PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

LONG LAKE

Cumberland and Oxford Counties, Maine

Long Lake PCAP-TMDL Report

Maine DEPLW 2005 - 0691

Maine Department of Environmental Protection

Lakes Environmental Association and

Maine Association of Conservation Districts

Final EPA Approval - May 17, 2005

LONG LAKE Phosphorus Control Action Plan (PCAP)

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LONG LAKE

Total Maximum Daily (Annual Phosphorus) Load

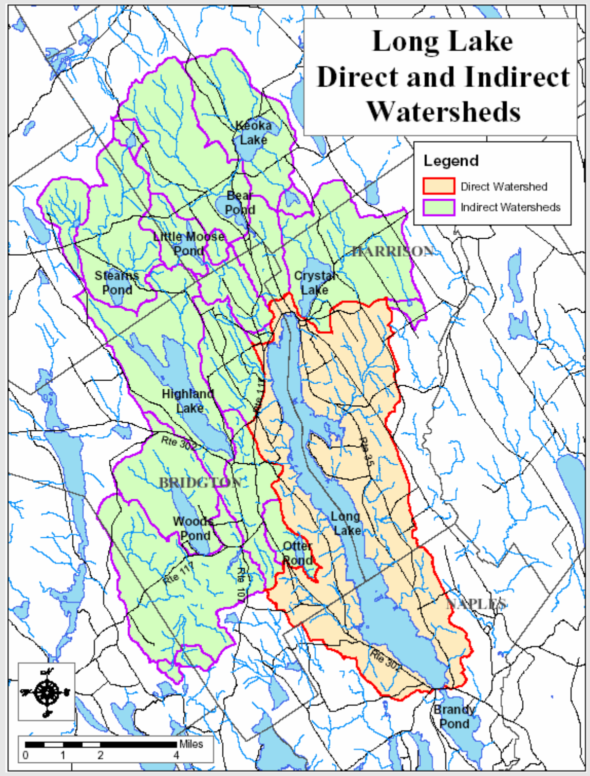
ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA New England Region I staff, the following individuals, groups and agencies were instrumental in the preparation of this combined Long Lake Phosphorus Control Action Plan-Total Maximum Daily (Annual Phosphorus) Load report: Lakes Environmental Association (Peter Lowell, Colin Holme, Dave Welch, Bridie McGreavy, Dan Bishop, Liz Rolerson, Kempton Randolf, Jesse Logan-Cottingham, Thayer McKeith); MACD staff (Jodi Michaud Federle, Forrest Bell, Tim Bennett and Fred Dillon); Cumberland County Soil & Water Conservation District (Tamara Lee Pinard); Town of Bridgton (Bill Foye, Georgiann Fleck, Jim Kidder); Town of Naples (John Thompson); Sawyer Engineering (George Sawyer), Frank White, Gerry Smith, Rosemary Mosher (Orbis Mapping); USDA (Lindsay Hodgman); VLMP (Scott Williams), Maine Department of Inland Fisheries and Wildlife (Francis Brautigam, Region A, Gray Office), and Maine Department of Conservation (Tom Skolfield), Maine Forest Service (Chris Martin) and Maine Department of Agriculture (Dave Rocque).

LONG LAKE PHOSPHORUS CONTROL ACTION PLAN SUMMARY FACT SHEET

Background

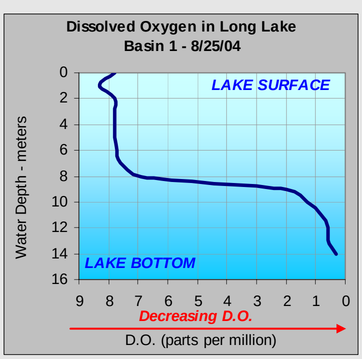
LONG LAKE is a very large 5,358 acre waterbody located in the towns of Bridgton, Harrison and Naples in Cumberland County, southwestern Maine. Long Lake has a direct **watershed** area (see map below) of 36 square miles; a maximum depth of 59 feet, a mean depth of 25 feet; and a **flushing rate** of 0.94 flushes per year. The total Long Lake watershed drainage area, inclusive of associated sub-watersheds (see figure to right), is 115 square miles.



Long Lake has experienced a gradual decline in water quality over the past decade. Average dissolved oxygen levels in the lake's lower layer during July, August and September has declined to levels that threaten the lake's cold water fishery (see chart below). This decline is due in large part to the historical annual accumulation of **phosphorus** that is prevalent in area soils and is effectively transported to Long Lake via storm flows. Excessive soil erosion in lake watersheds can have far-reaching water quality consequences. Soil particles transport phosphorus, which accumulates in the bottom sediments and essentially "fertilizes" the lake, feeding algal blooms and decreasing water clarity. Studies on lakes in general have also shown that as lake water clarity decreases, lakeshore property values decline. Excess phosphorus can also stimulate the growth of non-indigenous aquatic invasive plants such as variable leaf milfoil, which fortunately has not yet been found to occur in Long Lake.

Stakeholder Involvement

Federal, state, county, and local groups have been working together to effectively address this nonpoint source water pollution problem in Long Lake. During 2002-04, the Maine Department of Environmental Protection funded a project in cooperation with the Maine Association of Conservation Districts and Lakes Environmental Association to identify and quantify the potential sources of phosphorus and identify the **Best Management Practices** needed to be implemented in the Long Lake watershed. A final report, completed in the winter of 2005, is entitled "Long Lake Phosphorus Control Action Plan (PCAP)" and doubles as a **TMDL** report, to be submitted to the US Environmental Protection Agency, New England Region, for their final review and approval.



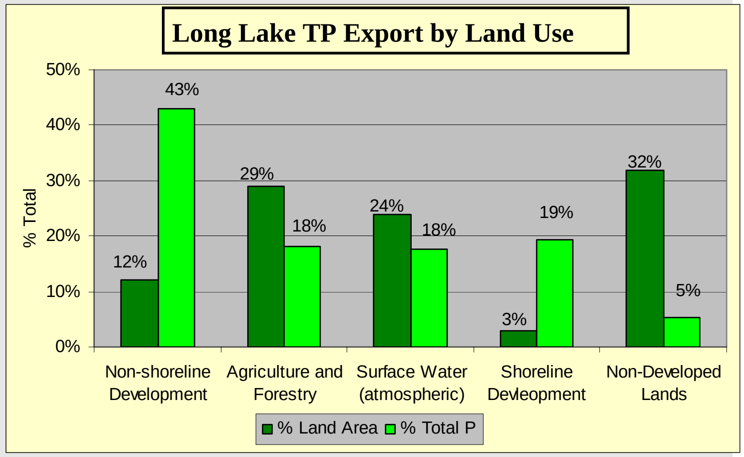
Dissolved oxygen declines rapidly beginning at around 8 meters below the lake surface during late summer months.

What We Learned

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

Phosphorus Reduction Needed

Long Lake can naturally process as much as **1,923 kg** of phosphorus annually without harming water quality. Based on lake water quality modeling for current phosphorus levels, and adding an additional allocation for potential future watershed development, the ultimate in-lake total phosphorus load is estimated at **2,483 kg.** Therefore, the total phosphorus reduction needed to maintain water quality (nuisance algal bloom-free conditions) standards in Long Lake is approximately **560 kg (2,483 kg - 1,923 kg).**



How to Address Long Lake Phosphorus Loading

Based on a separate land use model, it is estimated that **2,376 kilograms (kg)** phosphorus per year is "exported" to Long Lake from the direct watershed. Reducing phosphorus input from the surrounding watershed is a scientifically proven way to improve lake water quality. By promoting best management practices to treat runoff from contributing watershed land uses, reductions approaching **560 kg** may be attained over time through a phased approach based on incremental annual phosphorus reductions (360 kg) reflecting interim water quality goals (320 to 400 kg). The bar chart (above) illustrates the land area for land use groups in the Long Lake watershed compared to the estimated total phosphorus export load. There are also phosphorus inputs to Long Lake from indirect sources (associated waterbodies) and in-lake bottom sediment phosphorus recycling - see page 22 and the appendices of the full PCAP – TMDL report for more information on related nutrient loading models.

What You Can Do To Help!

