PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

HIGHLAND LAKE

Cumberland County

Highland Lake PCAP-TMDL Report

DEPLW 2002 - 0536

Maine Department of Environmental Protection

and Maine Association of Conservation Districts

FINAL EPA REVIEW DOCUMENT

June 9, 2003 (Final Revision August 15, 2003)

Highland Lake Phosphorus Control Action Plan

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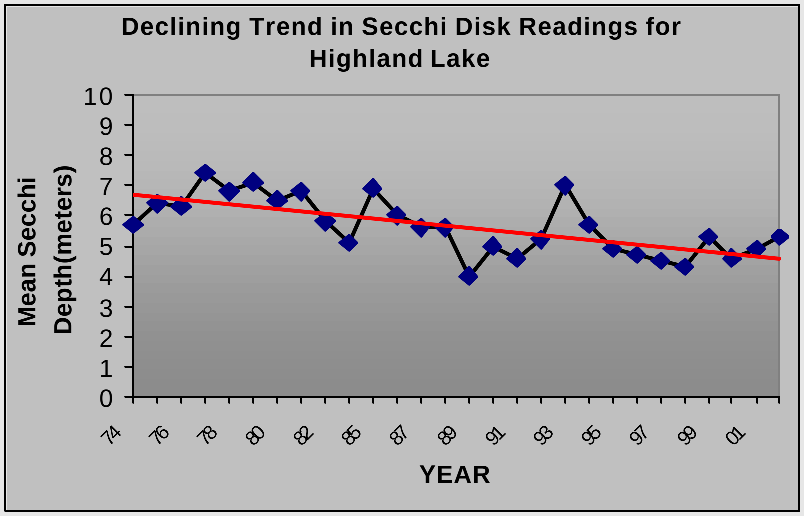
APPENDICES

ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA Region I staff (guidance), the following individuals and groups were instrumental in the preparation of this Highland Lake Phosphorus Control Action Plan-TMDL Report: MACD staff (Jodi Michaud Federle', Forrest Bell and Tim Bennett); Cumberland County Soil and Water Conservation District (Tamara Pinard, Vallana Pratt-Decker, Betty Williams); the entire Highland Lake Association (including VLMP monitors Keith Williams and Rosie Hartzler); Windham, Falmouth, Westbrook town officials and office staff, Maine Forest Service (Morten Moesswilde); Maine Department of Inland Fisheries and Wildlife (Francis Brautigam), and a very special thanks to current Highland Lake Association president Ralph Johnson for the use of his boat and involvement to complete the TMDL-associated water quality monitoring during the 2002 field season.

Highland Lake Phosphorus Control Action Plan Summary Fact Sheet

Background



HIGHLAND LAKE is a 623-acre waterbody located in the towns of Windham, Falmouth, and Westbrook in Cumberland County, southern Maine. Highland Lake has a direct **watershed** area of approximately 8.4 square miles; a maximum depth of 65 feet, a mean depth of 25 feet; and a **flushing rate** of 0.7 times per year. The total Highland Lake watershed drainage area, inclusive of upstream situated Little Duck Pond subwatershed, is 8.7 sq. mi.

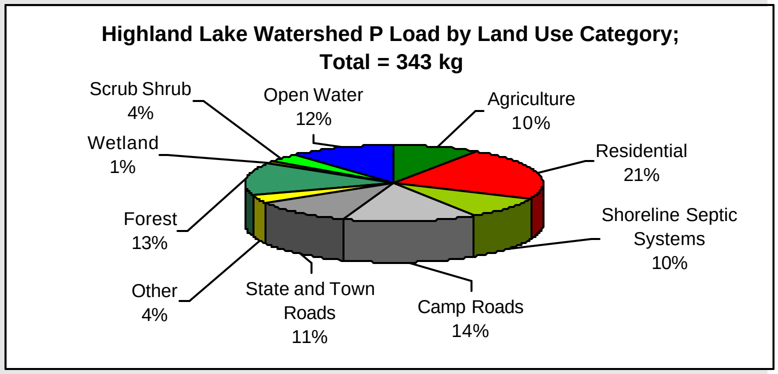
Highland Lake has experienced a gradual decline in water quality over the past decade. Average annual Secchi disk readings (measures of water clarity) over the past decade are about one meter less than during the previous decade, which reflects increases in algae and sediment deposits in the lake. In addition, the average dissolved oxygen in the lake's lower layer during September has declined to levels that threaten the lake's cold water fishery. This decline is due in large part to the contribution of **phosphorus** that is prevalent in area soils and effectively transported via stormwater discharge. Excessive soil erosion in lake watersheds can have far-reaching water quality consequences. Soil particles transport phosphorus, which essentially "fertilizes" the lake and decreases water clarity (see photo of an eroding Highland Lake boat launch below). Most importantly, studies have also shown that as lake water clarity decreases, lakeshore property values also decline.

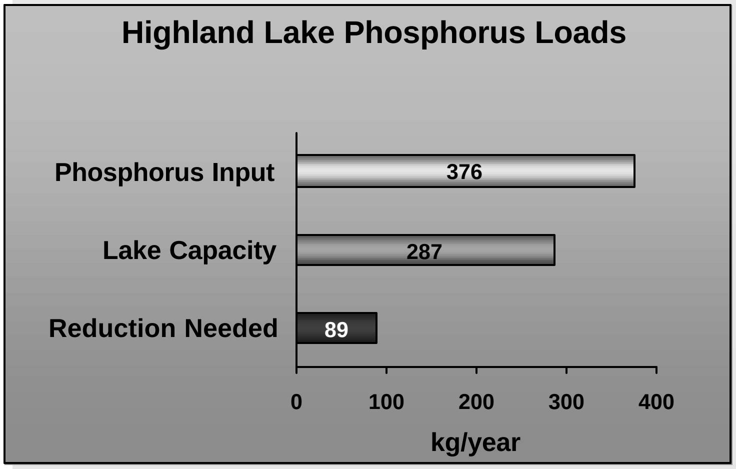
Stakeholder Involvement

Federal, state, county, and local groups have been working together to effectively address this problem. In 2001, the Maine Department of Environmental Protection funded a project in cooperation with the Maine Association of Conservation Districts, the Cumberland County Soil and Water Conservation District, and the Highland Lake Association to: (1) identify and quantify the potential sources of total phosphorus; (2) to recommend **Best Management Practices** needed to be installed in the watershed; and (3) to develop a feasible implementation plan to effectively reduce total phosphorus loads to Highland Lake. A final report, completed in the spring of 2003, is entitled Highland Lake Phosphorus Control Action Plan (**PCAP**) and Total Maximum Daily/Annual Load (**TMDL**) report, to be submitted to the US-EPA, New England Region, for their review and final approval.

What We Learned

A land use assessment was conducted for the Highland Lake watershed to determine potential sources of phosphorus that may run off from land areas during storm events and springtime snow melting. This assessment involved utilizing many resources, including generating and interpreting maps, inspecting aerial photos, and conducting field surveys.





An estimated 343 kilograms (kg) of phosphorus per year is exported to Highland Lake directly from the external watershed, from both point (stormwater discharge) and nonpoint (overland) sources. The pie chart (top right) depicts the land use breakdown of the estimated phosphorus load for representative land uses. As can be seen, there are numerous types of land uses that all contribute phosphorus to the lake.

The estimated phosphorus input (343 kg/yr + 33 kg/yr from future development = 414 kg/yr) exceeds Highland Lake's modeled capacity (287 kg/yr) to effectively process phosphorus (see above). In the absence of lake bottom P-loads, the remaining phosphorus load (89 kg/yr) is the minimum amount needed to be reduced on an annual basis to ensure that Highland Lake will continue to remain free of nuisance summer algal blooms.

What You Can Do To Help!

As a watershed resident there are many things you can do to protect the water quality of Highland Lake. Lakeshore owners can use phosphorus-free fertilizers and maintain natural vegetation adjacent to the lake. Agricultural and commercial land users can consult the CC-SWCD or Maine DEP Stormwater Program for information regarding BMPs for reducing phosphorus. Watershed residents can become further involved by volunteering to help the Highland Lake Association and participating in CC-SWCD sponsored events. All stakeholders and watershed residents can learn about their lake and the many resources available, including review of the Highland Lake PCAP-TMDL report. Following EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work - will be available online at http://www.state.me.us/dep/blwq/docmonitoring/tmdl2.htm or can be viewed and/or copied (at cost) from Maine DEP offices in Augusta.

Key Terms

- ***Watershed*** *is a drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*
- ***Flushing rate*** *refers to how often the water in the entire lake is replaced on an annual basis.*
- ***Phosphorus****: total phosphorus (TP) is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits the plant growth in lakes. Generally, as phosphorus increases, the amount of algae also increases.*
- ***Best Management Practices*** *are techniques to reduce sources of polluted runoff and their impacts. BMP's are low cost, common sense approaches to reduce storm runoff and velocity to keep soil out of lakes and tributaries.*
- ***TMDL*** *is an acronym for Total Maximum Daily Load which represents the total amount of a pollutant (e.g., phosphorus) that a waterbody can receive and still meet acceptable water quality standards.*

Project Premise

This project, funded through a 319 grant from the United States Environmental Protection Agency (EPA), was directed and administered by the Maine Department of Environmental Protection (Maine DEP) in partnership with the Maine Association of Conservation Districts (MACD), from the summer of 2001 through the late spring of 2003.

The objectives of this project were twofold: First, a comprehensive land use inventory was undertaken to assist Maine DEP in developing an Phosphorus Control Action Plan (PCAP) and Total Maximum Daily Load (TMDL) report for the Highland Lake watershed. Simply stated, a TMDL is the total amount of phosphorus that a lake can receive without harming water quality. Maine DEP, with the assistance of the MACD Project Team and the Cumberland County Soil and Water Conservation District, will address and incorporate all public comments before final submission to the US EPA. *(For more specific information on the PCAP-TMDL process and results, refer to the appendices or contact Dave Halliwell at the Maine DEP Augusta Office at 287-7649 or at David.Halliwell@maine.gov*).

> ***Nonpoint Source (NPS) Pollution*** *- is polluted runoff that originates from numerous, small overland sources as opposed to a larger, direct (or point) source.*

Secondly, watershed survey work, including a shoreline and septic survey evaluation, were conducted by the Maine DEP-MACD project team to help identify the need for phosphorus reduction techniques that would be beneficial for the Highland Lake watershed. Watershed survey work included assessing direct drainage ***nonpoint source (NPS) pollution*** sites that were not identified during the Highland Lake Nonpoint Source Pollution Survey conducted in 1997. The Action Plan portion of this report is intended to complement the Watershed Management Plan (1999), recently developed by the Cumberland County Soil and Water Conservation District (CC-SWCD) and the Highland Lake Association (HLA). The results of this report includes recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Highland Lake. In order to protect the confidentiality of landowners in the watershed, site-specific information is not provided as part of this report.

This Phosphorus Control Action Plan (PCAP) project compiles and refines land use data derived from various sources, including the municipalities of Falmouth, Windham, and Westbrook, the CC-SWCD, and the HLA. Local citizens, watershed organizations, and conservation agencies should benefit from this current compilation of data as well as the watershed assessment and NPS Best Management Practice (BMP) recommendations. Above all, this document is intended to help Highland Lake stakeholder groups to effectively prioritize future BMP work in order to obtain the funding resources necessary for NPS pollution mitigation work in the watershed.

PCAP-TMDL Study Methodology

Background information regarding Highland Lake was obtained by several methods, including a review of previous studies of the watershed area, numerous phone conversations and personal interviews with municipal officials, regional organizations and state agencies, and several field tours of the watershed, including boat reconnaissance of the lake and shoreline.

Land use data were determined using several methods, including (1) ***Geographic Information System (GIS)*** map analysis, (2) analysis of topographic maps, (3) analysis of town property tax maps and tax data, (4) analysis of aerial photographs (US-FSA 1998) and (5) field visits. Much of the undeveloped land use area (i.e., forest, wetland, grassland) was determined using GIS maps utilizing data from the Casco Bay Estuary Project. The developed land use areas were obtained using the best possible information available through analysis of methods 2 through 5 listed above. Necessary adjustments to the GIS data were made using best professional judgment.

> ***GIS****—or* ***geographic information systems*** *combine layers of information about a place to give you a better understanding of that place. The information is often represented as computer generated maps.*

Roadway data were gathered by taking actual road width measurements of the various types of roads (state, town, private/camp) in the watershed. Roads were measured between the two outer edges of the roadside ditches or berms. An average width was used for each of the three road types. Final measurements for all roadways within the watershed were extrapolated using GIS, Delorme Mapping software, and USGS topographical maps. Finally, the roadway area was determined using linear distances and average widths for each of the three main road types .

Non-shoreline residential areas in the watershed were calculated using GIS cover mapping provided by Maine DEP, topographical maps (1977), and groundtruthing by MACD (traveling each road and counting each dwelling in the watershed).

Additional land use data (e.g., residential and institutional) were determined using GIS, aerial photos, topographic and property tax maps as well as personal consultation and, when necessary, field visits. Agricultural information within the Highland Lake watershed was provided by the Cumberland County Soil & Water Conservation District (CC-SWCD). Information regarding harvesting operations was provided by the Maine Forest Service, Department of Conservation.

Limitations of Study

Land use data gathered for the Highland Lake Watershed is as accurate as possible given available information and resources utilized. However, the final numbers for the land use analysis and phosphorus loading numbers are approximate at best, and should be viewed as carefully researched estimations only.

