of current problems associated with declining water quality in Lake Wentworth and to help promote lake/watershed stewardship. The educational goal of the Plan is to elevate public understanding of these connections and to encourage actions that maintain high water quality and a healthy watershed ecosystem. Action items related to education and outreach are outlined in the Action Plan (Section 5.2).

5.6 MONITORING PLAN

The objective of this plan is to achieve a stable or improving trophic state and to reduce the probability of future late summer or early fall nuisance algae blooms in Lake Wentworth and Crescent Lake. 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 LWA Water Quality Committee has developed a long-term strategy for monitoring the water quality of Lake Wentworth and Crescent Lake, and should continue to take the lead on coordinating future monitoring activities in coordination with NHDES, UNH Center for Freshwater Biology (CFB), and the UNH Lakes Lay Monitoring Program (LLMP). Sampling should continue to be conducted by LLMP volunteers or UNH CFB from May through October at three locations in Lake Wentworth and one location in Crescent Lake. The sampling should be conducted biweekly for temperature, chlorophyll a, color, alkalinity, and Secchi disk transparency. Phosphorus sampling (epicore) and hypolimnetic (during stratification) should be conducted monthly during the ice free season and analyzed by UNH according to standard methods. Tributaries will be sampled for phosphorus and flow during a variety of wet and dry weather events throughout the year. All water quality data will be entered into a database to enable tracking and reporting of results and share all monitoring results with NHDES. LWF will also continue its volunteer aquatic invasive plant surveys throughout the summer as well as funding courtesy boat inspections at public ramps. In addition, the LWF, in consultation with UNH and NHDES should implement a program for volunteer surveys of key tributaries during storm events to identify visual NPS pollution. A steering committee can evaluate priority areas for NPS reduction based on these qualitative surveys. Refer to Monitoring and Assessment within the Action Plan (Section 5.2) for additional monitoring activities.

5.7 EVALUATION PLAN

Annual steering committee meetings should be organized to review the status of goals and objectives presented in this watershed management 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. All achievements, such as press releases, outreach activities, number of sites repaired, number of volunteers, amount of funding received, number of sites documented, should be tracked. Stakeholders can then use the established indicators (Section 5.3) to determine the effectiveness of the Plan.

5.8 CONCLUSION

Watershed residents, landowners, business owners, and recreationalists alike should have a vested interest in protecting the long-term water quality of Lake Wentworth and Crescent Lake for future generations. With a goal of reducing in-lake phosphorus concentrations by 15%, Crescent Lake may once again qualify as a high-quality waterbody according to state standards, and water quality trends such as increasing phosphorus levels in the lake and declining water clarity may be reversed. Water quality improvements in the Lake Wentworth watershed will not only help improve the water quality of Crescent Lake, but should also help improve low levels of dissolved oxygen at the bottom of the lake, reduce the amount of nutrients supplied to invasive aquatic plant species, and reverse the trend of declining water clarity, chlorophyll-a, color, and phosphorus that has resulted in an increased presence of algae.

Implementation of this plan over the next ten years is expected to cost close to $6 million, and will require the dedication and hard work of both municipal employees and volunteers to ensure that the actions identified in this plan are carried out accordingly.

ADDITIONAL RESOURCES

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

Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Chase, et al. 1997. NH Audubon Society. Online: http://extension.unh.edu/CommDev/Buffers.pdf

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

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

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

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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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FB Environmental Associates (FBE). (2012a). *Lake Wentworth and Crescent Lake Nutrient Modeling: Using Lake Loading Response Modeling to Estimate Phosphorus Loads*. Portland, ME: FBE.

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