As a watershed resident, there are many things you can do to protect the water quality of Long Lake. Lakeshore owners can use phosphorus-free fertilizers and maintain natural vegetation adjacent to the lake. Agricultural and commercial land users can consult Lakes Environmental Association, Cumberland County Soil and Water Conservation District or Maine Department of Environmental Protection for information regarding Best Management Practices (BMPs) for reducing phosphorus loads. Watershed residents can become further involved by volunteering to help Lakes Environmental Association and participating in events sponsored by LEA. All stakeholders and watershed residents can learn more about their lake and the many resources available, including review of the Long Lake Phosphorus Control Action Plan. Following final EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work, will be available online at www.maine.gov/dep/blwq/docmonitoring/tmdl2.htm, at the Lakes Environmental Association office in Bridgton as well as Bridgton, Harrison, and Naples town offices, or can be viewed and/or copied (at cost) at Maine DEP offices in Augusta (Land and Water Bureau, Ray Building, Hospital Street).

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****: is one of the major nutrients needed for plant growth. It is naturally 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. BMPs 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, representing the total amount of a pollutant (e.g., phosphorus) that a waterbody can annually receive and still meet water quality standards.*

Project Premise

This project, funded through a Clean Water Act section 319 grant from the United States Environmental Protection Agency (EPA New England Region), was directed and administered by the Maine Department of Environmental Protection (Maine DEP) in partnership with the Maine Association of Conservation Districts (MACD) and Lakes Environmental Association (LEA), from the summer of 2002 through the winter of 2005.

The objectives of this project were twofold: first, a comprehensive land use inventory was undertaken to assist Maine DEP in developing a Phosphorus Control Action Plan (PCAP) and a Total Maximum Daily Load (TMDL) report for the Long 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, will address and incorporate public comments before final submission to the US Environmental Protection Agency (Region I).

Secondly, watershed survey work, including a shoreline survey, was conducted by the Maine DEP-MACD-LEA project team to help assess total phosphorus reduction techniques that would be beneficial for the Long Lake watershed. Watershed survey work included assessing many direct drainage **nonpoint source (NPS) pollution** sites that were not previously identified.

> ***Nonpoint Source (NPS) Pollution*** *- is polluted runoff that cannot be traced to a specific origin or starting point, but appears to flow from many different sources.*

Note: *To protect the confidentiality of landowners in the Long Lake watershed, site-specific watershed survey information is not provided as part of this report.*

This Phosphorus Control Action Plan (PCAP) report compiles and refines land use data derived from various sources, including the municipalities of Bridgton, Harrison and Naples; the Maine Office of GIS; the Casco Bay Estuary Project; the Cumberland County Soil & Water Conservation District (CC-SWCD); and Lakes Environmental Association (LEA). Local citizens, watershed organizations, and conservation agencies should benefit from this compilation of data as well as the watershed assessment and the NPS Best Management Practice (BMP) recommendations. Above all, this document is intended to help Long Lake stakeholder groups to effectively prioritize future BMP work in order to obtain the funding resources necessary for NPS pollution mitigation work in their watershed.

For more specific information on this process, please refer to the appendices or contact Maine Lakes PCAP-TMDL Program Manager Dave Halliwell at the Maine DEP Augusta Office at 287-7649 or at david.halliwell@maine.gov).

Study Methodology

Long Lake background information was obtained using several methods, including a review of previous studies of the lake and 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.

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

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 (CITIPIX 2001) and (5) field surveys. Much of the undeveloped land use area (i.e., forest, wetland, reverting fields) was interpreted from GIS maps created by Lakes Environmental Association using the 2001 "ortho-hfs" aerial photographs available from the Maine Office of GIS. 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.

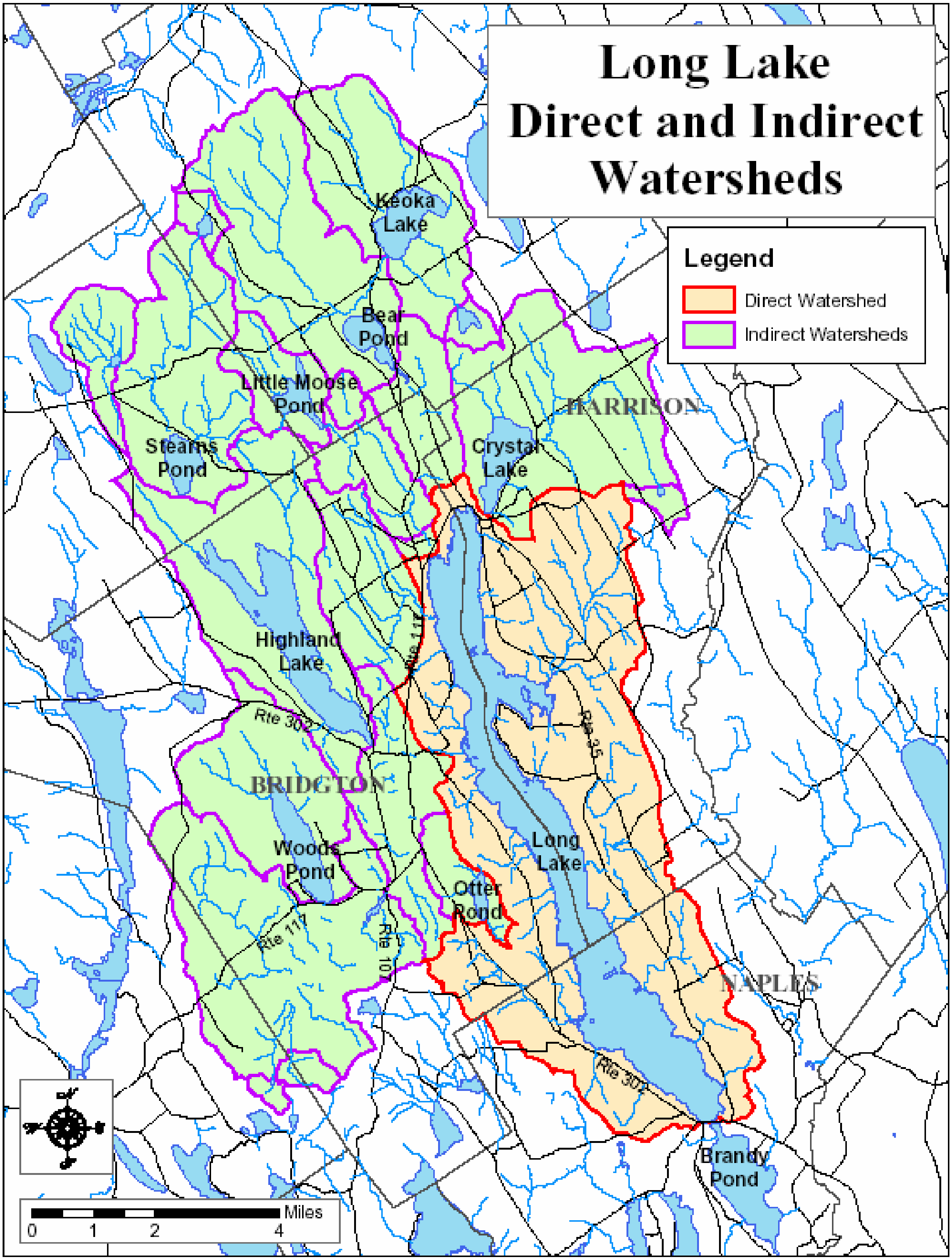
Roadway data were gathered by taking actual road width measurements of the various types of roads (state, town, private/camp) in the watershed. Roads were measured between the two outer edges of the roadside ditches or berms. An average width was used for each of the three road types. Final measurements for all roadways within the watershed were extrapolated or screen digitized using GIS (Casco Bay Estuary Project, LEA and road and aerial photo data from the Maine Office of GIS). Roadway area was determined using GIS area calculations for the final road polygons.

Additional land use data (i.e. non-shoreline residential, institutional, operated forestland) were determined using GIS cover mapping, aerial photos, topographic and property tax maps, personal consultation and field visits.

Study Limitations

Land use data gathered for the Long 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, and should be only viewed as carefully researched estimations.