Highland Lake Phosphorus Control Action Plan

1. DESCRIPTION of WATERBODY and WATERSHED

*The **direct watershed** refers to the land area that drains to the lake without first passing through another lake or pond.*

HIGHLAND LAKE is a single-basin 623-acre (252 hectare, 2.5 km^2) drainage lake (to Presumpscot River) located within the towns of Windham (47.3%), Falmouth (44.4%) and Westbrook (8.3%) in Cumberland County in southern Maine. Highland Lake has a **direct watershed** area of 5,221 acres (See Figure 1, following page), or 8.4 square miles with a maximum depth of 65 feet, an overall mean depth of 25 feet and a relatively slow flushing rate of 0.70 times/year. The total Highland Lake watershed drainage area, including Little Duck Pond, is 5,453 acres or 8.7 square miles.

Drainage System – Several perennial streams flow into Highland Lake. The largest of these streams is McIntosh Brook, which begins north of Highland Lake at the outlet of Little Duck Pond. McIntosh Brook is the only inlet stream that is officially named on the US Geological Survey (USGS) topographic map. The following locally recognized, but unnamed USGS streams, also drain into the lake: Johnson, Ridge, Vista, Pine, Haven, Percy Hawkes, and Suckfish Brooks. The Highland Lake watershed also has several intermittent streams, many of which originate from wetland areas. Tributary streams generally have gravel or sand substrates and steep banks (Williams, 1998). The lake's sole outlet stream is Mill Brook, which begins at the Highland Lake dam - situated at the southern end of the lake. The dam, owned by the City of Westbrook, controls the water levels of both Highland Lake and Mill Brook. Highland Lake water levels have historically been controlled by the City of Westbrook, in cooperation with the Maine Department of Marine Resources (Maine DMR), to maintain year-round minimum flows in Mill Brook. The Highland Lake Association's appointed Dam Committee also provides local input related to dam management and informally monitors water levels (CC-SWCD 1999).

Water Quality Information

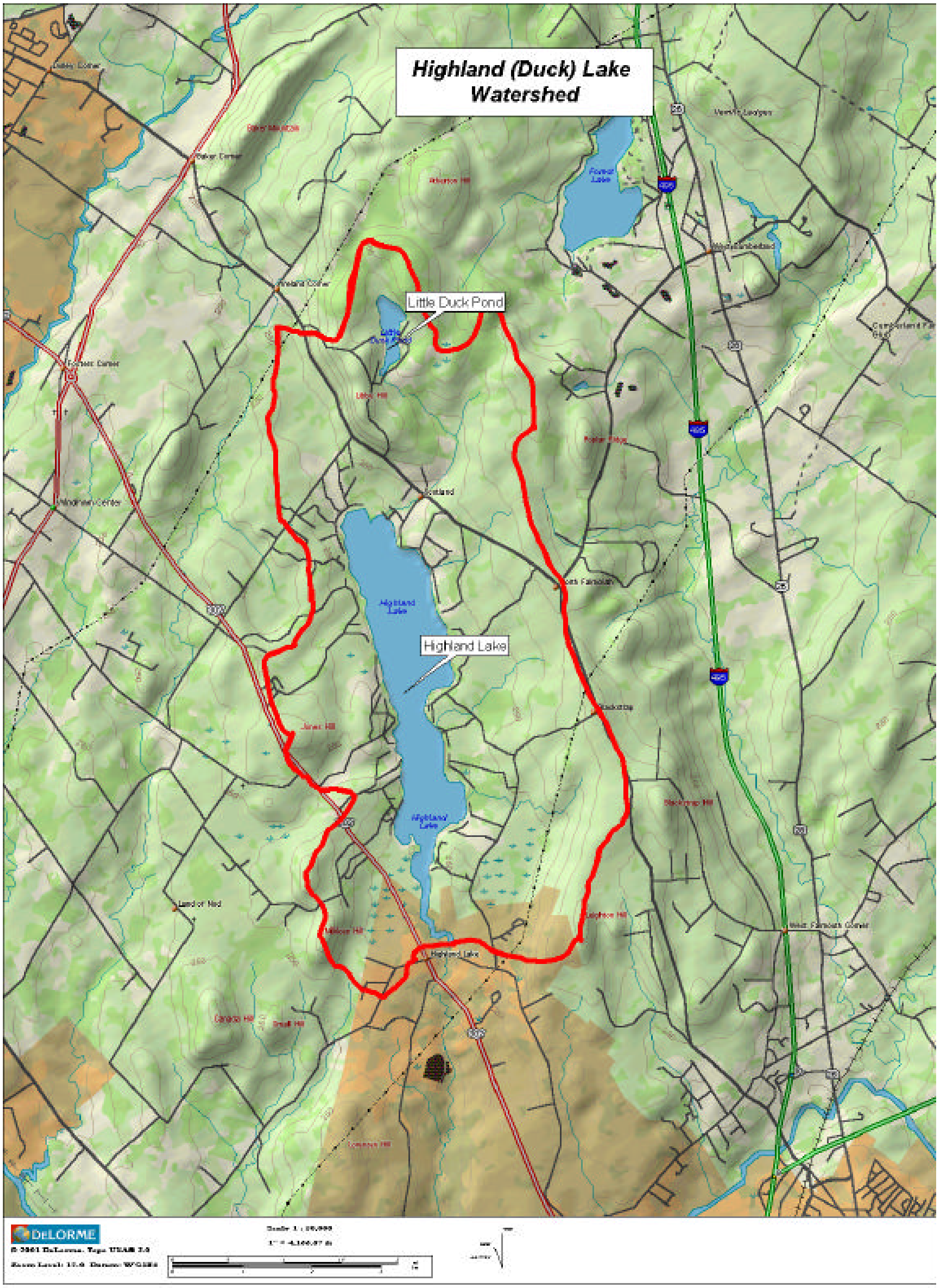
*181 lakes were listed on the **Nonpoint Source Priority Watersheds** list released by the Maine Department of Environmental Protection in 1998. Highland Lake was listed among 41 lake watersheds as the "highest priority". This list and the evaluation process used to determine the list are available on the Maine DEP website: www.state.me.us/dep/blwq/docwatershed/prilist5*

Highland Lake is listed on the Maine Department of Environmental Protection's 303(d) list of lakes that do not meet State water quality standards as well as the State's **Nonpoint Source Priority Watersheds** list. Hence, the preparation of a Phosphorus Control Action Plan (and TMDL) was required and completed in the Spring of 2003.

__Secchi Disk Transparency__—a measure of the transparency of water (the ability of light to penetrate water) obtained by lowering a black and white disk into water until it is no longer visible.

Water quality data for Highland Lake has been collected from the deep hole station (01) since 1974. Continuous **Secchi disk transparency** (SDT) measures have been obtained to the present, with the exception of 1984 (Maine VLMP 2002). During this 28 year water quality sampling period, 12 years of **chlorophyll-a** and basic chemical information was collected,

Figure 1: Highland Lake Watershed Map



including total phosphorus (core and grab samples). Together these data document a trend of increasing **trophic state** and hence a violation of Class GPA criteria requiring a stable or decreasing trophic state.

***Chlorophyll-a** is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass—the higher the Chl-a, the greater the algae in the lake.*

Historically, there has been a gradual decline in Highland Lake's water quality. Dissolved oxygen readings recorded in 1996 and 1997 were the lowest readings observed since Maine DEP/VLMP record keeping began in 1974. Based on Maine VLMP water quality records, the average dissolved oxygen in the hypolimnion (bottom layer) during September has dropped from a high of 3.0 parts per million (ppm) in 1975 to 2.5 ppm in 1980; 1.6 ppm in 1990; 0.5 ppm in 1995; and, most recently, 0.3 ppm in 1997 (CC-SWCD 1999).

***Trophic state**—the degree of lake eutrophication. Transparency, Chlorophyll-a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can be used to assess lake trophic state.*

Trout and other coldwater fish require oxygen levels greater than 5 ppm to survive and even higher levels (7-8 ppm) to grow and reproduce. Since dissolved oxygen levels in Highland Lake's hypolimnion fall far below this level in most summers, it is possible that the lake has experienced a moderate to severe reduction in coldwater fish habitat (CC-SWCD 1999).

***Dissolved Oxygen**— the amount of oxygen measured in the water. It is used by aquatic organisms for respiration. The higher the temperature, the less oxygen the water can hold. Oxygen will naturally decline during the summer months as water temperatures rise.*

Nonpoint source pollution is the main reason for declining water quality in Highland Lake. During and after storm events, nutrients, such as phosphorus—naturally found in Maine soils– drain into the lake from the surrounding watershed by way of streams and overland flow.

Phosphorus can be thought of as a fertilizer—a primary food for plants, including algae. Phosphorus is naturally limited in lakes. When lakes receive excess phosphorus from NPS, it "fertilizes" the lake by feeding the algae. Too much phosphorus can result in algae blooms, which can damage the ecology/aesthetics of a lake, as well as the economic well-being of the entire community.

Principle Uses: Highland Lake is highly valued by the area's seasonal and year-round residents for its seemingly pristine waters and sense of wilderness that it offers while still providing the conveniences of the nearby City of Portland. It is a popular lake for winter activities such as snowmobiling and ice fishing and summer activities such as boating, kayaking and canoeing. The lake's carry-in boat launch also makes it an accessible and popular recreational destination for visitors from both within and outside the watershed.

Human Development: Highland Lake is highly developed along all shorelines with the exception of the area just north of the outlet. There are approximately 883 housing units within the entire direct watershed, including a total of 248 lakeshore housing units: 53% (n = 131) seasonal and 47% (n = 117) year-round (MACD PCAP-TMDL Project Team 2002).

The predominance of residential areas and roads, in spite of their low percent of area coverage, are of major concern in the Highland Lake watershed. Many existing roads and residential sites are located close to the lake, and overland/soil and septic system pollution from these land uses poses a threat to the lake's water quality. In addition, it is projected that 23% of the existing forestland will be developed in the next 50 years (Highland Lake Study Committee, 1996). This conversion from forest to residential developments and roads will place additional strain on the water quality of Highland Lake. Without progressive erosion and sediment controls, the amount of soil erosion and stormwater runoff will no doubt increase and deliver additional pollutants to the lake (CC-SWCD 1999).

Due to this projected increase in development, watershed residents have worked with the towns of Falmouth and Windham on formulating Phosphorus Control Ordinances for new development. Falmouth enacted a Phosphorus Control Ordinance in November, 2000, while Windham adopted a similar ordinance in 2002.

Highland Lake is also on the Maine DEP's list of Lakes *Most At Risk From Development* due to rapid population growth rates in the surrounding towns and sensitive nature of the waterbody. At this time, the potential for nuisance algal blooms in Highland Lake is low to moderate (Maine VLMP 2002). To date, minimal lake water transparencies of 2.0 to 2.1 meters were observed only during the years 1991 and 1996.

This area of Highland Lake's shorefront is relatively undisturbed with the exception of a beach which potentially can contribute phosphorus to the lake if it is not properly maintained and undergoes active erosion.

Highland Lake Fish Assemblage and Fisheries Status Report

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) and a recent conversation with fish biologist Francis Brautigam (Region A, Gray Maine DIFW office), Highland Lake (Falmouth-Windham) is currently managed as both a warmwater and coldwater fishery and was last surveyed in 1999. There are a total of 15 fish species listed, including: 8 native indigenous fish species (American eel, Golden shiner, Fallfish, White sucker, Brown bullhead, Chain pickerel, Pumpkinseed, and Yellow perch); 3 introduced non-indigenous managed fish species (annually-stocked sea-run Alewife [Maine DMR], Rainbow smelt, and Largemouth bass [Maine DIFW];); two introduced salmonids (land-locked Atlantic salmon and brown trout) which are stocked annually as fall-yearlings; and possibly two illegally introduced fish species (Smallmouth bass and White perch). Splake (lake trout-brook trout hybrid) were first stocked by Maine DIFW in Highland Lake in the late 1990s, but are no longer stocked due to water quality problems (i.e. dissolved oxygen depletion in hypolimnion). An excellent **put-and-take only** fishery exists for larger Brown trout (2 to 3 pounds, up to 7). Warmwater fisheries include primarily Chain pickerel, White perch and Largemouth bass, and to a much lesser extent, Smallmouth bass.

Put-and-take-only *is the process of stocking game fish that are intended to be harvested in a short period of time.*

Historically, Highland Lake had excellent water quality for salmonids, with a large band of cold, oxygenated water present to a depth of 60 feet (18 meters) in the deeper upper or northern portion of the lake. The smaller and shallower lower (southern) portion, with its numerous coves and outlet areas, provides ample habitat to sustain warmwater fisheries. Today, due to increasing nutrient levels, lake sediment organic matter deposition and subsequent decomposition by aerobic microbes, hypolimnetic oxygen depletion (under 5 parts per million and down to 2 ppm and below dissolved oxygen) is apparent within 75% of the water column (6-20 meters) in the deep hole sampling station of Highland Lake. Morphometrically expanded for the entire lake, these numbers translate into a loss of 47 to 60 percent on the basis of volume and area, respectively. In-lake oxygen levels below 5 ppm stress coldwater fish and a persistent loss of oxygen may further eliminate suitable habitat for both warm- and cold-water fish species.

Anadromous Fish Restoration (from CC-SWCD HLW Management Plan 1999) In 1986, the Maine Department of Marine Resources (DMR) constructed a fish passage structure at the Highland Lake dam, following which they stocked the lake with Alewives in 1987, 1989, 1990 and 1991. After the Alewife run was established, the DMR continued to manage the fishway by maintaining minimum flow in Mill Brook to accommodate seasonal Alewife migration. In October of 1996, floods damaged the Smelt Hill Dam fishway on the Presumpscot River, thereby blocking fish migration between Highland Lake and the ocean. Central Maine Power, the dam's owner, has since resumed Alewife stocking in Highland Lake. In 1997, they stocked 1,000 adults, and in 1998 they stocked 2,000 adults. They will cease annual stocking of Alewives as the Smelt Hill Dam has been removed on the Presumpscot River and anadromous fish now have natural access to Mill Brook.

Anadromous *fish are born in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn.*

Watershed Topography and Characteristic Soils - According to the *Casco Bay Land Use Inventory* (USDA NRCS 1995), the Highland Lake watershed is located in the Coastal Lowland region, which is characterized by rolling hills with small changes in elevation. Several parts of the watershed, however, have more significant slopes. Libby Hill, located on the north end of the watershed, is very steep (with slopes greater than 25%), and areas immediately adjacent to the lake tend to be moderately steep (with 8-15% slopes).

Most of the Highland Lake Watershed (approximately 72%) is covered by glacial till. Nearly all of the watershed's soils are from the Paxton-Woodbridge-Hollis association. Paxton soils are deep, well-drained, fine sandy loams that formed in glacial till and have a compact layer at 17-25 inches. Woodbridge soils are generally found at lower elevations in less steep areas. Hollis soils are somewhat excessively drained, shallow to bedrock areas on crests of ridges or surrounded by Paxton soils (USDA NRCS 1974).

Highland Lake watershed soils tend to be well drained to moderately well-drained coarse-textured soils that range from fine to very stony sandy loams. About 18% of the watershed's soils are characterized as very poorly drained, or hydric, soils.

Land Use Inventory

The results of the Highland Lake watershed land use inventory are depicted in Table 1 (following page). The various land uses are categorized by developed vs. undeveloped land. The developed land area comprises approximately 17% of the watershed and the undeveloped land, including the surface area of Highland Lake, comprise the remaining 83% of the watershed. These numbers may be used to help make future planning and conservation decisions relating to the Highland Lake watershed. The information in Table 1 was also used as a basis for preparing the Total Maximum Daily Load report (see Appendices).

Descriptive Land Use and Phosphorus Export Estimates

Agriculture and Forestry - The amount of land used for agricultural and silvicultural purposes in the Highland Lake watershed is comparatively minimal to other land uses. Land acreages were measured using (1998) air photos and (1977) USGS topographical maps with follow-up field visits throughout the entire watershed to confirm (ground-truth) the current use of fields and woodlots. It appears that many grassland areas in the watershed have been converted to residential properties during the past 12 years. Only a single, small working farm is currently present in the watershed (MACD 2002). There are currently two large tracts of land in the watershed (one in Windham and one in Falmouth) that are in Tree Growth management. These tracts are harvested every ten years and there would likely be an increase in soil erosion and runoff during times of harvest (Tamara Pinard, personal communication 2002).

Agriculture accounts for only 2.2% of the total land area of watershed and 9% of the phosphorus loading (Table 1). Hayland is estimated to contribute the most phosphorus (6%) with pasture contributing the remaining phosphorus load (3%). All hayland in the watershed was determined

Table 1. HIGHLAND (Duck) Lake Direct Watershed - Land Use and P-Load Summary.

LAND USE CATEGORY	Total Land Area Acres		Total Land Area %	TP Export Total %
Agricultural Land				
Low-Intensity Hayland (Non-Manured)	84		1.6	6.4
Pasture	33		0.6	3.2
Sub-Totals	**117**		**2%**	**10%**
Shoreline Development				
Low Impact Residential	45		0.9	1.3
Medium Impact Residential	65		1.2	3.8
High Impact Residential	32		0.6	2.6
Septic Systems	—		0.0	9.6
Camp and Private Roads	62		1.2	14.6
Sub-Totals	**204**		**4%**	**32%**
Non-Shoreline Development				
Low Density Residential	476		9.1	4.9
Commercial Property	11		0.2	5.7
State Roads	28		0.5	14.1
Town Roads	32		0.6	1.9
Cemeteries	1		0.0	0.1
Institutional and Recreational	9		0.2	1.5
Sub-Totals	**557**		**11%**	**28%**
Total: DEVELOPED Land	**878**	**HIGHLAND**	**17%**	**70%**
Non-Developed Land				
Inactive/Passively Managed Forest	2,894		55.4	13.7
Wetlands	530		10.2	1.3
Scrub Shrub	296		5.7	3.5
Total NON-DEVELOPED Land	**3,720**	**HIGHLAND**	**71%**	**18%**
Total Surface Water (Atmospheric)	**623**		**12%**	**12%**
TOTAL DIRECT WATERSHED	**5,221**	**HIGHLAND**	**100%**	**100%**

(through field observation) to be “low intensity” - meaning that the land is minimally fertilized and cut only once or twice a year.

Shoreline Residential Lots (Houses and Camps): A total of 248 homes populate the lakeshores and an estimated 300 homes occupy the shoreland zone (within 250 feet of high water line). Based on a shoreline survey with a lot-by-lot cottage count, there are 131 seasonal (53%) and 117 year-round (47%) dwellings on the immediate shoreline of Highland Lake.

In order to evaluate the impact of lake shoreline homes, project staff conducted a shoreline survey in the summer of 2002 with the assistance of Maine DEP, Highland Lake Association and Cumberland County SWCD. This visual survey was carried out while observing the Highland Lake shoreline from boats and the results are based on subjective determinations of potential impact rates using best professional judgment. The visual survey included a residential structure tally along with estimating a potential NPS pollution impact rating ranging from 1 to 5, with 1 being low-impact and 5 being high-impact. A lot given a score of 1 would be a best case scenario, generally undeveloped and having a full naturally occurring vegetated buffer. Conversely, a lot given a score of 5 would be a worst case scenario, exhibiting little or no vegetative buffer (natural or ornamental) and supporting bare (eroding) soil - a visible source of phosphorus input to the lake. In addition to the impact rating, project staff estimated the residency status of the dwelling (seasonal vs. year-round), the relative distance of the dwelling to the lake, the percent slope of the lot, the presence or lack of vegetated buffers, presence of bare soils, existing rip rap, and other notable features such as presence of retaining walls or boat launches. A summary of the survey results for Highland Lake is depicted in Table 2. In order to protect landowner confidentiality, detailed spreadsheets (by map and lot #) developed as part of the survey will only be distributed to local stakeholders for use in future nonpoint source BMP implementation work.

Table 2: Results of 2002 Highland Lake Shoreline Survey

Variable	Number	Percent
Total number of lots surveyed	284	n/a
Number of developed lots	248	n/a
Average impact rating	3.0	n/a
Dwellings less than 100’ from lake	202	82%
Lot on steep slope of more than 20%	78	28%
Inadequate shoreline buffer	127	45%
Bare soil evident	63	22%
Existing shoreline riprap evident	34	12%
“Good” natural vegetation present	92	32%
“High impact” lots	83	30%
“Medium impact” lots	137	48%

Findings of the shoreline residential survey show evidence of a high percentage of inadequate shoreline buffers on lakefront lots (45%) on Highland Lake. There is also a reasonably high percentage of steep slopes along the shoreline (28%) and a high percentage of dwellings less than 100 feet from Highland Lake (82%).

In addition to completion of the shoreline survey, more than 300 property tax files were reviewed at the Falmouth and Windham town offices (no shoreline residences are located in the City of Westbrook). These files were used to confirm the determination of seasonal vs. year-round properties and lot sizes, as well as septic system information.

- *To convert kg of total phosphorus to pounds—multiply by 2.2046*
- *To convert kg/hectare to lbs/acre—multiply by .892*

Phosphorus loading from Highland Lake shoreline residential areas is categorized into low, medium, and high impact rating classes. These ratings are derived directly from the shoreline visual survey impact classes. The lot sizes have been calculated for each of the three impact ratings and an average lot size is used and multiplied by the phosphorus loading coefficient developed using information on residential lot stormwater export of algal available phosphorus from Dennis et al (1992) . For Highland Lake, shoreline residential sites (not inclusive of septic systems) are estimated to contribute 8% of the total watershed (external) phosphorus load. Low impact sites contribute only 4.6 kg/yr of the TP-load, medium impact sites contribute 13.2 kg/yr, and high impact sites (which comprise only 0.6% of the total land area within the watershed) annually contribute 9 kg of the external, watershed derived TP-load to Highland Lake.

A developed shoreline lot with a naturally vegetated buffer on Highland

Shoreline Septic Systems - It is important to consider the potential for total phosphorus loading from septic systems due to the combination of compounding factors present: (1) high percent of homes in close proximity to the lake; (2) high percent of homes built on relatively steep slopes; and (3) the prevalence of some sandy, highly permeable glacial outwash soils. Approximately 28% of the shoreline lots exceed 20% slope (MACD PCAP-TMDL Project Team 2002). These steep areas are dominated, in part, by sandy soils which provide a poor and often inadequate filter (low phosphorus retention rate) for septic system effluent (SCS 1982).

In the summer of 2002, septic system related data were gathered from town records in order to obtain a baseline of information on the status of shoreline septic systems. After 1974, the towns of Falmouth and Windham required landowners within the Shoreland Zone to register their new septic systems at the Town Office.

Overall, more than 300 files for private lots were reviewed and a total of 220 files for dwellings were evaluated within the Shoreland Zone of Highland Lake. The phosphorus loading for each individual septic system was determined based on the following selected attributes: seasonal or year-round occupancy; estimated age of the system; estimated distance of the system to the lake; and a standard 3 people per dwelling. These attribute values were determined by shoreline survey, town records and personal interviews with Windham, Falmouth and Westbrook town officials.

Estimates of the loading from residential septic systems on Highland Lake range from a low of 10 to a high of 50 kg of total phosphorus per year with an average value of 33 kg/yr, representing 9.6% of the watershed P-load, equal to the combined agricultural-silvicultural contribution.

Private/Camp Roadways: The average road width for private roads in the Highland Lake watershed are 8.6 meters (28.3 ft). There are 29 linear kilometers (18 miles) of camp roads within the entire watershed. When multiplied by the average road width, camp roads cover 25 hectares (61.8 acres) in the direct Highland Lake watershed. In total, camp roads contribute an estimated 14.6% (50 kg/ha/yr) of TP to the total phosphorus load to Highland Lake. This estimate does take into account the significant number of NPS-BMPs installed in the watershed by the local stakeholders funded through Federal 319 funds.

Overall, shoreline development alone comprises 4% of the total watershed area and contributes 110 kg of total phosphorus annually, approximately 32% of the estimated total phosphorus load.

Other Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreline of Highland Lake - including residential areas, commercial areas, state and town roads, and other land uses such as cemeteries, institutional (public) areas, and recreational areas. The residential area category was determined by counting every housing unit away from the immediate shoreline (635 dwellings) and multiplying the median low density phosphorus loading coefficient (0.5) by the estimated average cleared lot area (0.75 acres). For Highland Lake, the non-shoreline residential land uses contribute an estimated 48.2 kg/yr or 14.1% of the total phosphorus load. Commercial areas - including stores, and restaurants – were determined by field survey and evaluation to contribute an additional estimated 6.7 kg/yr of TP to Highland Lake.

State and Town Roadways – Total phosphorus loading estimates for non-shoreline State and Town roads were calculated using the same methods as camp roads (see page 7). Based on a median phosphorus loading coefficient of 1.5 kg/ha/yr, the total loading for State roads (5 linear miles x average width of 42.5 ft = 11.3 ha) is estimated at 16.9 kg/yr of TP and Town roads (7.11 linear miles x average width of 37.3 ft = 13 ha) is estimated at 19.5 kg/yr of TP, which combine to total 10.6% of the phosphorus load to Highland Lake.

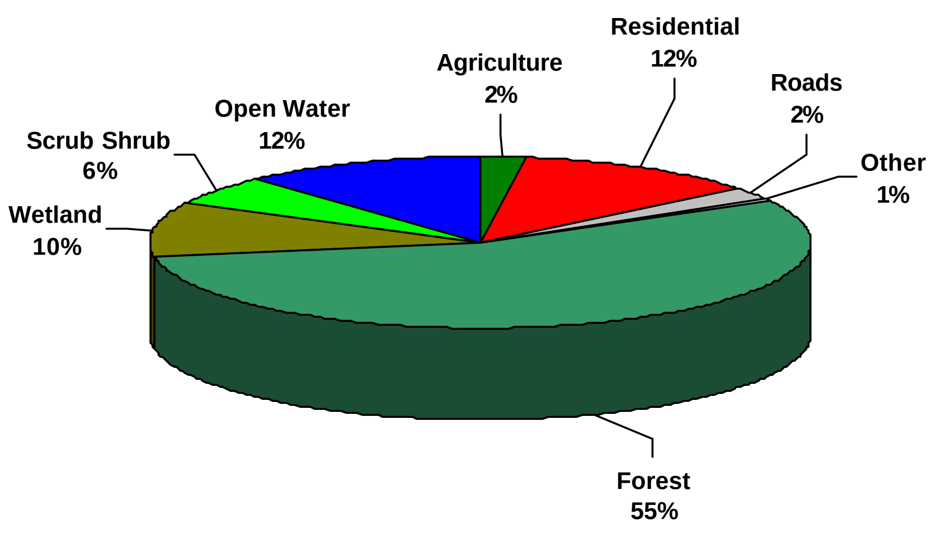
Other - The remaining land uses include a single cemetery, and various public areas (including athletic fields) - which are estimated to contribute 5.5 kg/yr or less than 2% of the total phosphorus loading to Highland Lake.

Phosphorus Loading from Undeveloped Lands

Non-Cultural (Undeveloped) comprises 71.3% of the total land area in the Highland Lake watershed. This includes forested areas, wetlands, and grassland. An estimated 18% of the total phosphorus load to Highland Lake is derived from these non-cultural, natural sources.

Atmospheric Deposition (see Surface Water in Table 1) is estimated to account for 11.98 of the total phosphorus load to Highland Lake. Highland Lake surface water area comprises 623-acres (252 ha), or 12% of the total land area in the Highland Lake watershed.