Figure 1. Map of Long Lake Direct Watershed



LONG LAKE Phosphorus Control Action Plan

DESCRIPTION of WATERBODY (MIDAS Number 5780) and WATERSHED

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

LONG LAKE is a very large 5,358 acre three basin waterbody, located within the towns of Bridgton, Harrison and Naples (DeLorme Atlas, Maps 4 and 10), in Cumberland County, located in south-western Maine. Long Lake has a **direct watershed** area (see Figure 1) of 22,869 acres (36 square miles), within the Sebago Lake - Presumpscot River drainage system. Long Lake has a maximum depth of 18 meters (59 feet), an overall mean depth of 7.7 meters (25 feet) and has a flushing rate of 0.94 times per year. The total Long Lake watershed drainage area, including the upstream sub-watersheds of Black Pond, Duck Pond, Stearns Pond, Highland Lake, Little Moose Pond, Bear Pond, Keoka Lake, Mud Pond, Crystal Lake, Otter Pond, Bear River, Stevens Brook, Willett Brook, Woods Pond, Smith Brook, Bog Pond and Cabbage Yard Pond is 73,527 acres (115 square miles).

Drainage System – In the north-central portion of the indirect watershed, Mud Pond drains into Keoka Lake, which flows into Bear Pond through City Brook, then outlets into the Bear River which flows into Long Lake. Also in the north-central portion of the indirect watershed, Little Moose Pond and Cabbage Yard Pond both drain into Smith Brook, which then flows into Long Lake. In the north-western portion of the indirect watershed, both Duck and Black Ponds drain into Stearns Pond which outlets through Trull Brook into Highland Lake, which then drains through Stevens Brook into Long Lake. In the north-eastern portion of the indirect watershed, Bog Pond flows out through Woodsum Brook into Crystal Lake, which then flows out through Harrison into Long Lake. In the western portion of the indirect watershed, Otter Pond feeds into Long Lake indirectly through Sucker Brook. Also in the west, Rogers Brook and Woods Pond both flow into Willet Brook, which is dammed adjacent to Rte 107 and provides water for the Town of Bridgton. Willet Brook then flows into Stevens Brook, which flows down into the Long Lake and outlets through the Chute River into Brandy Pond. Brandy Pond outlets into the Songo River, joining with the Crooked River before flowing into Sebago Lake. The water level of Long Lake is controlled at the Songo Lock Gates by the Long Lake Water Level Committee.

Water Quality Information

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

__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 number, the higher the amount of algae in the lake.

Long Lake is listed on the Maine DEP's Clean Water Act section 303(d) list of lakes that do not meet State water quality standards, hence, the preparation of a Phosphorus Control Action Plan (and TMDL) was prepared, publicly reviewed, and submitted to EPA for final approval in the spring of 2005.

Water quality monitoring data for Long Lake, including comprehensive total phosphorus testing since 1986 and temperature, oxygen, **Secchi disk transparency**, color, pH, conductivity, alkalinity and **chlorophyll-a** have been collected regularly since 1976. Together, these data document an overall trend of increasing **trophic state,** in direct violation of the Maine Department of Environmental Protection Class GPA water quality criteria requiring a stable or decreasing trophic state.

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

> ***Hypolimnion****—lower, cooler layer of a lake during summertime thermal stratification.*

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 Long Lake's **hypolimnion** fall far below this level during the summer months, the lake most likely has experienced a moderate to severe reduction in coldwater fish habitat (LEA-VLMP 2004). Nonpoint source pollution is the main reason for declining water quality in Long Lake. During 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 - and annually accumulate in lake bottom sediments.

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

Principle Uses: The dominant human uses of the Long Lake shoreline are residential (both seasonal and year-round occupancy) and recreational—boating, fishing and swimming/beach use. A public boat launch is located at the northern tip of Long Lake off Route 117 in Harrison. There are also two town boat launches. The Harrison town boat launch is located on the eastern side of the lake off Route 35 at the end of the Zekelo Road. The state boat launch in Bridgton is located on the western side of the lake at the end of the Powerhouse Road off the Kansas Road. There is one commercial boat launch on Long Lake in Naples. However, there are three more commercial launches just over the Route 302 causeway in Brand Pond which connects to Long Lake and numerous private boat launches within all three towns. In addition to two commercial marinas, there are seven commercial campgrounds and two large boys and girls summer camps, all located along the Long Lake shoreline.

Human Development: The Long Lake shoreline is moderately developed. Of the 935 shorefront lots (LEA GIS and database analysis on 12/8/04), there are 387 in Harrison, 293 in Bridgton and 255 in Naples. It is estimated that 830 of these lots are developed of which 60% are estimated to be seasonal residences. Although, the majority of residences within the shoreland zone are used only seasonally, numerous seasonal to year-round conversions are made annually (Peter Lowell, LEA).

The direct watershed of Long Lake is located within the towns of Harrison (45% of the watershed), Bridgton, (26% of the watershed) and Naples (29% of the watershed). Bridgton is a rural, residential suburb, located in the northwest corner of Cumberland County, 40 miles from Portland, 45 miles from Lewiston-Auburn and 25 miles from North Conway, New Hampshire. Commercial and employment centers are located in and around the Bridgton area, concentrated primarily along Routes 302 and 117. Harrison is located in Cumberland County and abuts Long Lake to the east and north. Harrison is a primarily rural town with a densely populated town center located at the northern tip of Long Lake . The southern portion of Long Lake and the Long Lake watershed lie within the Town of Naples, also in Cumberland County. Naples is a primarily rural town with a densely populated center that is located at the southern tip of Long Lake. Long Lake is on the State's **Nonpoint Source Priority Watersheds** list due primarily to a declining trend for dissolved oxygen levels.

*Waterbodies within designated **NPS priority watersheds** have significant value from a regional or statewide perspective and have water quality that is either impaired or threatened to some degree due to NPS water pollution. This list helps to identify watersheds where state and federal agency resources for NPS water pollution prevention or restoration should be targeted.*

Increase in human populations cause development to expand and generally increase the amount of NPS pollution in an area. For this reason, high population growth rates are a concern for the watershed. Based on estimates from the 2000 census: 4,883 people reside in Bridgton; 3,274 people reside in Naples; and 2,315 people reside in Harrison. Between 1990 and 2000, Bridgton's population has increased by 13.4%, Naples' population has increased by 14.5%, and Harrison's population has increased by 18.7%. In addition, summer residents and visitors can cause the population to expand by as much as 50% in all three towns during peak summertime months (June, July, and August). Some of the population increase that has occurred during this time period involves the conversions from seasonal to year-round residences.

Outlet Dam Management - The sluice gates at the Songo Lock serve as the dam for Long Lake and Brandy Pond and are operated by the Long Lake Water Level Committee and maintained by the State of Maine. The Songo Lock was originally constructed in 1829 and opened in 1830. Maintenance work has been done on the locks since there installation, however, major reconstruction and repair of the lock occurred in 1911, the 1960s, the early 1980s and in 2003. (Tom Skolfield, Maine Department of Conservation) .

The lock was built as part of the Cumberland-Oxford Canal system. This canal system consisted of a 27 lock canal that was built parallel to the Presumpscot River and ran from Casco Bay up to Sebago Lake. The Songo Lock then allowed for a connection between Sebago Lake and Brandy Pond and Long Lake. After construction, the Songo Lock raised the water level in Long Lake and Brandy Pond approximately six to seven feet (Gerry Smith). The lock was originally constructed for the transportation of commercial and industrial products. By the late 1800s, most freight was transported through the newly constructed railroad system and the Songo Lock was then used primarily for passenger steam boats (Gerry Smith). Today the primary use of the lock is for recreational boating and tourism.

Under the Long Lake Water Level Management Plan, the lake is kept between 268'-8" and 269' (Mean Sea Level) from May 1st to November 1st. The gates are then fully opened November 1st and remain open until closing after ice-out. Within the first four weeks of draw-down, the lake level normally recedes about 4 feet to its winter level. Opening of the gates prior to November 1st is prohibited by the Department of Inland Fisheries and Wildlife as a management tool to entice spawning salmon to the Crooked River, which flows into the Songo River below the lock.

Long Lake Fish Assemblage & Fisheries Status

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) and a recent conversation with Francis Brautigam (Region A, Gray DIFW office), Long Lake (Town of Bridgton - Presumpscot River drainage) is managed as a mixed coldwater (stocked salmonids) and warmwater (black bass and chain pickerel) fishery. Long Lake, the second largest waterbody in southern Maine (Sebago Lake is much larger), was originally surveyed by Maine DIFW in 1939 and their lake fisheries survey report was revised in 1953 and 1984. A total of **18** fish species are listed, including: **11** native indigenous fishes (American eel, golden shiner, common shiner, fallfish, white sucker, brown bullhead, chain pickerel, burbot, brook trout, pumpkinseed and yellow perch); and **7** previously introduced fishes (white perch, smallmouth and largemouth bass, landlocked Atlantic salmon, lake and brown trout, and rainbow smelt). Reportedly, Long Lake supports a high quality black bass fishery and is one of the more popular lakes in southern Maine for bass angling tournaments.