Figure 2: Highland Lake Land Use Coverage

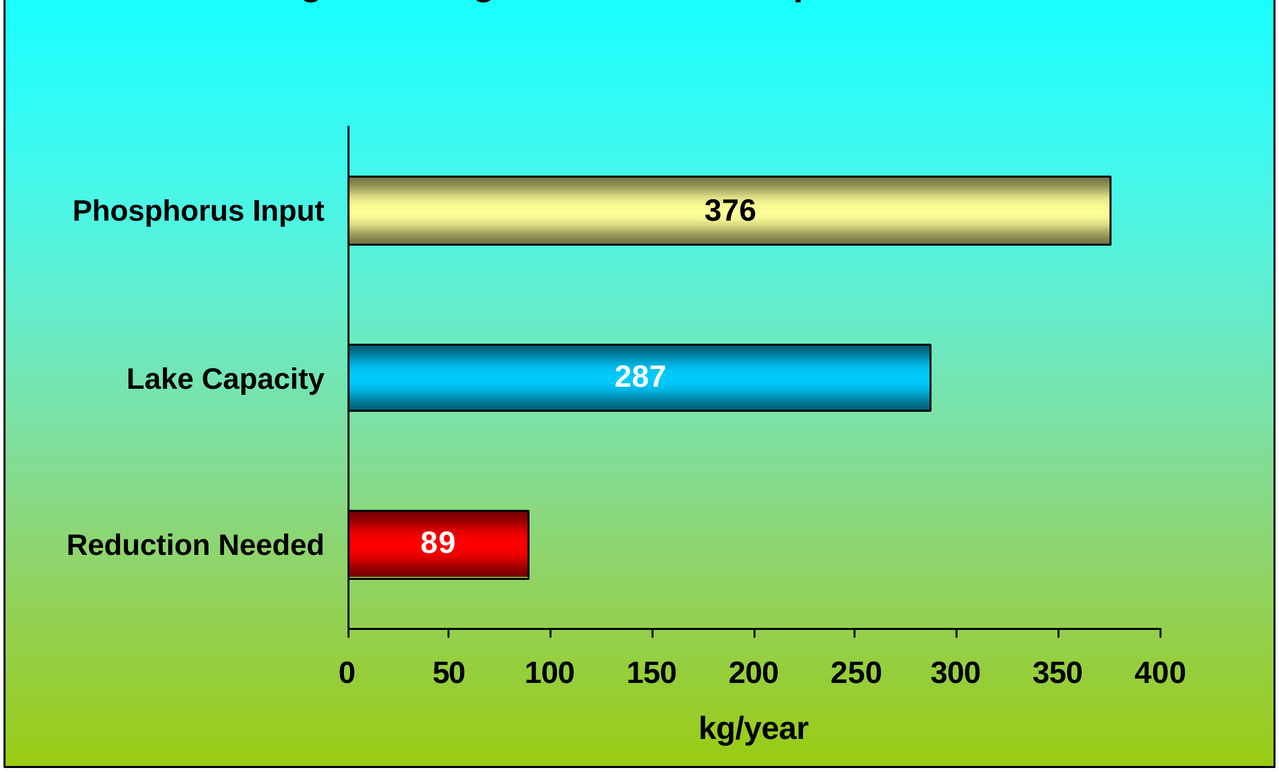


PHOSPHORUS LOADS – Watershed, Bottom Sediment and In-Lake Capacity

Supporting documentation for the phosphorus loading analysis includes the following: water quality monitoring data from Maine DEP and the Volunteer Lake Monitoring Program, watershed-land use maps using GIS-derived data layers, literature-derived export coefficients, and a phosphorus retention model (see Appendices for more detailed information), including both empirical models and retention coefficients.

- External TP sources, averaging 376 kg annually, have been identified and accounted for by the sum of all land use contributions = 343 kg (see Table 3, page 30) + 33 kg (estimated future watershed development). An estimated 60% of the land use derived P-load (206 kg) is from urban-residential properties and can be directly attributed to stormwater runoff.
- At this time, the relative contribution of phosphorus derived from lake bottom sediment (internal sources) in Highland Lake is negligible.
- The load allocation (lake phosphorous assimilative capacity) for all existing and future pollution sources for Highland Lake is 287 kg of total phosphorus per year, based on a stable or decreasing trophic state target goal of 10 ppb.
- Given that reducing algal productivity will also reduce oxygen losses and help maintain healthy coldwater fisheries: then a 89 kg annual reduction in the external (watershed) loading of total phosphorus to Highland Lake will lead to maintaining suitable in-lake nutrient levels (287 kg TP/year) ensuring trophic level stability for future generations.

Figure 3: Highland Lake Phosphorus Loads



PHOSPHORUS CONTROL ACTION PLAN

Highland Lake is a waterbody that has impaired water quality from a combination of point source (regulated stormwater runoff) and nonpoint source (NPS) pollution resulting in excessive amounts of phosphorus being contributed from its watershed. In light of recent and current efforts addressing watershed restoration, identified Best Management Practices (BMP's) and specific actions to reduce watershed derived phosphorus loadings to further improve and maintain suitable water quality conditions in Highland Lake are as follows:

Recent and Current NPS/BMP Efforts

A Maine DEP funded and Cumberland County SWCD sponsored watershed survey was completed during April and May of 1997. Fourteen volunteers conducted the survey in groups of two or three over 8 sectors. The survey identified 104 sites with a high, medium, or low priority ranking. A large number of sites (42%) were grouped in the private road category. State and town roads accounted for another 13%, while residences accounted for 24% of sites. Thirty sites received a "high priority" ranking.

The Cumberland County SWCD has been working with the Highland Lake Association, Maine DEP, Towns of Windham and Falmouth and other lake stakeholders to implement appropriate BMPs in the watershed. A Clean Water Act Section 319 grant for $206,975 was awarded in FFY '99 to install numerous BMPs on both residential and road sites. One component of this project, the Highland Lake Youth Conservation Corps worked to install BMPs on 88 sites in the watershed during 2000 - 2002 and provided technical assistance on 70 sites.

In the spring of 2002, the MACD project team conducted additional inventory field work in the Highland lake watershed. Eight additional sites (all on camp roads) were located and the information provided to the Cumberland County SWCD, the local stakeholder. In addition, 83 sites have been further identified as high impact as part of the shoreline survey conducted by MACD and Maine DEP in the summer of 2002.

The Highland Lake Watershed Management Plan (CC-SWCD 1999) outlines a comprehensive and very effective NPS-BMP implementation plan. In order to avoid duplication of effort, our PCAP-TMDL report focuses solely on specific recommendations that are not listed in the recent CC-SWCD Management Plan.

Recommendations for Future Work

Specific Recommendations - Best Management Practices (BMPs) and actions taken for the reduction of external (both stormwater related and non-point source) total phosphorus loadings to improve water quality conditions in the Highland Lake watershed include:

1) Watershed Management: Since the mid-1990's, the Cumberland County SWCD and Highland Lake Association have taken an active role in documenting and mitigating nonpoint source (NPS) pollution sites throughout the Highland Lake watershed. The last documented survey was performed in 1997 and the Highland lake Watershed Management Plan outlines future plans for the watershed. This plan can help achieve locally supported watershed management programs to facilitate widespread implementation of BMPs or other management measures in order to reduce or eliminate NPS pollution in Highland Lake. The Highland Lake Association, watershed residents, municipal officials and the Maine DEP should all support current efforts to effectively implement the Watershed Management Plan.

Action Item # 1: Implement Existing Watershed Management Plan		
Activity	**Participants**	**Schedule & Cost**
Develop a Highland Lake Leadership Team to oversee Management Plan Implementation	HLA, CC-SWCD, Maine DEP, municipalities, local businesses, watershed citizens	Bi-Annual Roundtable Meetings beginning in 2003— **minimal cost**

2) Agriculture and Forestry – The 1997-98 Highland Lake Watershed Survey did not list any agriculture or forest harvesting sites as problem areas. There are two tracts of land in Tree Growth that need to be monitored for excess runoff during times of harvest (every ten years). A small farm exists with less than 25 animals but no significant water pollution problems were observed at this site. BMP recommendations for agricultural land uses include providing education on conservation practices and planning, as available, from the Cumberland County Soil and Water Conservation District and Natural Resources Conservation Service offices located in Gorham.

Landowners, loggers and foresters working within the watershed should contact the Maine Forest Service (1-800-367-0223) for a copy of Forestry BMP guidelines and other forest management assistance. Special attention should be given to adequate maintenance of forest access roads and the proper use of erosion control measures.

Action Item # 2: Conduct Workshops for Agriculture and Forestry Operators		
Activity	**Participants**	**Schedule & Cost**
Conduct workshops encouraging the use of phosphorus control measures	HLA, CC-SWCD, NRCS, MFS, forestry and agriculture community	Annually beginning in 2003 **$1,000/yr**

3) Shoreline Residential – Numerous residential sites have been identified as having the potential to negatively impact the water quality of Highland Lake. The 1998 watershed survey identified 11 problem residential sites in the watershed and the shoreline survey and field reconnaissance identified another 83 lots as potential problem sites. The cumulative impact of all of these problematic residential sites can significantly add to existing total phosphorus levels in Highland Lake. Large-scale buffer campaigns should be implemented for shoreline lots and educational efforts should be aimed at all landowners and land users on the shoreline of Highland Lake, as well as associated tributary streams.

Action Item # 3: Expand Shoreline Homeowner Education and Technical Assistance Programs		
Activity	**Participants**	**Schedule & Cost**
Increase outreach and education efforts to watershed citizens including technical assistance to landowners	HLA, CC-SWCD, Maine DEP	Annually beginning in 2003 **$1,500/yr includes printing of educational materials**

4) Non-Shoreline Residential and Commercial properties should also be considered as potential problem areas, especially areas adjacent to Highland Lake watershed brooks and streams. It was noted during routine field observations that residences not located on the immediate shoreline are likely to be significant contributors of total phosphorus to the lake. This is partly due to the common clustering of many house lots located on private roads situated 100 –1000 feet away from the lake. Education plans should be encouraged (with the assistance of the Highland Lake YCC) for strategic use of vegetation and improved treatment of stormwater from all residential lots in the watershed. Commercial areas should be included in education and outreach campaigns as many of them can directly benefit from maintaining suitable water quality in Highland Lake and its tributary streams.

Action Item # 4: Develop Stewardship Initiatives for Highland Lake Tributaries		
Activity	**Participants**	**Schedule & Cost**
"Adopt" local streams to promote stewardship efforts including education and water quality monitoring	HLA, CC-SWCD, Maine DEP Stream Team, local schools, and watershed citizens	Annually beginning in 2003 **$500/yr**

5) Septic Systems – Older, poorly designed and installed septic systems within the shoreland zone may contribute significantly to water quality problems, adding to the cumulative total phosphorus load to Highland Lake. MACD PCAP-TMDL project staff worked with the Towns of Falmouth and Windham to analyze the current state of septic systems in the shoreland zone of Highland Lake. While Highland Lake septic systems – when properly sited, constructed, maintained, and set back from the water – should not affect water quality, many septic systems do not meet all of these criteria and thus have the potential to contribute phosphorus and other contaminants to lake water. Septic systems around Highland Lake that are sited in coarse, sandy soils with minimal filtering capacity are especially likely to contribute nutrients to lake waters, as are older septic systems that pre-date Maine's 1974 Plumbing Code.

Recommendations for reducing existing phosphorus inputs include replacement of pre-Plumbing Code septic systems and other poorly functioning systems within the shoreland zone of Highland Lake. Identification of potential problem septic systems can be accomplished through town records and sanitary surveys. Lakeshore residents who believe they may have problems with their septic systems are encouraged to contact their town office for possible technical and/or financial assistance. In some cases, a revolving (Maine DEP) loan fund could be established to assist in the replacement of malfunctioning septic systems. Above all, educational efforts should make lake residents aware of impending problems and possible cost-effective solutions. The Town of Windham has been fairly proactive with septic system issues, having conducted a septic survey and distributed educational materials around Highland Lake in 1995. Both the Towns of Windham and Falmouth have implemented inspection and replacement programs and promoted grant programs such as the Maine DEP's Small Communities Program to help landowners finance new/ improved septic systems.

Additional measures may be needed, however, to protect Highland Lake from septic system pollution. Each municipality, including Windham, should consider conducting a comprehensive inventory of watershed septic systems (including pump out records), distributing educational materials to watershed landowners and requiring septic system inspections during all property sales (CCSWCD 1999).

Action Item # 5: Encourage Updating Septic Systems for some Highland Lake Shoreline Properties		
Activity	**Participants**	**Schedule & Cost**
Seek replacement of pre-Plumbing code (1974) septic systems and other poorly functioning systems	HLA, CC-SWCD, watershed municipalities and watershed citizens	Annually beginning in 2003 **Cost will vary**

6) Roadways – The 1998 Highland Lake watershed survey identified 14 problem sites on state and town roads and 44 problem sites on camp and private roads. In addition, MACD road survey work during 2002 identified 8 additional camp and private road sites. While these sites are generally more complex and costly to repair than residential home sites, the long-term savings to the town and landowners may be substantial. It is not unthinkable to treat all potential problem sites on state and town roads located in the lake watershed. Camp and private roads offer more of a challenge, due to ownership issues and the complex nature of maintaining gravel roads in the Highland Lake watershed.

Action Item # 6: Implement Roadway Best Management Practices		
Activity	**Participants**	**Schedule & Cost**
Continue to Implement Roadside BMPs watershed-wide	HLA, CC-SWCD, municipalities, watershed road associations	Annually beginning in 2003 **$10,000/yr**

The Cumberland County SWCD has worked extensively on roadside BMP projects on state, town and private roads. To date, 21 sites have been addressed through the current 319 grant and over 112 tons of sediment have been saved from entering Highland Lake as a result (CC-SWCD 2003).

7) Municipal actions should include ensuring public compliance with local and state water quality laws and ordinances (Shoreland Zoning, Erosion and Sedimentation Control Law, Plumbing Code) through education and enforcement action, only when necessary.