Smallmouth bass

Largemouth bass

According to Maine DIFW reports, Long Lake thermally stratifies in all (three) major basins during the summer months, however, serious dissolved oxygen depressions in the deeper cold water layers greatly diminish the potential for coldwater fishery management. Improvements in water quality will serve to greatly enhance this important lake. Given that the trophic state of Long Lake has been disturbed by cumulative human impacts over the past several decades, a moderate reduction in the total phosphorus load in the Long Lake watershed may lead to maintaining in-lake nutrient levels within the natural assimilative capacity of this lake to effectively process phosphorus - and enhance existing landlocked Atlantic salmon and brown trout fisheries.

Landlocked Atlantic salmon

Brown trout

Watershed Topography and Characteristic Soils (Source: USDA SCS 1974): Most of the soils within the Long Lake drainage area are deep, somewhat poorly to moderately well drained, in association with glacial till. Approximately 52% of the soils within the watershed are potentially highly erodible, while an additional 17% are known to be highly erodible. Soils within the Long Lake drainage area are described by the following associations:

Hermon-Peru-Paxton These deep, somewhat excessively drained to moderately well drained soils dominate the Long Lake watershed.

Hermon series soils are type A hydrologic soils which indicates a high groundwater transport rate. The Hermon series consists of deep, well drained, to somewhat excessively drained soils. These soils are formed in granitic glacial till and contain many small and large stone fragments. The water table generally is at a depth of 3 to 5 feet. Permeability is rapid and available water capacity is low. Malfunctioning septic systems located in these soils have the potential to contribute phosphorus to the lake through groundwater transport.

Peru series soils are type C hydrologic soils which have the potential for moderate-to-high surface runoff. The Peru series consists of deep, moderately well drained soils that are formed in very firm, stony, glacial till. Permeability is moderate to moderately slow and available water capacity is high.

Paxton series soils are also type C soils which have the potential for moderate-to-high surface runoff. The Paxton series consists of deep, well drained moderately coarse textured soils. These soils are formed in very firm stony glacial till. Permeability is moderate to moderately slow and available water capacity is high.

Land Use Inventory

The results of the Long Lake watershed land use inventory are depicted in Table 1 (following page). The various land uses are categorized by developed land vs. non-developed land. Developed land area, including transitional conversion forest land and operated forest land, comprises approximately 44% of the watershed. Non-developed land, including the water surface area of Long Lake, comprises the remaining 56% of the watershed. These numbers may be used to help make future planning and conservation decisions relating to the Long Lake watershed. The information in Table 1 was also used as a basis for preparing the Total Maximum Daily (Annual Phosphorus) Load report (see Appendices).

Descriptive Land Use and Phosphorus Export Estimates

Agriculture: Non-manured hayland (660 acres) is the primary agricultural land use within the watershed. Most of the hayland is in the eastern portion of the watershed along Maple Ridge Road, Edes Falls Road and Route 35, which all run parallel to Long Lake. There are also open fields on Lamb's Mills Road, the Burnham Road and the Perley Road. Most of the fields are in the middle to outer portion of the watershed and have existed for many years. There is a 46 acre orchard on Maple Ridge Road and a small part of another, larger, orchard in North Bridgton. There are also three small tree farms within the watershed. Nine separate areas, encompassing 32 acres are being used for livestock grazing, primarily horses, within the watershed. There farm buildings that are not connected with a residential use in the watershed, including a horse stable, three farm

Table 1. Long Lake Direct Watershed - Land Use Inventory and Phosphorus Loads

LAND USE CLASS	Total Land Area (Acres)	Land Area (% Total)	TP Export (% Total)
Agricultural and Forested Land		**Long**	**Lake**
Operated Forest Land	5,819	25%	8.6%
Low Intensity Hayland	658	3%	8.0%
Livestock Areas	32	0%	0.5%
Orchard	51	0%	0.4%
Cultivated Cropland	8	0%	0.3%
Farm Buildings	3	0%	0.1%
Sub-Totals	**6,571**	**29%**	**17.8%**
Shoreline Development			
Septic Systems		0%	6.1%
Medium Density Residential	472	2%	8.8%
Private/Camp Roads	43	0%	1.5%
Low Density Residential	157	1%	1.4%
Campgrounds	51	0%	0.6%
High Density Residential	17	0%	0.3%
Boys and Girls Camps	15	0%	0.2%
Commercial	5	0%	0.1%
Institutional Public	1	0%	0.0%
Parks and Cemeteries	1	0%	0.0%
Sub-Totals	**762**	**3%**	**19.1%**
Non-Shoreline Development			
Private and Public Roads	425	2%	11.6%
Low Density Residential	1,344	6%	12.4%
Medium Density Residential	568	2%	10.1%
Institutional (Public)	98	0%	2.6%
Commercial	62	0%	1.6%
Campgrounds	111	0%	1.4%
Industrial	46	0%	1.2%
Boys and Girls Camps	86	0%	0.7%
High Density Residential	45	0%	1.0%
Parks and Cemeteries	22	0%	0.3%
Utilities	20	0%	0.1%
Landfill	8	0%	0.1%
Gravel Pits	38	0%	0.0%
Sub-Totals	**2,873**	**13%**	**43.0%**
Total: DEVELOPED LAND	**10,206**	**45%**	**79.9%**
Non-Developed Land			
Inactive/Passively Managed Forest	6,222	27%	4.7%
Reverting Fields	199	1%	0.7%
Islands	29	0%	0.0%
Other waters	15	0%	0.0%
Wetlands	821	4%	0.0%
Total: NON-DEVELOPED Land	**7,286**	**32%**	**5.5%**
Total: Surface Water (Atmospheric)	**5,358**	**23%**	**14.6%**
TOTAL: DIRECT WATERSHED	**22,850**	**100%**	**100.0%**

equipment and storage buildings, a large discontinued chicken barn, and a newly constructed barn. There are fields used for corn cultivation for cultivating mixed vegetables. All agricultural land uses combined currently account for 754 acres or 3% of the total watershed area and approximately 9.3% of the watershed total phosphorus load.

Forest Lands: 53% (12,041 acres) of the total land area in the Long Lake watershed is forested.

***Operated Forest Lands* -** 5,819 acres (26%) were actively managed during the past three years. While poorly managed forestry operations have the potential to negatively impact a waterbody through erosion and sedimentation from logging sites, properly managed forestry operations generally do not. Sustainable forest management can enhance water quality through sequestering excess nutrients particularly in forested riparian areas. This land use type accounts for approximately 8.6% of the watershed total phosphorus export.

Inactive/Passively Managed Forests - 6,222 acres (27%) did not incur active management during this study period. Characterized by privately-owned non-managed deciduous and mixed forest plots (LEA GIS 2004), these forests may support active management in the future. About 4.7% of the phosphorus load is estimated to be derived from inactive/passively managed forested areas within Long Lake's direct drainage area.

Shoreline Development consists of all lands within the immediate shoreland area (250 feet) of Long Lake. Some land uses extend both inside and outside of this area. The following section describes only those land uses (or parts of land uses) that are within 250 feet of Long Lake.

Most of Long Lake is surrounded by medium to low-density residential development. There are few large tracts of natural undeveloped shorefront. There are three public boat launching facilities, one commercial launch and numerous private launching facilities around the shore. Seven commercial campgrounds, two commercial summer camps, four condominium developments, and part of one small mobile home park are along the shore. There is also some light commercial use associated with the waterfront in both downtown Harrison and Naples.

A complete shoreline survey was conducted in October of 2002 by Maine DEP-MACD-LEA project staff. The survey was conducted from boats, approximately 50 feet from the shoreline. The survey results provide a shoreline structure tally and qualitatively evaluate the nonpoint source pollution impact of each lot in regard to phosphorus loading. A total of 830 developed lots were evaluated during the shoreline survey of Long Lake.

To help characterize shoreline development and to assist stakeholders with targeting and implementation of future shoreline best management practices, each lot was assigned an NPS pollution impact rating using best professional judgment. The ratings range from 1 to 3, with 1 being very low impact (primarily natural vegetation with development set back from the lake) and 3 being high impact (little vegetation, development near the shoreline). Table 2 outlines the impact ratings assigned to each shoreline lot during the survey.

Table 2. Long Lake Shoreline Survey Results (2002)			
NPS Pollution Potential Severity Score	**Impact rating characterized by one or more of the following:**	**Number of shoreline sites identified within each category**	**% of sites within each category**
1 = low impact	Good natural vegetation; good setback from lake	188	23%
2 = moderate impact	Lack of adequate buffer; close to lake	577	69%
3 = high impact	Lack of buffer; steep slopes; close to lake	65	8%

Overall, 69% of all shoreline lots that were surveyed on Long Lake have a moderate impact due to inadequate vegetative buffers and/or close proximity to the lake. Many of the shoreline areas have been rip-rapped at the toe of the slopes, but lack vegetative plantings (other than mowed lawns) above the rip-rapped areas. Vegetative buffers help to decrease the amount and flow of run-off from the sites. Many of the homes and cottages have mowed grass lawns that stretch down to the lake and do not serve as adequate vegetated buffers. In addition, 8% of the lots surveyed have a high impact to the lake due to a lack of any vegetation or visual erosion on banks and access ways. On the positive side, 23% of the lots were rated as low impact. These lots retained a healthy buffer of natural vegetation between the lake and any substantial development.

To estimate quantitative phosphorus loading from residential shoreline use, the shoreline area was classified as low, medium and high density development. Town tax records, property tax maps, high resolution aerial photos and GIS maps were used to determine low, medium and high density residential areas within the shoreland zone. Phosphorus loading coefficients were developed using information on residential lot stormwater export of algal available phosphorus (Dennis et al. 1992). Low density residential development occurs sporadically along the shoreline except for a portion of the central eastern shoreline and a northwestern section of the shoreline. Medium density residential development is the dominant type of development along the shoreline. Many of these lots are 'grandfathered' and do not meet the current shoreland zoning standards for new development. Four condominium complexes and one small mobile home park make up the high density residential development along the shoreline. Combined low, medium and high density residential development along the shoreline of Long Lake comprise only 3% of the land area in the watershed, which accounts for approximately 10.5% of the estimated total phosphorus load.

Shoreline Septic Systems: It is important to consider the potential for phosphorus loading from septic systems around the immediate vicinity of Long Lake. Antiquated and/or poorly designed and installed septic systems within the shoreland zone may contribute substantially to the annual total phosphorus load to adjacent lake water, adding to the cumulative phosphorus load to Long Lake.

Total phosphorus export loading from residential septic systems within the 100-foot shoreline zone has been assessed for Long Lake. The primary information source for this assessment originates from the shoreline survey that was conducted during the summer of 2002 by MACD, LEA and Maine DEP. Long Lake shoreline soils are classified for septic suitability based on the identified soil type's ability to filter and purify effluent in septic tank and drain field systems. As such, nearly 99% of soils are rated as adequate and the small remainder are rated as inadequate for septic suitability (LEA 2004).

In order to estimate total phosphorus loading from shoreline septic systems, a simple model was used based on the following attributes: seasonal or year-round occupancy; estimated age of the system; estimated distance of the system from the lake; and surveyed usage (derived from East Pond survey), while taking into account a groundwater phosphorus loading range based on low, medium and high flow estimates. These attribute values were determined by the shoreline survey and personal interviews with local officials.

For purposes of these calculations it was estimated that 80% of the dwellings along the shoreline had septic systems installed after 1974. Based on the results of the shoreline survey: 52% of residences (and their septic systems) were estimated to lie less than 50' from the shoreline while 48% were located 50 feet or greater from the shoreline; and, 60% of the structures were assumed to be seasonal residences (occupied 90 days/year) while 40% were assumed to be year-round residences (occupied most of the year). Estimates of the loading from residential septic systems on Long Lake range from a low of 89 to a high of 275 kg total phosphorus per year. Based on best professional judgment, a medium groundwater flow estimate and annual phosphorus export of 144 kg was chosen, which is approximately 6.1% of the total phosphorus export.

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

Additional septic information was also attained during the report compilation showing a small part of downtown Bridgton within the watershed as served by a municipal sewage system. Only the homes or businesses in this area that cannot meet state requirements are served by the municipal system. Neither Harrison or Naples have a municipal sewage system. Boys' and girls' camps, commercial campgrounds, and condominium developments in the watershed generally have combined collection systems that drain to engineered storage tanks and disposal fields.

Bridgton's Shoreland Zoning Ordinance has a provision to increase the minimum setback distance beyond 100 feet from Great Ponds, rivers and wetlands to the most suitable location within the Shoreland Zone as determined by the Code Enforcement Officer. The CEO considers soil suitability, runoff conditions and existing land uses in making the determination. Harrison and Naples have the minimum, mandatory standards from the State of Maine Subsurface Wastewater Disposal Rules, which require new systems to be set back at least 100 feet from the normal high-water line.

Private (Camp) and Public Roadways: There are 43 acres of private (camp) and public roads within the immediate shoreland zone (250' from shore) of Long Lake. Approximately 4,200 linear feet of Route 117, 2,500 linear feet of Route 35, and about 600 linear feet at the junction of Routes 302 and 114 are all within the shoreland zone. The rest of the roads are almost all small private and public roads used to access waterfront property. These roadways adjacent to Long Lake account for 1.5% of the watershed total phosphorus load.

Other shoreline land uses: Commercial development along the shoreline is primarily located in the downtown areas of Harrison and Naples. A marina, ice cream parlor, combined variety store and café, restaurant and commercial dock facility are located in Naples. A marina, three small office buildings, a combined convenience store and gas station, ice cream parlor and restaurant are located in Harrison. Near Bluff Point on the eastern shore in Harrison, Camps Newfound and Owatonna are adjacent but separate boys' and girls' ("sleep-away") camps under one ownership - 10 acres of this camp complex is within the shoreland zone. On the eastern side of the lake in Naples, five acres of Camp Takajo for boys (also "sleep-away) is within the shoreland zone. There are eight commercial campgrounds within the shoreland zone totaling 51 acres. Seven of these areas are primarily recreational vehicle campgrounds, one is an old boys' camp that has been converted to weekly cabin rentals. Public or institutional uses along the shore include a Grange Hall, library, and Post Office in Harrison as well as the Bridgton Academy Beach in North Bridgton. There are also three public parks with beaches, one in Harrison between Route 117 and Long Lake, one at Salmon Point in Bridgton, and one in Naples off Route 302. The combined export of all these 'other' shoreline land uses accounts for less than 1% of the total phosphorus load.

Other Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreland area (250 feet) of Long Lake. Some land uses extend outside the shoreland zone. The following section describes only those land uses (or parts of land uses) more than 250 feet away from Long Lake.

Residential Homes: Town tax records, property tax maps, high resolution aerial photos and GIS maps were used to determine low, medium, and high density residential areas within the Long Lake watershed. Low-density residential areas, characterized by dispersed, low-density single-family homes with less than one residence per acre, are scattered throughout the watershed and account for approximately 12.4% of the total phosphorus load to Long Lake and 6% of the total watershed land area. Medium-density residential area areas are characterized by one or more single family residences per acre. Medium-density development is concentrated mostly in downtown Bridgton, Naples and Harrison and just outside the 250 foot shoreland zone. Medium-density development accounts for 3% of the total watershed and approximately 10.1% of the total phosphorus load. High-density residential development is found in eight areas within the watershed. This includes areas with densely clustered housing units. High-density development accounts for 45 acres within the watershed and approximately 1% of the total phosphorus load.

Private and Public Roadways: There are 426 acres of public roadways outside the shoreland zone within the Long Lake watershed. Route 302, Route 117 and Route 35 all run nearly parallel to the lake and serve as major travel ways in the region. The Kansas Road, Cape Monday Road, the Lewis/Shore Road, and the Pond Road are all paved public roads that branch these travel corridors to better access the lake. From these larger roads, numerous, small public and private roads branch off and down to access lakefront property. As elsewhere, non-shoreline roadways account for a much greater percentage of the phosphorus load (11.6%) versus their minimal land area (2%) in the Long Lake watershed.