Water Quality Monitoring Plan: Historically, the water quality of Highland Lake has been monitored via measures of Secchi disk transparencies during the open water months since 1974 (Maine DEP and VLMP). Continued long-term water quality monitoring of Highland Lake will be conducted bi-weekly, from May to October, through the continued efforts of VLMP, in cooperation with Maine DEP and the Highland Lake Association. Under this planned, post PCAP-TMDL water quality-monitoring scenario, sufficient data will be acquired to adequately track seasonal and inter-annual variation and long-term trends in water quality in Highland Lake. A post-TMDL status update (adaptive management) report will be prepared 5-10 years following EPA final approval.

PCAP Closing Statement

The current level of watershed and lakeshore restoration work nearing completion within the Highland Lake watershed is a very promising feature. Direct results of all of the hard work of the Cumberland County SWCD, as supported by Maine DEP and the Highland Lake Association, is evidenced by viewing the completed projects in the watershed and talking to the enthusiastic lake watershed residents. The Youth Conservation Corps continues to effectively implement projects in the Highland Lake watershed under the direction of the Highland Lake Association. Both of the towns of Windham and Falmouth are very proactive in implementing lake protection efforts and providing support for existing lake/watershed improvement efforts. In all, adequate tools are in place for the continued protection and improvement of the Highland Lake watershed and lake water quality. Future post PCAP-TMDL funding should be directed to the lake/watershed stakeholders to further support and build upon existing, successful projects and programs.

Highland Lake TMDL/Phosphorus Control Action Plan

APPENDICES

Maine Lake TMDLs and Phosphorus Control Action Plans (PCAPs)

You may be wondering what the acronym 'TMDL' represents and what it is all about. TMDL is actually short for 'Total Maximum Daily Load.' This information, no doubt, does little to clarify TMDLs in most people's minds. However, when we think of this as an annual phosphorus load (*Annual Total Phosphorus Load),* it begins to make more sense.

Simply stated, excess nutrients or phosphorus in lakes promote nuisance algae growth/blooms - resulting in the violation of water quality standards as measured by water clarity depths of less than 2 meters. A lake TMDL is prepared to estimate the total amount of total phosphorus that a lake can accept on an annual basis without harming water quality. Historically, development of TMDLs was first mandated by the Clean Water Act in 1972, and was applied primarily to *point sources* of water pollution. As a result of public pressure to further clean up water bodies, lake and stream TMDLs are now being prepared for watershed-generated *Non-Point Sources* (NPS) of pollution.

Nutrient enrichment of lakes through excess total phosphorus originating from watershed soil erosion has been generally recognized as the primary source of NPS pollution. Major land use activities contributing to the external phosphorus load in lakes include residential-commercial developments, roadways, agriculture, and commercial forestry. Statewide, there are 38 lakes in Maine which do not meet water quality standards due to excessive amounts of in-lake total phosphorus.

The first Maine lake PCAP-TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. PCAP-TMDLs have been approved by US-EPA for Madawaska Lake (Aroostook County), Sebasticook Lake, East Pond (Belgrade Lakes), and China Lake. PCAP-TMDLs are presently being prepared by Maine DEP, with assistance from the Maine Association of Conservation Districts (MACD) and County Soil and Water Conservation Districts (SWCDs) - for Mousam Lake in southern Maine (final EPA review). Ongoing PCAP-TMDL lake studies include: Long and Highland lakes (Bridgton); Threecornered, Webber, and Threemile Pond (Kennebec County); Annabessacook & Little Cobbossee lakes & Pleasant & Upper Narrows Ponds - the latter two under separate contract with CWD. A non-MACD supported PCAP-TMDL for Unity Pond (Waldo County) is also being developed with the assistance of Unity College staff. PCAP-TMDL studies have also been initiated for Sabattus, Togus, and Lovejoy ponds.

Lake TMDL reports are based in part on available water quality data, including seasonal measures of total phosphorus, chlorophyll-a, Secchi disk transparencies, and dissolved oxygen-water temperature profiles. Actual reports include: a lake description; watershed GIS assessment and estimation of NPS pollutant sources; selection of a total phosphorus target goal (acceptable amount); allocation of watershed/land-use phosphorus loadings, and a public participation component to allow for stakeholder review.

TMDLs are important tools for maintaining and protecting acceptable lake water quality. They are primarily designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to address the problem. Landowners and watershed groups are eligible to receive technical and financial assistance from state and federal natural resource agencies to reduce watershed total phosphorus loadings to the lake.

For further information, please contact Dave Halliwell, Maine Department of Environmental Protection, Lakes PCAP-TMDL Program Manager, SHS #17, Augusta, ME 04333 (287-7649).

Water Quality Monitoring data for Highland Lake has been collected from the deep hole station (01) since 1974. Continuous Secchi disk transparency (SDT) measures have been obtained to the present, with the exception of 1984 (Maine VLMP 2002). During this 28 year water quality sampling period, 12 years of chlorophyll-a and basic chemical information was collected, including measures of total phosphorus (core and grab samples).

Water Quality Measures – Although considered a single basin lake, the water quality in Highland Lake may differ somewhat between the deeper northern portion of the lake (50 to 60 foot depths) and the southern, more shallow end (10-20 foot depths). Overall, Highland Lake is a <u>non-colored</u> waterbody – with an average of 17 color units (SPU's). Average minimum summer water column transparencies vary from 2 to 10 meters, while the range of water column (epilimnion core vs. bottom grab) TP for Highland Lake averages only 9-10 ppb. Chl-a measures range from 1.3 to 8.0 ppb, with an average of 3.5 ppb. Recent dissolved oxygen (DO) profiles show significant levels of DO depletion in deep areas of the lake: below 5 parts per million (ppm), and in most cases approaching and dropping below 2 ppm in approximately <u>75 percent</u> of the water column (below 5-6 meters down to the 20 m bottom) at the deep hole sample station. These numbers translate to a realized dissolved oxygen deficiency of 47 to 60 percent on the basis of lake volume and area, respectively.

Historically, there has been a gradual decline in Highland Lake's water quality. Dissolved oxygen readings recorded in 1996 and 1997 were the lowest readings observed since Maine DEP/ VLMP record keeping began in 1974. The average dissolved oxygen in the hypolimnion (bottom layer) during September dropped from a high of 3.0 parts per million (ppm) in 1975 to 2.5 ppm in 1980; 1.6 ppm in 1990; 0.5 ppm in 1995; and, most recently, 0.3 ppm in 1997 (CC-SWCD 1999).

Trout and other coldwater fish require oxygen levels greater than 5 ppm to survive and even higher levels (7-8 ppm) to grow and reproduce. Since dissolved oxygen levels in Highland Lake's hypolimnion fall far below this level in most summers, it is assumed that the lake has experienced a moderate to severe reduction in coldwater fish habitat (CC-SWCD 1999).

A gradual decline in water clarity has also been documented. Based on Highland Lake's Secchi disk trend analysis, it appears there has been a negative trend in Highland Lake's mean and seasonal minimum Secchi disk transparency values (Maine DEP 1997). The average annual secchi disk reading for the eleven-year period from 1985 to 1995 was 5.5 meters, whereas from 1975 to 1984 the average was 6.4 meters (Figure 2). This average overall decline of nearly one meter corresponds to the decline in dissolved oxygen and signals an increase in algal biomass and sediment deposition.

The USGS, Maine DEP, Portland Water District (PWD), HLA, University of New Hampshire, and University of Maine (Orono) have periodically measured additional water quality parameters including pH (acidity), chlorophyll-a (a rough measure of algae), nutrients and alkalinity. The chlorophyll-a, total phosphorus and Secchi disk values have been used to determine Highland Lake's productivity, or Trophic State Index (TSI). According to these data Highland Lake has moderate algal production usually associated with above average transparency (5.5 vs. 4.9 meters) and average chlorophyll-a.

Priority Ranking and Algae Bloom History- At this point, Highland Lake's trophic status indicates that the lake has only moderate algal production, and impairment has been limited to declines in water clarity and mid to deep-water/hypolimnetic dissolved oxygen. However, if current declining water quality trends continue without mitigation, it is only a matter of time before the lake's water quality is further degraded (CC-SWCD 1999). Hypolimnetic dissolved oxygen levels have apparently declined over the past decade and water quality standards, in terms of providing coldwater fish habitat, are not being met. At this time, there are no prevalent nuisance summer algal blooms (a.k.a. 'China Lake Syndrome'). Highland Lake is currently on the State's 303(d) listing of lakes in non-attainment of water quality standards (Maine DEP 2002 draft) by virtue of a significant declining trend in water transparency over the past decade, concurrent with observed declines in dissolved oxygen levels. Together these data indicate a documented trend of increasing trophic state and hence a violation of the Class GPA criteria requiring a stable or decreasing trophic state.

Natural Environmental Background levels for Highland Lake were not separated from the nonpoint source load because of the limited and general nature of available information. Without more and detailed site-specific information on non-point source loading, it is very difficult to separate natural background from the total non-point source load (US-EPA 1999).

WATER QUALITY STANDARDS & TARGET GOALS

Maine State Water Quality Standard for nutrients which are narrative, are as follows *(July 1994 Maine Revised Statutes Title 38, Article 4-A*): "Great Ponds Class A (GPA) waters shall have a stable or decreasing trophic state (based on appropriate measures, e.g., total phosphorus, chlorophyll a, Secchi disk transparency) subject only to natural fluctuations, and be free of culturally induced algae blooms which impair their potential use and enjoyment."

Maine DEP's functional definition of nuisance algae blooms include episodic occurrence of Secchi disk transparencies (SDTs) < 2 meters for lakes with low levels of apparent color (<26 SPU) and for higher color lakes where low SDT readings are accompanied by elevated chlorophyll a levels. Highland Lake is a non-colored lake (average color 17 SPUs), with relatively high late summer minimal SDT readings (overall average of 5.7 meters), in association with fairly low chlorophyll a levels (3.5 ppb avg.). Currently, Highland Lake does not meet water quality standards due to a significant decline in water transparency trends over time and hence a trend of increasing trophic state. This water quality assessment uses historic documented conditions as the primary basis for comparison.

Designated Uses and Antidegradation Policy: Highland Lake is designated as a GPA (Great Pond Class A) water in the Maine DEP state water quality regulations. Designated uses for GPA waters in general include: water supply; primary/secondary contact recreation (swimming and fishing); hydro-electric power generation; navigation; and fish and wildlife habitat. No change of land use in the watershed of a Class GPA water body may, by itself or in combination with other activities, cause water quality degradation that would impair designated uses of downstream GPA waters or cause an increase in their trophic state. Maine's anti-degradation policy requires that "existing in-stream water uses and the level of water quality necessary to sustain those uses, must be maintained and protected."

Numeric Water Quality Target: The water quality goal for Highland Lake is to halt its trend of increasing trophic state so that it can meet the water quality standard of stable or decreasing trophic state. The numeric (in-lake) water quality target to meet this goal for Highland Lake is conservatively set at 10 ppb total phosphorus to reflect current trophic state. Since numeric criteria for phosphorus do not exist in Maine's state water quality regulations - and would be less accurate targets than those derived from this study - we employed best professional judgment to select a target in-lake total phosphorus concentration that would attain the narrative water quality standard. Spring-time total phosphorus levels in Highland Lake averaged approximately 8-12 ppb historically (1974-2002), while in-lake (epilimnion core) total phosphorus summer-time (June through August) measures ranged from 6-14 ppb (non-bloom conditions), In summary, the numeric water quality target goal of 10 ppb for total phosphorus in Highland Lake was based on available water quality data (average epilimnion grab/core samples) corresponding to continued maintenance of current trophic conditions.

TOTAL PHOSPHORUS LAND USE LOADINGS

Estimates of total phosphorus export from different land uses found in the Highland Lake direct watershed are presented in Table 3 (following page) and represents the extent of direct external phosphorus loading to the lake. Total phosphorus loading from the associated upstream Little Duck Pond (4.5 kg/yr) accounts for loading from the indirect watershed determined on the basis of *flushing rate x volume x TP concentration* (Jeff Dennis, personal communication).

Key for Columns Depicted in Table 3

Land Use Class: The land use category that was analyzed for this report

Land Area Acres: The area of each land use as determined by GIS mapping, aerial photography, DeLorme Topo USA software, and field reconnaissance.

Land Area %: The percentage of the watershed covered by any given land use category.

TP Coeff. Range kg/P/ha: The range of the coefficient values listed in the various literature associated with the corresponding land use.

TP Coeff. Value kg/P/ha: The selected coefficient for each land use category. The total phosphorus coefficient is determined from previous research – usually the median value, if it is provided by the author. The coefficient is often adjusted using best professional judgment based on conditions including soil type, slope, BMPs installed, and in some cases, estimates of bioavailability (or algal available P).

Land Area Hectares: (conversion) 1 Acre = .404 hectares

TP Export Load kg P: = Total hectares multiplied by the selected TP coefficient value.

TP Export Total %: The percentage of estimated phosphorus export by the land use.

Total phosphorus loading measures are expressed as a range of values to reflect the degree of uncertainty associated with such relative estimates (Walker 2000). Watershed total phosphorus loadings were primarily determined using published literature and locally-derived export coefficients as found in Reckhow et al. (1980), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for roadways, agriculture and other types of land uses (institutional, commercial).

The selected (range of) phosphorus loading coefficients in Table 3 have been adjusted for the estimated bioavailability of urban runoff sources according to available literature (Lee et al. 1980 and Sonzogni et al. 1982) and better reflect algal available-P export values as reported in Dennis et al. (1992). These adjustments account not only for the readily available SRP (soluble-reactive-phosphorus) in the runoff, but also a substantial portion of the particulate inorganic component, particularly the P which is weakly adsorbed on the surface of soil particles (relative to discussion in Chapra 1997, pg. 524). Note: these necessary adjustments in P-load coefficients did not effectively alter the overall conclusions and final recommendations of the Highland Lake PCAP-TMDL report regarding identified needs and NPS/BMP implementation plans for the Highland Lake watershed.