Other Non-Shoreline Land Uses

Parks and Cemeteries: A 3 acre park with basketball court and baseball field lies on the outskirts of the Long Lake watershed in Harrison. There is also a 3 acre cemetery on Route 35, just south of downtown Harrison. At least four, very small, old cemeteries can be found in the eastern portion of the watershed. There is a 10 acre cemetery along the watershed border at the beginning of the Kansas Road in Bridgton. The northern portion of this cemetery is still being developed and the combined effect of little vegetation and sandy soils make the area prone to erosion. There is also a town cemetery on Route 302 in Naples. A small, forested recreational park is located on Willis Park Road in Bridgton. Parks and cemeteries account for less than 1% of the total phosphorus load.

Industrial: At the southern tip of the watershed there is a heating oil and construction equipment storage facility. On Route 302 there is large automobile junkyard attached to a small used car dealership. Also on Route 302 there is a 2.5 acre lot used for industrial storage. There is a 2 acre equipment storage facility off the Kansas Road. East of the Kansas Road there is an 8 acre lot used as junkyard and for industrial equipment storage. The Harrison Public Works has a 4 acre facility used for sand and salt storage as well as equipment storage. There is also a Maine Department of Transportation highway maintenance facility off Route 302 in Bridgton used for sand, salt and equipment storage. Industrial land uses account for approximately 1.2% of the total phosphorus export.

Utilities: There is an electrical substation near the Stevens Brook outlet into Long Lake and utility transmission lines leading to and from the station. The lines are kept vegetated with grasses or low growing shrubs and parts are periodically sprayed with defoliant to suppress tree and sapling growth. ATV and snowmobile trails are common along the transmission lines and erosion is often pronounced on steep trail sections. Other utilities include two cellular phone towers off the Perley Road in Naples and two buildings used by the Harrison Water District at the Bear River Entrance to Long Lake. Utilities account for 20 acres of the watershed and less than 1% of the total phosphorus export.

Commercial: Most commercial development is located off Route 302, Route 117, Route 35 or near the town centers. Development includes small retail stores, antique dealers, boat storage facilities, office space, welding/metal fabrication, automobile repair, nursery and garden supply, storage facilities, restaurants, a driving range, building supply store, microwave technology manufacturing, small equipment testing laboratory, flooring store, gift shops, a bank, a multi-use health studio, variety store, boat dealer/marina, dock supply store, small batting cage facility, redemption center, car wash, two veterinary clinics, and two lots currently under development. This land use accounts for 62 acres within the watershed and approximately 1.6% of the total phosphorus load to Long Lake.

Institutional Public: A church, library, municipal complex, post office, information center and fire station are located in downtown Naples. Lake Region High School and Middle School have multiple athletic fields located between Route 302 and the Kansas Road. The High School has an engineered stormwater pond that outlets into a forested wetland. A Masonic Hall is located on

Route 117 outside Bridgton and 20 acres of Bridgton Academy in North Bridgton is within the Long Lake watershed. In Harrison, there are several public buildings including the town office, public library, fire station, two churches and post office. Harrison Elementary School is along route 35 in the eastern portion of the watershed. Institutional Public land uses account for approximately 2.6% of the total phosphorus export to Long Lake.

Gravel Pits: There are 14 gravel pits located within the watershed. Most of the pits are under 3 acres in size. The largest pit is located off the west side of the Kansas road and is approximately 9 acres. All the pits in the watershed are more than 500 feet from the lake. Because most gravel pits are internally draining, there is limited phosphorus export associated with this land use category.

Boys' and Girls' Camps: 37 acres of camps Newfound and Owatonna are outside the shoreland zone and 46 acres of Camp Takajo are outside the shoreland zone. Athletic fields, tennis courts, and a variety of camp buildings are found in these areas. These camps account for slightly less than 1% of the total phosphorus export load to Long Lake.

Recreational Campgrounds: Parts of all eight recreational campgrounds found within the shoreland zone extend outside the shoreland zone. Generally, as the distance from the lake increases, the density of campsites decreases. Most of the campgrounds in the watershed are occupied only seasonally (spring, summer, fall), however almost all have large amounts of impervious surfaces to accommodate recreational vehicles, automobile parking and vehicular access. Recreational campgrounds account for 1.4% of the total phosphorus export to Long Lake.

Landfills: One 8.3 acre landfill lies within the watershed. The landfill is located on the Perley Road and was used by the town of Naples until closure in 1993. Abutting the landfill are unused emergency septage holding tanks for the town of Naples. The landfill accounts for a minute portion of total phosphorus load to the lake.

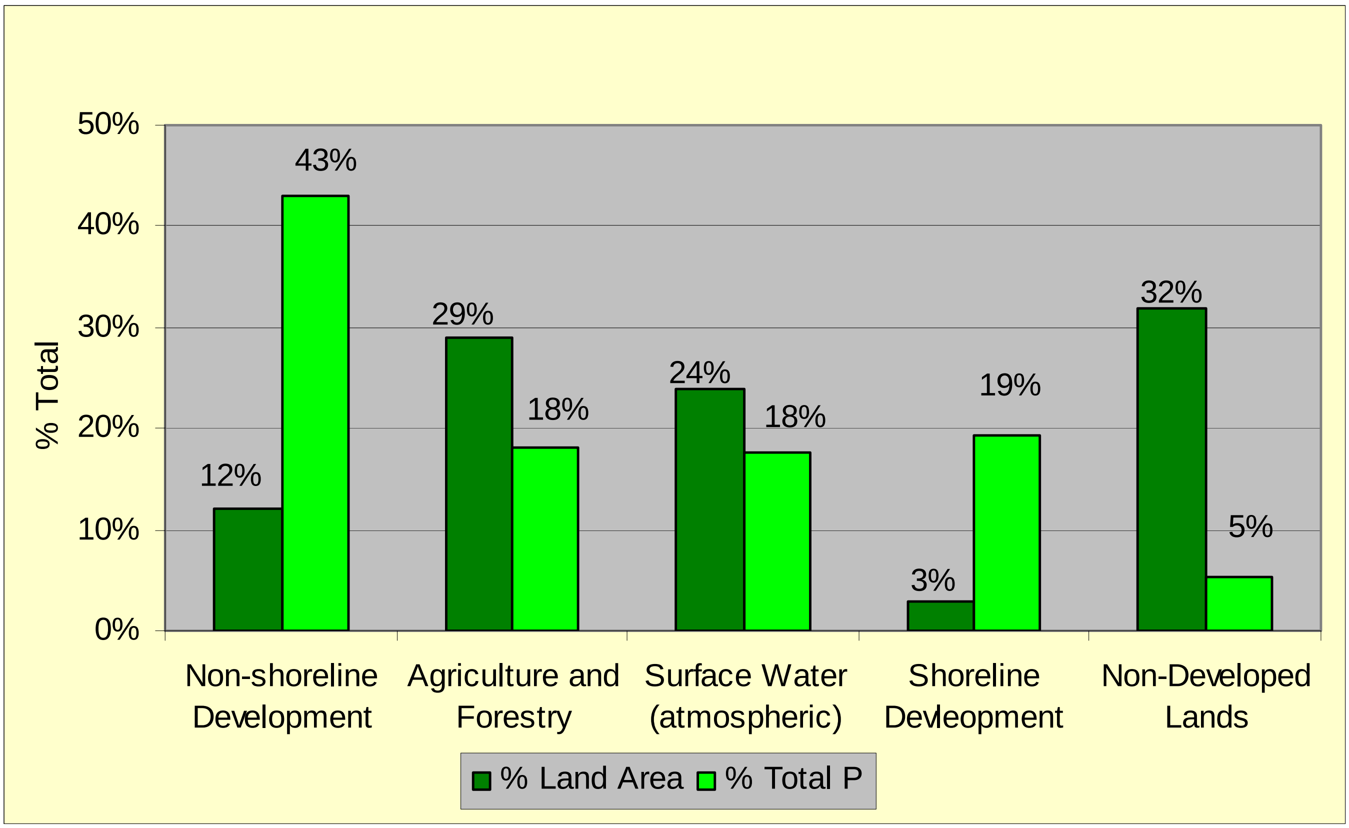
Phosphorus Loading from Non-Developed Lands and Water

Other Non-Developed Land Areas: Forested and open water wetlands are scattered throughout the watershed. They range in size from over 150 acres to less than 1 acre. Wetlands filter and slow runoff, provide important wildlife habitat and help reduce flooding. There are 821 acres of wetland within the watershed. Of the approximately 200 acres of reverting fields, the majority are found in the eastern portion of the watershed adjacent to or nearby existing farmland. Much of this land was previously farmland and has now grown up with shrubs and young trees. There are six named islands in Long Lake. The three largest are Long Point, Zakelo Island, and Bluff Point. During periods of low water, Long Point and Bluff Point become connected to the land by sand and rock shoals. Only one of these islands is developed. During high water, the central portion of Long Point can become flooded. Zakelo Island contains 9 buildable lots and has five residential structures on it. Pine Island is in of Mast Cove and has one small camp on it. Loon Island and Mosquito Island are both located off the eastern shoreline and are too small to be developed. In addition to the named islands there are several small rocky outcrops and floating bog islands in the lake. Combined wetlands, reverting fields and islands account for the remaining 5% of the land area and less than 1% of the total phosphorus export load.

Atmospheric Deposition (Open Water): Long Lake's surface waters (5,358 acres) and other open waters (15 acres) comprise 23% of the total watershed area, and because of atmospheric deposition of sediment and particulate matter, account for 14.6% of the total phosphorus load entering the lake.

Figure 2 depicts the percentage of land use areas and corresponding total phosphorus loadings.

Figure 2. Long Lake Direct Watershed
Land Use Areas and Total Phosphorus Loadings



PHOSPHORUS LOAD Summary – Watershed, Sediment and In-Lake Capacity

Supporting documentation for the phosphorus loading analysis includes the following: water quality monitoring data from LEA, the Maine DEP and the Volunteer Lake Monitoring Program, LEA/MACD GIS analysis and field ground-truthing, and the development of a phosphorus retention model (see Appendices for detailed information). Please note that two methods were used in our analysis to assist with the preparation of this report. However, the phosphorus reduction needed for the Long Lake TMDL was determined using only the in-lake concentration model.

1. Modeling total phosphorus input into Long Lake

Watershed Land Use: Total phosphorus loadings to Long Lake originate from a combination of external watershed and internal lake sediment sources. Watershed total phosphorus sources, totaling approximately **2,376 kg TP** annually have been identified and accounted for by land use (See Table 3 - page 31).

Loading from the Indirect Watershed: Total phosphorus loading from associated upstream sources accounts for an estimated indirect watershed average load of **750 kg TP** annually, determined on the basis of *flushing rate x volume x TP concentration* (c page 32 for more information).

The sum of these two potential sources of TP indicates that an estimated **3,126 kg of TP/yr** may be contributing to the current in-lake phosphorus levels of Long Lake. However, these models do not take into account many of the complex factors that affect lake water quality. Instead, these figures provide stakeholders with estimates that should assist with targeting implementation measures in the watershed.

2. Modeling Long Lake's in-lake concentrations of total phosphorus (TMDL)

Lake Capacity: The lake's assimilative capacity for all existing and future non-point pollution sources for Long Lake is 1,923 kg of total phosphorus per year, based on a target goal of 6 ppb (See Phosphorus Retention Model—page 35).

Target Goal: A change in 1 ppb in phosphorus concentration in Long Lake is equivalent to 320 kg. The difference between the target goal of 6 ppb and the measured average summertime total phosphorus concentration (7 ppb) is 1 ppb (1 x 320) or 320 kg.

Future Development: The annual total phosphorus contribution to account for future development for Long Lake is 240 kg (0.75 x 320) (See page 34 for more information).

Reduction Needed: Given the target goal and a 240 kg allocation for future development, the total amount of phosphorus needed to be reduced, on an annual basis, to maintain water quality standards in Long Lake is estimated to be 560 kg (320 + 240). However, more realistic and attainable interim annual phosphorus reduction goals would be considerably less (e.g., 320 to 400 kg, or ca. 360 kg on an annual basis).

PHOSPHORUS CONTROL ACTION PLAN

Recent and Current NPS/BMP Efforts

In 1990, Lakes Environmental Association (LEA) produced the Long Lake Watershed Study - A handbook for long-term lake protection. This document was written as a guide for citizens and lake associations to use in developing effective strategies to help protect Maine lakes from non-point source pollution. Using the Long Lake watershed as a model, the study shows a step by step process to evaluate water quality, set future water quality goals, evaluate and inventory current land use, quantify development potential, and determine allowable phosphorus loading rates. The study also included a model site plan ordinance, upgrades for shoreland zoning ordinances, lake protection language for comprehensive plans, and worksheets to help determine development and phosphorus loading rates for a watershed. Many of the same ideas and methods covered in the Long Lake Watershed Study were used to compile information for this and other TMDL reports (i.e. Highland Lake, Bridgton). The Long Lake Watershed Study project was authored by Peter Lowell and primarily funded by the US-EPA, under section 319 of the Clean Water Act.

In addition to the Long Lake Watershed Study, LEA offers free property consultations to help landowners with land erosion issues, low-impact development and ordinance interpretation. Over the past ten years, LEA has given over 100 individual consultations for landowners on Long Lake. LEA has also reviewed numerous subdivision and site plan applications within the watershed to help ensure phosphorus standards are met and sensitive habitat or riparian areas are protected.

Recommendations for Future NPS-BMP Work

Long Lake is a waterbody that has impaired water quality due to dissolved oxygen depletion in the waters below the thermocline - originating from nonpoint source (NPS) pollution. Specific recommendations regarding recent and current efforts in the watershed, best management practices (BMPs), and actions to reduce external watershed total phosphorus loadings in order to improve water quality conditions in Long Lake are as follows:

Existing erosion sites: Obtain funding to repair existing erosion sites for all land uses within the watershed. Many of the chronically eroding sites are associated with older public and private roads accessing the lake. Fixing these areas usually requires cooperation between multiple landowners, and/or a road association or municipality.

Action Item # 1: Fix existing watershed erosion sites		
Activity	**Participants**	**Schedule & Cost**
Repair or mitigate existing erosion sites within the watershed	Watershed residents, LEA, CC-SWCD, Municipalities, Road Associations, local contractors	2006 - 2014 **$100,000 annually**

Shoreline residential: Erosion control on residential construction sites and small projects is often overlooked. The cumulative impact of erosion from these sites is large. For this reason, detailed site plans for earthmoving, soil disturbance or new construction activities that affect more than 200 square feet of area within the shoreland zone should be required. Expanding the number of tributaries covered under shoreland zoning will require more projects to use proper erosion control and development standards. Local shoreland zoning standards should be enhanced to limit non-conforming expansions to the rear of the building only, improve vegetative clearing standards to regulate the cutting of brush and vegetation taller than three feet in height and encourage strong

Action Item # 2: Enhance local shoreland zoning standards		
Activity	**Participants**	**Schedule & Cost**
1. Enhance erosion control standards and building expansion and brush cutting standards in Shoreland Zoning. 2. Require site plans for earth moving.	Watershed municipalities, LEA, local contractors, town citizens, and Maine DEP.	For consideration by 2006 Town Meeting **$4,000/yr**

enforcement of existing shoreland zoning standards.

Roadways: Institute a series of inspections and technical assistance workshops for camp roads and road associations. Enhance shoreland zoning to require new public and private roads to meet

Action Item # 3: Camp road inspections and enhanced phosphorus standards for new road development		
Activity	**Participants**	**Schedule & Cost**
1. Institute inspections and offer technical assistance for camp roads. 2. Require new public and private roads to meet phosphorus standards	Watershed municipalities, LEA, CC-SWCD, camp road associations, private landowners, developers, Maine DEP	Annually beginning in 2006 **$20,000/yr**

the phosphorus control standards outlined in the DEP's Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development (1992).

Action Item # 4: Encourage conservation on agricultural lands		
Activity	**Participants**	**Schedule & Cost**
1. Encourage participation in agricultural conservation programs. 2. Promote nutrient management	Watershed municipalities, CC-SWCD, USDA NRCS, agricultural landowners	Annually beginning in 2006 **$2,000/yr**

<u>Agriculture</u>: Encourage conservation practices on agricultural lands that will be environmentally friendly and economically beneficial. Increase landowner awareness of agricultural BMPs.