Agricultural/Forest Operational Practices: Total phosphorus loading coefficients applied to agricultural practices were adopted from Reckhow (hayland 0.64 kg/TP/ha, pasture 0.81 kg/TP/ha).

Shoreline Residential Lots (House and Camp): The range of total phosphorus loading coefficients used (0.25 – 2.70 kg/ha/yr) were adopted from the original (EPA approved) Cobbossee Lake TMDL (ATPL), Maine (Monagle 1995, Maine DEP 1999).

Private Camp Roads: Phosphorus loading coefficients for private camp roads (2.00 kg/TP/ha) were chosen based on studies from rural Maine highways (Dudley et al. 1997), taking into account biologically available phosphorus contributions (Jeff Dennis, personal communication).

Table 3. HIGHLAND (Duck) Lake Direct Watershed - Phosphorus Export by Land Use Class.

LAND USE CLASS	Land Area Acres	Land Area %	TP Coeff. Range kg/P/ha	TP Coeff. Value kg/P/ha	Land Area Hectares	TP Export Load kg P	TP Export Total %
Agricultural Land							
Hayland (Non-Manured)	84	1.6	0.35 -1.35	0.64	34	21.8	6.4
Pasture	33	0.6	0.14 -4.90	0.81	13	10.8	3.2
Sub-Totals	**117**	**2%**			**47**	**33**	**9.6%**
Shoreline Development							
Shoreline Low Impact Residential	45	0.9	0.25 - 1.75	0.25	18	4.6	1.3
Shoreline Med. Impact Residential	65	1.2	0.40 - 2.20	0.50	26	13.2	3.8
Shoreline High Impact Residential	32	0.6	0.56 - 2.70	0.70	13	9.0	2.6
Residential Septic Systems	**HIGHLAND**	0.0	**Lake**	**Septic**	**Model**	33.0	9.6
Camp and Private Roads	62	1.2	0.60 -10.0	2.00	25	50.0	14.6
Sub-Totals	**204**	**4%**			**82**	**110**	**32%**
Non-Shoreline Development							
Low Density Residential	476	9.1	0.25 - 1.75	0.25	193	48.2	14.1
Commercial Property	11	0.2	0.77 - 4.20	1.50	4	6.7	1.9
State Roads	28	0.5	0.60 -10.0	1.50	11	16.9	4.9
Town Roads	32	0.6	0.60 -10.0	1.50	13	19.5	5.7
Cemeteries	1	0.0	0.14 - 1.90	0.80	1	0.3	0.1
Institutional and Recreational	9	0.2	0.77 - 4.18	1.50	3	5.2	1.5
Sub-Totals	**557**	**11%**			**225**	**97**	**28.2%**
Total: DEVELOPED Land	**878**	**17%**	**HIGHLAND**	**Lake**	**360**	**239**	**69.8%**
Non-Developed Land							
Inactive/Passively Managed Forest	2,894	55.4	0.01 - 0.04	0.04	1,171	46.8	13.7
Wetlands	530	10.2	0.00 - 0.05	0.02	215	4.3	1.3
Scrub Shrub	296	5.7	0.10 - 0.20	0.10	120	12.0	3.5
Total: NON-DEVELOPED Land	**3,720**	**71%**	**HIGHLAND**	**Lake**	**1,506**	**63**	**18.4%**
Total Surface Water (Atmospheric)	**623**	**12%**	0.11 - 0.21	0.16	**252**	**40**	**11.8%**
TOTAL DIRECT WATERSHED	**5,221**	**100%**	**HIGHLAND**	**Lake**	**2,113**	**343**	**100.0%**

Public Roadways: Town and state roadways were assigned a total phosphorus loading rate of 1.5 kg per hectare per year. This available phosphorus loading coefficient was chosen based on studies from rural Maine highways (Dennis 2002).

Non-Shoreline Development: Non-shoreline residential areas in the watershed are best characterized as low density residential, as reflected in the 0.25 TP loading coefficient.

Total Cultural Phosphorus Loading: A total of 70% (239 kg) of the total phosphorus loading to Highland Lake is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture (9.6% - 32.6 kg); non-shoreline development (including roadways (28.2% - 96.8 kg) and shoreline development (32% - 109.8 kg), including septic systems (9.6% - 33 kg) and camp/private roads (14.6% - 50 kg) – as depicted in Table 3.

Non-Cultural Phosphorus Loading: The phosphorus export coefficient for forested land (0.04) is based on a northeast US regional study (Likens et al 1977). The lower total phosphorus loading coefficient chosen for atmospheric deposition (0.16 kg/P/ha) is similar to that used for the China Lake TMDL (Kennebec County), while the upper range (0.21 kg/P/ha) generally reflects a watershed that is 50 percent forested, combined with agricultural areas interspersed with urban/ suburban land uses (Reckhow et al. 1980). Other Non-Cultural Land Uses: combined wetlands, and old field scrub shrub accounts for the remaining 4.8% (16.3 kg) of the total non-cultural total phosphorus export load – 63.1 kg.

Atmospheric Deposition and Dry Fallout: Highland Lake surface waters (252 ha) comprise 12% of the total watershed area (2,113 ha) and account for an estimated 40.3 kg of total phosphorus, representing 11.9% of the total phosphorus load entering Highland Lake.

Phosphorus Load Summary

Highland Lake total phosphorus loads approximate 376 kg annually - less the 287 from in-lake processing capacity, which equals 89 kg as the amount of total annual phosphorus needed to be reduced on an annual basis to attain suitable water quality (stable and/or decreasing trophic status). This phosphorus reduction estimate includes the additional 32.5 kg needed to be reduced, given reasonable watershed development rates based on Maine DEP standards. This total annual phosphorus reduction of 89 kg may be attained given adequate reductions in either or both external watershed phosphorus loads and regulated stormwater discharges into Highland Lake. Such actions will ultimately result in stabilizing and perhaps ultimately reversing the downward trophic trend and providing gradual improvement in Highland Lake water quality over time.

It is our best professional opinion that the selected export coefficients are appropriate for the Highland Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external (watershed generated) nonpoint source pollution averages 343 kg TP/yr. This 'average' annual external watershed generated loading to Highland Lake equates to a total phosphorus loading modeled at 12 ppb (344 kg) - 57 kg above the TMDL target goal of 10 ppb (287 kg TP/year).

LINKING WATER QUALITY & POLLUTANT SOURCES

The Highland Lake TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity, or other appropriate measures. It is thought appropriate to express the Highland Lake TMDL as an annual load, in part because the lake has a relatively long hydraulic residence time (0.70 flushes per year or less than 1/2 of the Maine state average of 1.50).

The lake assimilative capacity for all existing and future non-point pollution sources for Highland Lake is capped at 287 kg TP/yr - as derived from the empirical phosphorus retention model based on a target (springtime P-concentration) goal of 10 ppb. This value reflects the modeled annual phosphorus load that yields Highland Lake's current trophic state.

Future Development: In order to effectively meet the stated goal of maintaining current trophic state, further reductions in existing watershed phosphorus loading is necessary for two important reasons. First, Highland Lake has a flushing rate of only 0.70 times per year (annual residence time of 1.43 years) and is a well-mixed waterbody. Hence, much of the phosphorus laden water in the lake entered from 2 to 5 years ago. Some development has occurred in the watershed over the past 5 years, no doubt resulting in an increase in annual phosphorus loading from the watershed. Given the lag time in lake response to this additional P-load, existing annual watershed phosphorus loads should be reduced by at least the amount of increase in load over the past 5 years. The unmitigated rate of increase in Highland Lake's annual phosphorus load due to new development approximates 2.5 kg TP/yr, or 12.5 kg TP over a 5 year period (Dennis et al. 1992 application).

The Maine DEP water quality goal of maintaining a stable trophic state includes a reduction of current P-loading which accounts for both recent P-loading as well as potential future development in the watershed. The methods use by Maine DEP to estimate future growth (Dennis et al. 1992) are inherently conservative, as they provide for relatively high-end regional growth estimates and largely un-mitigated P-export from new development. This provides an additional non-quantified margin of safety to ensure the attainment of state water quality goals.

This amount is a conservative estimate, since most of the development during this period (1998-2002) did in fact incorporate measures to mitigate stormwater phosphorus export from the Highland Lake watershed. The second reason for reducing existing watershed phosphorus loading is that growth will continue to occur in the watershed, contributing new sources of phosphorus to the lake - even with the incorporation of strict phosphorus export controls. Hence, existing phosphorus load sources must be reduced to allow for anticipated new sources of phosphorus to the lake. The towns of Falmouth and Windham have incorporated land use ordinances that, along with the state's Stormwater Management Law, have the long term goal of limiting total future increases in annual phosphorus load, attributable to permitted development, to approximately 20 kg TP/yr.

Based on the above discussion, the trend of increasing trophic state in Highland Lake can be halted and the trophic state maintained at current levels, well into the future - if (1) the Towns of Falmouth and Windham and the state continue to implement local ordinances and state law, and (2) if the existing watershed phosphorus loading is reduced by 32.5 kg TP/yr (12.5 kg + 20 kg). Reductions already underway in nonpoint source total phosphorus loadings are expected from the continued implementation of best management practices - primarily from improvements to camp roads and shoreline septic systems (see NPS/BMP Implementation Plan and PCAP Summary).

Internal Lake Sediment Phosphorus Mass - the relative contribution of internal sources of total phosphorus within Highland Lake - in terms of sediment recycling – were evaluated between early and late summer on the basis of water column TP data from 1999 and 2002. These were the only two years for which adequate lake profile TP concentration measures were available to derive reliable estimates of internal lake mass. Given the relatively low levels of phosphorus in the water column and in the absence of nuisance algae blooms, it was expected that internal sediment derived phosphorus mass would not be a major problem in Highland Lake. Internal sediment total phosphorus mass appears to have declined through the summer months, but not to the same extent as was found in Mousam Lake in York County. If the external watershed total phosphorus load is not maintained at or below current levels, it can be expected that the sediment recycling of total phosphorus will become more apparent in future years.

Linking Pollutant Loading to a Numeric Target - The basin loading assimilative capacity for Highland Lake was set at 287 kg/yr of total phosphorus to meet the numeric water quality target of 10 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to the numeric target.

Supporting Documentation for the Highland Lake TMDL Analysis –includes the following: Maine DEP and VLMP water quality monitoring data and specification of a phosphorus retention model – including both empirical models and total phosphorus retention coefficients.

Total Phosphorus Retention Model

Highland Lake Basin

(after Dillon and Rigler 1974 and others)

L = P (A z p) / (1-R) where,

287 = **L** = in-lake assimilative TP load capacity (kg TP/year)

10 = **P** = spring overturn total phosphorus concentration (ppb)

2.5 = **A** = lake basin surface area (km^2)

7.5 = **z** = mean depth of lake basin (m) **A z p = 13.2**

0.7 = **p** = annual flushing rate (flushes/year)

0.46 = **1- R** = phosphorus retention coefficient, where:

0.54 = **R = 1 / (1+ sq.rt. p)** (Larsen and Mercier 1976)

Previous use of the Vollenwieder (Dillon and Rigler 1974) type empirical model for Maine lakes, e.g., Cobbossee, Madawaska, Sebasticook, East Pond, China Lake, and Mousam Lake TMDLs (Maine DEP 2000-2002) has shown this approach to be effective in linking watershed (external) total phosphorus loads to existing in-lake total phosphorus concentrations (after Dillon and Rigler 1974 and others)

Strengths and Weaknesses in the Overall TMDL Analytical Process: The Highland Lake TMDL was developed using existing water quality monitoring data, derived watershed export coefficients (Reckhow et al. 1980, Maine DEP 1981 and 1989, Dennis 1986, Dennis et al. 1992, Bouchard et al. 1995, Soranno et al. 1996, and Mattson and Isaac 1999) and a phosphorus retention model which incorporates both empirically derived and observed retention coefficients (Vollenwieder 1969, Dillon 1974, Dillon and Rigler 1974 a and b, and 1975, Kirchner and Dillon 1975). Use of the Larsen and Mercier (1976) total phosphorus retention term, based on localized data (northeast and north-central U.S.) from 20 lakes in the US-EPA National Eutrophication Survey (US-EPA-NES) provides a more accurate model for northeastern regional lakes.

Strengths:

- ❖ Approach is commonly accepted practice in lake management
- ❖ Makes best use of available water quality monitoring data
- ❖ Based upon experience with other lakes in the northeastern U.S. region, the empirical phosphorus retention model was determined to be appropriate for the application lake.

Weaknesses:

- ❖ Inherent uncertainty of TP load estimates (Reckhow 1979, Walker 2000) and associated variability and generality of TP loading coefficients.
- ❖ Inherent uncertainty of phosphorus bioavailability estimates on different land use class P-loads and effect on model predictions.

Critical conditions in Highland Lake occur during the summertime, when the potential (frequency and occurrence) of hypolimnetic dissolved oxygen deficiencies are greatest. The loading capacity of 287 kg of total phosphorus was set to achieve desired water quality standards during this critical time period, and will provide adequate protection throughout the year (see Seasonal Variation section).

LOAD ALLOCATIONS (LA's): The load allocation for Highland Lake equals 115 kg TP on an annual basis and represents that portion of the lake's assimilative capacity allocated to only nonpoint (overland) sources of phosphorus (from Table 3). Note: Stormwater discharges from regulated areas are considered to point sources and are allocated as waste loads (see section G).

TMDL (287) = LA (115) + WLA (172)

WASTE LOAD ALLOCATIONS (WLA's): The three towns that comprise the Highland Lake watershed (Windham, Falmouth, and Westbrook) are regulated urbanized areas that are subject to Maine's National Pollution Discharge Elimination System (NPDES) Phase II Stormwater Program. With the assumption that all urban runoff is occurring in regulated areas, the WLA for the Highland Lake Watershed is derived from the TP export percentage from all developed urban-type categories (See Table 3, page 30 - developed shoreline and non shoreline totals). The WLA can therefore be expressed as 60% of the loading capacity (.60 x 287 kg TP/yr) or 172 kg TP/yr).

MARGIN OF SAFETY: An implicit margin of safety was incorporated into the Highland Lake TMDL through the selection of a conservative numeric water quality target and the selection of relatively conservative phosphorus export loading coefficients for cultural pollution sources (Table 3). Based on both Highland Lake historical records and a summary of statewide Maine lakes water quality data for non-colored (< 26 SPU lakes) - the target of 10 ppb (287 kg TP/yr in Highland Lake) represents a fairly conservative goal to assure attainment of Maine DEP water quality goals of non-sustained and non-repeated blue-green summer-time algae blooms due to NPS pollution or cultural eutrophication and stable or decreasing trophic state. The statewide data base for uncolored Maine lakes indicates that summer nuisance algae blooms (growth of algae which causes Secchi disk transparency to be less than 2 meters) are more likely to occur at 18 ppb or above. The difference between the in-lake target of 10 ppb (287 kg) and 17 ppb (486 kg) represents a 41% (199 kg) implicit margin of safety for Highland Lake, based on water clarity alone.

SEASONAL VARIATION: The Highland Lake TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year – during the summer, when conditions most favor the growth of algae and aquatic plants. With a hydraulic retention rate of 0.70 flushes/year, the average annual phosphorus loading is most critical to the water quality in Highland Lake. However, the non-point source best management practices (BMPs) and implementation plan proposed for the Highland Lake watershed have been designed to address total phosphorus loading during all seasons.

PUBLIC PARTICIPATION:

Adequate ("full and meaningful") public participation in the Highland Lake TMDL development process was ensured through the following avenues:

1. Southern Maine Lakes Coordinator, Wendy Garland, presented general Highland Lake TMDL information prepared for her by MACD Project Manager (Forrest Bell) to about 40 participants at the summer 2001 Highland Lake Region Association Annual Meeting.

2. MACD Project Manager (Forrest Bell), spoke at the summer 2002 Highland Lake Association Annual Meeting, which was attended by about 50 residents. A detailed presentation was given regarding the TMDL process, what was to be completed on Highland Lake, and the opportunity for public input. In addition, a comparison of total phosphorus loading to other Maine lakes (past completed TMDL studies) was discussed for comparison purposes.

3. MACD Project Manager, Forrest Bell, attended a Cumberland SWCD Board Meetings (Winter 2001-02) to present information regarding the Highland Lake TMDL. All District Board Supervisors as well as Associate Supervisors attended the meeting.

4. During the fall of 2001 and spring, summer and fall of 2002, MACD Project Staff Forrest Bell, Tim Bennett, and Jodi Michaud made visits to the watershed to meet with Cumberland County SWCD representatives, observe conditions in the watershed, conduct road and shoreline surveys, talk with officials from the towns of Windham and Falmouth, and speak to lake watershed residents.

5. Cumberland County Soil and Water Conservation District, has facilitated the process for involving local stakeholders, including the Highland Lake Association. One planning meeting was held in July and one more meeting with local stakeholders will be held before the final submission of this TMDL.

Preliminary Stakeholder Review

A preliminary stakeholder review draft Highland Lake TMDL report was prepared and distributed to associated environmental state agencies, including David Rocque (Maine Department of Agriculture), and Morten Moesswilde (Maine Department of Conservation, Forestry Service), as well as Highland Lake watershed groups and individuals, inclusive of Tamara Pinard (Southern Maine Lakes Coordinator); Betty Williams (CC-SWCD/Highland Lake Youth Conservation Corps Director); Tom Gordon, Bill Michaud, Bill Rust, Dick Wood, Jack Flaherty, John Malley, Charles Norman, and Jeff Brinck (CC-SWCD); Wayne Munroe (USDA Natural Resources Conservation Service); Keith Williams (Chair, Highland Lake Association Water Quality Committee), Ralph Johnston, (President, HLA); Rosie Hartzler, John Wilcox, and Bill Schwarz (HLA). Following the 2-week preliminary stakeholder review period (September 10th – 24th, 2002), a revised draft report was prepared and paper and electronic forms of a Public Review draft of the Highland Lake TMDL report were made available, including 'legal' advertising in local newspapers and posting on the Maine DEP Internet Web site. The following ad (in part) was printed in the Sunday editions of the Kennebec Journal (Augusta) and Portland Press Herald (Cumberland County edition) on September 29th and October 13th, 2002. The U.S. Environmental Protection Agency (New England

Region I) and interested public were provided a 30-day period to respond with draft comments (Friday, September 27th thru Monday, October 28th, 2002).

In accordance with Section 303(d) of the Clean Water Act, and implementation regulations in 40 CFR Part 130 - the Maine Department of Environmental Protection has prepared a **Total Maximum Daily (Annual) Load (TMDL)** nutrient report (DEPLW 2002-0536) for total phosphorus (TP) for the **Highland Lake** watershed, located in the towns of Windham, Falmouth, and Westbrook - within Cumberland County. This TMDL report identifies and estimates non-point source TP loadings within land use classes of the Highland Lake direct watershed and TP reductions required to establish and maintain acceptable water quality.

Note: This MS-Publisher retrofitted, frontloaded PCAP-TMDL report format, complete with revised phosphorus loadings and allocations to account for Stormwater contributions and future development, were reviewed by lake/watershed stakeholders and Maine DEP lakes/watershed staff and found to be very user friendly, preferable, and most acceptable.

SUMMARY OF STAKEHOLDER AND PUBLIC REVIEW COMMENTS

Preliminary Stakeholder Review - A preliminary stakeholder draft Highland Lake TMDL report was submitted to 18 individuals, who received hard copy or electronic versions of the report on September 10 and were requested to comment by the end of the day on September 24 (two week review period). The following summarized comments were provided:

Ralph Johnston, President, Highland Lake Association - expressed his gratitude (via telephone) for the production of the report and offered to provide a copy of Windham's Phosphorus Control Ordinance for our use.

Morten Moesswilde, Maine Forest Service, portrayed that the information in regard to forestry was well presented (see attached).

Tamara Pinard, Southern Maine Lakes Coordinator and former Highland Lake Project Manager for the Cumberland County Soil and Water Conservation District (CC-SWCD), provided written comments from her staff and Board members. Eighteen separate comments were provided ranging from informational corrections to suggestions for improvement of the report. Most of these review comments were incorporated into this public review draft TMDL report. Responses to all comments were provided by Maine DEP and MACD (see attached).

David Rocque, Maine Department of Agriculture provided specific comments on the septic loading model which are being addressed in regard to changes in methodology through the MACD/ MaineDEP Project team (see attached).

Keith Williams, Chair, Highland Lake Association Water Quality Committee, provided written comments focusing primarily on project methodology and referenced material. Many of the comments were incorporated into this public review draft TMDL report (see attached).

Public Review Comments (Review period: Sept. 27 to Oct. 28

The Public Review Document was posted on October 17, 2002. There was one comment/request provided by Keith Williams (see attached) which was addressed by Forrest Bell, Maine Association of Conservation Districts, following consultation with Dave Halliwell, Maine DEP.

Stakeholder Review Comments

Forrest,

Thank you – I looked through this briefly, and the forest/forestry piece seems well presented. Thanks very much for the chance to look at it and for keeping me posted.

Morten Moesswilde (12 September 2002)

Forrest Bell September 20, 2002
MACD Project Manager
16 Primrose Lane
Gorham, ME 04038

Dear Forrest: (Comments from **Tamara Lee Pinard,** Lakes Program Manager)

The following are comments submitted on behalf of the Cumberland County Soil and Water Conservation District (CCSWCD) for the preliminary draft of the Highland Lake TMDL report. I have discussed many of these comments with you, but wanted to provide the following in writing:

- The watershed size is listed as 21.2 square kilometers (8.4 square miles) on page five and then 19.9 square kilometers (7.7 square miles) on page eight.

  Thank you for noting the oversight – page 8 has been corrected.

- The statement on page 5, under Historical vs. Current Water Quality, "Potential for nuisance algae blooms is currently low (41.5% margin of safety)," seems to be contradictory to other information that is presented in the report. Discussion of water quality measures on pages 11 and 12 showcases the overall downward trend in water clarity and significant depletion of dissolved oxygen in the hypolimnion. If there is a low potential for algae blooms, then what is the "sensitive nature of the waterbody," and why is it being studied as a TMDL Lake? Maine lakes that now experience nuisance algae blooms first had negative trends in water clarity and depletion of dissolved oxygen in the hypolimnion.

- Since the narrative discussion under "Watershed Land Use & TP Load Allocations" on page 6 is a lot to digest, it would be helpful to refer to the pie chart figure at the beginning of that paragraph. In addition, there are no fairgrounds in the Highland Lake watershed.

  Comment noted and addressed on page 6

- Under "Water Quality Problem Solving Approach" on page 6, it would be more accurate to state that "the water quality and watershed conditions of Highland Lake are fairly well known and problem areas have started to be addressed to eliminate some watershed phosphorus sources." In addition, it is the Highland Lake Youth Conservation Corps (YCC), and while it began under the direction of the CCSWCD, the Highland Lake Association assumed leadership for the 2002 summer season and the CCSWCD now provides just technical assistance. Also, the YCC assists Highland Lake watershed landowners and not just shoreline landowners.

  Comments noted and addressed in text on page 6

- Also under "Water Quality Problem Solving Approach" on page 6, the last paragraph should be broken down into more than one sentence. It is confusing as presented

  Comments noted and addressed in re-worded paragraph on page 6

- Under "DESCRIPTION OF WATERBODY AND WATERSHED" on page 8, last paragraph, a new dam has been constructed. John Wilcox (jwilcox754@aol.com) is the chair of the Highland Lake Association's Dam Committee and should be contacted for further detail.

  Comment noted and addressed on page 8. Additional information may be provided in the *final report if it is relevant to our analysis.*

- Under "Anadromous Fish Restoration" on page 10, the Smelt Hill Dam is currently scheduled for removal in the fall of 2002.

  Comment noted and addressed on page 10

- Under "Residential Development" on page 11, paragraph 3, it was the watershed residents, and not the CCSWCD, who have been actively working with the towns of Falmouth and Windham on Phosphorus Control Ordinances. In addition, Windham's ordinance was just adopted in August, I believe. Please confirm with Keith Williams, who has been working closely with Windham on this.

  Comment noted and addressed on page 11.

- Figure 3, page 13, should include Secchi disk data through 2001. In addition, the description of the figure should state that Maine DEP's analyses show a statistically significant negative trend in water clarity over time. Melissa Evers personally communicated this to me for Secchi data through 2000, and I believe the trend continued when data was analyzed through 2001.

- Under "Priority Ranking and Algae Bloom History" on page 13, second paragraph, I question the necessity of including the following, "At this time, the potential for nuisance algal blooms in Highland Lake is low to moderate (Maine VLMP 2001). To date, minimal lake water transparencies of 2.0 to 2.1 meters were only observed during the years 1991 and 1996." This representation downplays the water quality issues in Highland Lake. Rather than noting "minimal lake water transparencies of 2.0 to 2.1 meters were only observed during the years 1991 and 1996," it would be good to reemphasize that MDEP analysis has shown a statistically significant negative trend in water clarity.

- Under "Descriptive Land Use Information, Agriculture and Forestry," it should be included that two large tracts of land – one on Percy Hawkes Road in Windham, and one on Sunset Road in Falmouth, are in Tree Growth. Therefore, they are harvested every ten years. In addition, it has been shared with me that when these tracts are logged, there is an increase in the volume of water that flows off that land, which does impact shoreland properties down slope. (Tree growth information should also be included in the "Agriculture and Forestry" section on page 27).

  Thank you for providing this information. It has been included on page 14 and 27.

- The median coefficient of 4.0 kg/ha/yr was used for both State and Town Roads and Camp and Private Roads. Since the State and Town Roads are paved and the Camp and Private Roads are predominantly gravel, would it be possible to break the roads down based on their composition rather than ownership so that coefficients can be assigned that better represent the phosphorus load from paved vs. gravel? It seems likely that the phosphorus loading from gravel roads would be higher than from paved roads.

  Although we will not be able to immediately address this comment it has been placed on the agenda for the MACD/MDEP methodology meeting on Oct. 1st. We are aware of the information and studies that exist and will make adjustments to the final report, if possible.

- Does Table 3 have to be included in this report? It contains a tremendous amount of information that is extremely confusing in this presentation format. There are so many variables in lake watersheds throughout Maine that makes it difficult to compare them. However, this table appears to present that comparisons can be drawn between these watersheds, which is ultimately misleading.

  Table 3 will be included, however, an additional graphic has been appended to the report in order to assist with this table.

- Under “Specific Recommendations, Shoreline Residential” page 27, the discussion of the work of the Youth Conservation Corps, should not be limited to the shoreline since the YCC implements conservation practices throughout the watershed.

  Comment is noted and addressed on page 27

- Under “Specific Recommendations, Non - Shoreline Residential and Commercial” page 28, education campaigns should also be encouraged for strategic use of vegetation and improved treatment of stormwater runoff from residential lots in the upper watershed. In addition, YCC should also be included in this section, since they work throughout the watershed.

  Comment is noted and addressed on page 28

- Under “Specific Recommendations, Roadways” page 29, it would be more accurate to state that “Camp and private roads offer more of a challenge, <u>due to the complex nature of maintaining gravel roads</u>” since road associations are present on about half of the private roads throughout the watershed.

  Comment is noted and addressed on page 29

- The use of both TMDL and ATPL, and the subsequent explanations that are included because both acronyms are used, is confusing and detracts from the report. Since TMDL has a specific definition in law and regulation, it seems appropriate to refer only to the TMDL acronym and remove ATPL from the text. There is no reason that you can’t still state that a TMDL for a lake watershed is an estimate of the total amount of total phosphorus that a lake can accept on an annual basis without harming water quality.

  Comment is noted and the term ATPL has been removed from the report

- Lastly, I want to encourage the inclusion of all the most recent monitoring data for Highland Lake. When discussing the above comments with you, you shared that new data had come in for total phosphorus levels throughout the water column of Highland Lake. Given the fact that the data supports that there is internal phosphorus recycling occurring in Highland Lake, it is extremely important that the data be incorporated into both the text and modeling of this report.

Thank you for your consideration of these comments. Please contact me if you have any questions or would like to further discuss any of these comments.

Sincerely, **Tamara Lee Pinard**
Lakes Program Manager

Stakeholder Review Comment (Dave Roque, Maine Department of Agriculture)

Thanks for the copy of the Highland Lake report. I have taken a quick look at the septic system section and offer the following comments:

I question the doubling of the age factor for 1974-1985 systems as compared to post 1985 systems. As I mentioned in our earlier phone conversation, the design and installation parameters have remained nearly the same since 1974. We also no longer consider septic systems to have a 20-25 year life expectancy. That figure came from a study Don Hoxie (former Director of Health Engineering) conducted while looking at about 20 years of data. Today, we have a much better education program for home owners who are the principle cause for failing septic systems now. We also have a septic system installer training and voluntary certification program in place that appears to be working well and an excellent Local Plumbing Inspector Training and Certification Program.

My personal experience is that installers and designers were the primary reason for failing systems 15-20 years ago. Today, the primary reason is homeowner misuse or lack of maintenance. Installation/design related problems generally result in quick failures (1-5 years). Therefore, those systems installed from 1974-1985 should no longer be in use (or they have been in failure mode for many years). That means that most of the pre 1985 systems in use today were most likely designed/installed properly. The problem comes from poor system maintenance (septic tank pumping) which allows for particles to enter the disposal field and clog the soil pores. Eventually, the soil becomes so clogged that it can not accept waste water being generated from the house, causing a back-up in the plumbing fixtures or a breakout on the ground surface. With proper use and maintenance of the system, this excessive clogging should not occur so the system should function indefinitely. Also, if a system was on track for a failure due to clogging it can be improved by discharging a higher quality waste water (through proper use and maintenance). Once the system has failed though, the only way to rejuvenate it is by resting it for a number of years to allow for the breakdown of organic matter plugging the soil pores. Usually, a back-up in the plumbing fixtures or breakout on the ground surface (depending on location) is quickly corrected. The much more significant problem is systems built in coarse gravel/sand or on top of fractured bedrock. Those systems do not form a minimal clogging layer (called bio-mat) which is an important part of the treatment in a properly functioning septic system (so long as it does not become too thick). Disposal field are designed to have a bio-mat which determines it's Long Term Acceptance Rate (rate at which effluent can enter the soil with some clogging of the soil pores). That is why such a large area is needed for a disposal field. In systems installed in coarse sands and gravel, the only treatment is dilution (and minimal adsorption to soil particles). I suggest a single rating for systems designed and installed post 1985 in deep soils with some silt and clay particles. For coarse sand and gravel soils (outwash), you may want to use a higher factor even if they were installed post 1985. This is particularly true for systems installed below the topsoil layer which is where roots and micro-organisms are present as well as fine soil particles (the plumbing code still allows for systems to be installed deep into these type of soils although post 1995 systems installed in the coarsest of soils within the shore land zone now need a liner of soil that has 4%-8% silt and clay). Shallow to bedrock soils might also be given a higher factor, especially the older ones) as they can result in direct paths to the water.

I also question the moderate factor given to systems that are 100'-200' back from the waters edge. I believe that 100' of soil is sufficient to remove phosphorous from most septic systems except, as above, for systems installed in sands/gravel or shallow to bedrock soils. If a system is installed in the subsoil of a sand/gravel or too close to bedrock, dilution is the primary mitigating factor. If installed on top of the ground, fine soil particle and plant roots as well as micro-organisms should remove much of the phosphorous even in sands/gravel. The only way I believe that phosphorous from septic systems installed in soils with a loamy sand or coarser texture that have a biomat is by overland flow. Unless the breakout is near a concentrated flow path or near the lake, it would probably be fixed as it would not look or smell pleasant. There would also be some filtering (depending on distance to the lake). You also noted that there was no problem with 98% of existing systems as per a survey done by the Town of Windham. If there was a problem with a system installed in a fine textured soil, it would be quite obvious unless there was a straight pipe from it into the lake. The biggest problems are those which are underground and which I call short circuits. You do not ever see a problem so none is presumed to not exist (all most people care about is that the toilet flushes and there is no mess on the lawn). Perhaps the 100'-200' category should only apply to sandy/gravelly soils and shallow to bedrock soils. In summary, I believe the septic systems which have the greatest phosphorous export to any lake are:

1. Systems installed directly upon fractured bedrock;
2. Systems installed in the subsoil of coarse sands and gravels;
3. Systems that are failing and have overland flow toward the lake or a concentrated flow path.

Hope this discussion is helpful. If you have any questions or would like to discuss this in greater depth, give me a call or e-mail.

David Rocque (16 September 2002)

Stakeholder Review Comment (Keith Williams, HLA) & MACD-Maine DEP Response

Forrest and David, Here are my comments. If you want clarification of any, contact me. Regards, **Keith Williams**

Highland Lake Association
Water Quality Committee
Keith Williams, Chair

Subject: ATPL (TMDL)
Date: Sept. 25, 2002

You are using one of the Dillon – Rigler models (page 23) I see. At the back of my 1998 study, which you have, you may see that I used a more extensive model of theirs and it fit remarkably well on Highland lake, so I believe you are on the right track. See also Chapra's work which I reference below.

I agree that internal recycling is perhaps not a significant contributor to the lake's average TP concentration; see Andrea Pearce' masters thesis (You didn't reference it). [it has been added]

Considering that the goal is 10 ppb TP in the water, or about 300 kg/yr, and the estimate for current load is about 600 kg/yr (but more on that later), and the current TP in the lake is near the goal, what is happening now to over 300 kg/yr? Evidently the estimate for the current load is too high, or internal assimilation and settling are removing a lot of TP, or both. I see evidence that your watershed loading is reasonable, if not a little low (See below.). Thus settling and in-lake sequestering by macrophytes, bacteria, etc., should be considered, I assert. See below.

The estimation of TP export is just that, an estimate, as you mention on page 24, without very expensive and long-term study, such as has been done for a half century at Hubbard Brook, New Hampshire. See "An Ecosystem Approach to Aquatic Ecoloty: Mirror Lake and Its Environment" Likens. Chapters 3 and 8. Short-term and occasional observations, measurements, and lab assays show how much scatter and uncertainty are in the estimates. For example, I've had stream chemistry assays from time to time for a total of 51 samples, and the scatter in the TP reports ranges from 6 to 354 ppb, with an average of 50 ppb. That indicates the streams have more TP concentration than does the lake, but the uncertainty is so large that I wouldn't put much reliability in any load calculations based on that. In the winter and spring of 2000 – 2001 we collected and had assayed for othophosphate at Bill McDowell's lab at UNH some 19 samples under varying flow rates at the same place. The scatter in the plots of PO4 to flow showed no correlation. I look forward to seeing Raquel Reinhardt's results. You are correct in showing a range of loading rates in Table 1 on page 15. That table is critical to the report, and I urge use of loading rates that follow from studies here in Maine, or at least New England, over studies that were done around Washington DC and Maryland. I agree with your rates for forest and open water. See "Biogeochemistry of a Forested Ecosystem, Second Edition" Likens & Bormann. Chapters 3 & 4. Your loadings for residential areas fit with Jeff Dennis' study.

I suspect the figure for loading from roads, State, Town, Camp, and Private, is too low. See "A Preliminary Study of Runoff of Selected Contaminants from Rural Maine Highways" USGS WRI 97-4041, for a report on monitoring that was conducted here in Maine. Its Table 10 shows 8 to 33 kg/yr, higher than the range you show in your Table 1. Table 9 page 12 of the USGS report shows assays from several road sediment samples, and they agree with three assays of composite road gravel that I took from our camp roads in Highland Lake watershed. Thus I see support for the USGS figures in our case. I note that you already figure loading from roads (all categories) as the single largest contributor to the total load.

Table 1 has total shoreline residential loading of over 50 kg/year. I note your discussion on page 17 that you used Ken Reckhow's loading rates. I have that EPA report somewhere, but couldn't put my hands on it on short notice, but vaguely recall that he used monitoring reports from places that weren't in Maine. Estimating the shoreline soil to contain about 300 mg/kg of TP (See the USGS study on Maine roads and my comments on its Table 9, below.) this works out to the equivalent of about 170 cubic yards washing into the lake yearly (average). Estimating the phosphorus due to fertilizer, etc. would reduce this, but it still might be a little high. I don't know of any careful monitoring study with sediment assay that would render a figure specific to Maine's typical soils.

Your report has an average loading of 0.29 kg/yr for the watershed, and I look at nearby studies that are based on extensive monitoring for comparison. See "Total Phosphorus Loads for Selected Tributaries to Sebago Lake, Maine." USGS WRI 01-4003. Table 4 has loads that are 1/5 to 2/3 what you report, but those watersheds are less developed than ours. "Effects on Agricultural Best-Management Practices on Total Phosphorus Yields on the Johnson Brook and Lovejoy Pond Watersheds, Kennebec County, Maine, 1980 – 84" USGS WRI Report 87-4118 reports much higher loads than do you, but that study was on a farm area.

You mention the discrepancy between observed and supposed TP based on watershed export per Table 1, at the top of Page 21, but don't follow through. I assert that the explanation is a lot of TP is settling out of the water column as particulate apatite, bound with the iron, aluminum, etc., that is chelated with the DOC when it settles as floc, settles with dying bacteria and algae, and sequestered in the macrophytes. Raquel is getting a grip on the settling through her PhD dissertation study. See also "Surface Water-Quality Modeling. Steven Chapra Lecture 29, particularly page 537 equation 29.7, with a settling rate at the lower end of the range reported. Figuring the macophyte angle is a real trick, as I know of no study in New England that would get a grip on quantities. In Europe a lot of work has been done; see "Ecology of Shallow Lakes" Scheffer Chapter 5, and most of the book "The Structuring Role of Macrophytes in Lakes" for studies in which more macrophytes mean lower TP.

Bottom of page 11 top of page 12, anoxic conditions have not gotten closer than 7 meters to the surface, and that was two years ago. Reconsider the percentages at the top of page 12.

At Appendix D you have Falmouth's ordinance for Highland Lake Conservation Overlay District. I urge you to also include Windham's new Surface Water Protection Ordinance.

On page 27 you mention the 319 grant and the CC-SWCD work; it would be good to attempt to quantify the impact that the $206,975 has, on reducing export from the road, shore erosion, by some (estimated) efficiency rate. (The loads in Table 1 are estimated, after all, so estimating on them could be in order.)

As you note, this watershed is one of the most rapidly urbanizing in the state. I have annual counts of building permits as an indicator of that progression, and it would be good to project that rate for a few years into the future to estimate the increase in load presuming doing nothing to mitigate it, by means of the increasing area in development in Table 1.

On page 12 last paragraph, add University of New Hampshire (UNH) to list as having measured additional water quality parameters.

On page 11 you say water quality data has been collected since 1974, then on the next page, 1955, and that is the correct year.

<u>Public Review</u> Comment (Keith Williams, HLA) and Response (MACD/Maine DEP)

Forest, David,

Here are some more thoughts about the ATPL study, about quantifying results and effort. Some of this came out at the most recent meeting of Highland Lake Association.

Years ago Jeff Dennis worked up the "Phosphorus Control in Lake Watersheds" having formulas and loadings for phosphorus, and that influenced your Table 1, as you say on your pg. 14 et seq. CC-SWCD is winding down its grant. Using Jeff's formulas and efficiencies, what has that grant bought for the lake by way of reduced phosphorus? Tamara has what was done on which road for what length, what buffer plantings, etc. to use in the formulas. Bottom line: what has it cost per pound of phosphorus reduction? Years ago I saw some figure from EPA for an estimate (guestimate) for how many dollars it cost to stop a pound of phosphorus. A GIS of the watershed, such as Peter Lowell uses, would really ease the calculations.

Extrapolating that to your conclusions, as you say on your pg. 30, more of the good work, what might it cost to cut the 600 kg TP per year, assuming it is any near correct, to an acceptable rate, a little less than half the 600, according to Dillon-Rigler? That figure would be appropriate in your report.

Best regards, Keith Williams (17 October 2002)

Hi Keith,

All of the suggestions that you have provided us in response to the Highland Lake TMDL make perfect sense. Your idea (below) of quantifying the work done by CC-SWCD should be pursued. I am not sure what final reporting requirements and figures CC-SWCD is providing to Maine DEP – but I would be glad to assist with an attempt to calculate the kg (or pounds) of phosphorus reduction from the on-the-ground work done over the past several years. From that, we could have an idea of how much $ was spent for a pound of phosphorus removal. My only hesitation with attempting this is that we are making estimates based on models which are based on more estimates. The “unknown” variable in this case is: just how much reduction of phosphorus loading occurs when a buffer is installed or a camp road is repaired on Highland Lake? To my knowledge the research is still fairly limited in this arena – although many studies are ongoing.

Regardless, I would be happy to take a look at the numbers (Tamara or Betty Williams – can you provide me with your final numbers?) if it would help the HLA in future endeavors. My opinion is that the true benefit of these TMDL reports is laying some groundwork for future work in the watershed. I am pleased to see that the HLA, CC-SWCD, and municipalities are pro-active and are moving ahead.

Sincerely yours,

Forrest Bell (12 December 2002)

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