<u>Land Use Conversion</u>: After timber harvesting, large view and shoreline lots are frequently subdivided and converted to residential housing. On these lots, logging access roads and yarding areas often become residential roads and house lots. Because these areas were designed and constructed for temporary use by harvesters they often cannot adequately meet phosphorus standards and this results in increased runoff and erosion entering nearby streams and waterbodies. Municipal requirements for simplified pre-harvest plans, filter areas and proper erosion control as described in <u>Best Management Practices for Forestry: Protecting Maine's Water Quality</u> would minimize erosion and sedimentation during the harvesting period and help prevent negative impacts if the lot is developed in the future. Watershed municipalities should investigate incentives for sustainable yield forestry including the purchase of development rights by land trusts or the town.

Action Item # 5: Financial incentives for sustainable forestry		
<u>Activity</u>	**<u>Participants</u>**	**<u>Schedule & Cost</u>**
1.Municipality required forestry permits that include site sketches and BMPS. 2.Incentives for sustainable forestry and purchase of development rights.	Watershed municipalities, forest landowners, logging professionals, local land trusts.	Beginning 2006 **Cost dependent on incentives**

<u>Individual action</u>: Seek technical assistance through LEA's Clean Lake Check-Up Program and SWCD/NRCS programs. Monitor and maintain individual septic systems. Continue to support non-phosphorus fertilizer standards in Bridgton. Maintain and enhance downslope buffers for all development within the watershed.

Action Item # 6: Technical assistance and self monitoring for individuals		
<u>Activity</u>	**<u>Participants</u>**	**<u>Schedule & Cost</u>**
1. Seek technical assistance and include support of non-phosphorus fertilizer 2. Monitor septic systems 3. Establish and enhance vegetated buffers	Landowners, LEA, CC-SWCD, USDA-NRCS	Ongoing **May involve cost to landowners or technical assistance programs**

Action Item # 7: Municipal and State implementation and enforcement		
<u>Activity</u>	**<u>Participants</u>**	**<u>Schedule & Cost</u>**
1.Implement town comprehensive plans and phosphorus control/buffer ordinances. 2. Improve and enhance zoning while supporting consistency of enforcement	Bridgton, Harrison and Naples municipalities, Maine DEP	2006 **$2,000**

Municipal action: Implement town comprehensive plans and phosphorus control ordinances. Improve shoreland zoning standards and implement land use standards for non shoreline development. Support strong enforcement of existing standards.

Watershed management: Adopt and implement a simple phosphorus control/ buffer ordinance in the towns of Bridgton, Harrison and Naples similar to the phosphorus control standards found in other municipal ordinances such as the Town of Sweden's ordinance which is available at the Lakes Environmental Association office in Bridgton.

Action Item # 8: Implement water quality ordinances		
Activity	**Participants**	**Schedule & Cost**
Develop and implement a simple phosphorus and buffer ordinance for Bridgton, Naples and Harrison	Watershed municipalities, LEA, watershed and town citizens	2006 Town Meeting, updates depend on water quality conditions—**minimal cost**

WATER QUALITY MONITORING PLAN

Historically, the water quality of Long Lake has been monitored since 1976, including Secchi disk transparencies, temperature and oxygen profiles, pH, alkalinity, color and some conductivity readings during the open water months. Chlorophyll-a has been monitored on the lake from the mid 1980s to the present. Total phosphorus has been measured regularly from 1989 to the present (LEA and Maine DEP). Continued long-term water quality monitoring within Long Lake will be conducted bi-monthly, from May to October, through the continued efforts of the Lakes Environmental Association in cooperation with Maine DEP. Under this planned, post-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 Long Lake. A post-TMDL adaptive management status report will be prepared five to ten years following EPA approval of the Long Lake PCAP-TMDL.

PCAP CLOSING STATEMENT

The Lakes Environmental Association (LEA), in cooperation with resident landowners, has worked since the late 1970's to correct both point and nonpoint source pollution within the Long Lake watershed. Today, point source pollution to Long Lake is no longer a problem and efforts have been focused on correcting nonpoint source pollution problems. LEA is continuing to work with landowners, businesses, the towns of Bridgton, Harrison, and Naples and state and federal agencies to help correct this problem. Through LEA's Clean Lake Check-Up program, property owners are able to receive free technical assistance regarding erosion, land use standards and camp road maintenance. LEA also assists the planning boards and comprehensive planning committees in all three towns to help ensure better development standards. In addition, LEA's water testing program, which is partially financed by the towns, continues to increase public awareness and interest in nonpoint source pollution and provide valuable water quality data. The Town of Bridgton has also shown a high level of commitment to protecting Long Lake by creating additional levels of protection such as the erosion and sedimentation control district. With continued diligent watershed work by residents, towns, and local and regional organizations - the water quality of Long Lake is apt to improve in future years to the benefit of sport fisheries and lake user groups.

APPENDICES

LONG LAKE

Total Maximum Daily (Annual Phosphorus) Load

Introduction to 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* (i.e. discharge pipes) 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 TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. TMDLs have been approved by US-EPA for Madawaska Lake (Aroostook County), Sebasticook Lake, East Pond (Belgrade Lakes), China Lake, Webber, Threemile and Threecornered ponds (Kennebec County), Mousam Lake, Highland Lake (Falmouth), Annabessacook Lake and Pleasant Pond (contract with Cobbossee Watershed District), Sabattus Pond, Highland Lake (Bridgton - with LEA), Unity Pond (Waldo County), Toothaker Pond (Franklin County) and Upper Narrows Pond (CWD). 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 Little Cobbosee Lake (contract with CWD), Togus, Duckpuddle and Lovejoy ponds. PCAP-TMDL studies have also been initiated for Lilly, Hermon-Hammond, and Sewall ponds, as well as two of the remaining seven 303(d) listed waterbodies in Aroostook County (Christina and Trafton lakes).

Lake PCAP-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.

PCAP-TMDLs are important tools for maintaining and protecting acceptable lake water quality and are designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to effectively address the lake's water pollution 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, you may contact Dave Halliwell, Maine Department of Environmental Protection, Lakes PCAP-TMDL Program Manager, SHS #17, Augusta, ME 04333 (287-7649).

Water Quality Monitoring: (Source: LEA, Maine DEP) Comprehensive water quality monitoring data for Long Lake has been collected annually since 1976. This water quality assessment is based on 28 years of Secchi disk transparency (SDT) measures, combined with 28 years of oxygen and temperature profiles, 10 years of epilimnion core total phosphorus (TP) data, 15 years of total phosphorus (TP) grab data and 28 years of water chemistry and chlorophyll-a monitoring data.

Water Quality Measures: (Source: LEA and Maine DEP) Long Lake is a non-colored lake (average color 17 SPU) with an (LEA corrected) average Secchi disk transparency (SDT) of 6.3 m (20.6 ft). The range of epilimnetic water column total phosphorus (TP) (from core samples only) for Long Lake is 3-15 parts per billion (ppb) with an average of 7 ppb, while chlorophyll-a ranges from 0.8 - 8.7 ppb with an average of 2.9 ppb. Dissolved oxygen (DO) profiles show moderate to severe DO depletion in deep areas of the lake. The potential for TP to enter the water column from the bottom sediments and become available to algae (internal loading) is moderate (VLMP 2003). Oxygen levels below 5 parts per million (ppm) stress most cold-water fish and a persistent loss of oxygen may eliminate habitat for sensitive cold-water species. Together, these data indicate a historical minor trend of increasing trophic state and hence a violation of the Class GPA water quality criteria requiring a stable or decreasing trophic state.

Priority Ranking, Pollutant of Concern and Algal Bloom History: Long Lake is listed on the State's 2002 303(d) list of waters in non-attainment of Maine state water quality standards and was moved up in the priority development order due to stakeholder interest and need to complete an accelerated approach to lakes TMDL development. The Long Lake TMDL has been developed for total phosphorus, the major limiting nutrient to algae growth in freshwater lakes in Maine. Although nuisance algal blooms do not occur per se, the water quality of Long Lake during the summers of 2001-2002 appeared to be unimproved in contrast to 2000 and the preceding 25 years of record.

Natural Environmental Background Levels for Long Lake were not separated from the total nonpoint source load because of the limited and general nature of available information. Without more and detailed site-specific information on nonpoint source loading, it is very difficult to separate natural background from the total nonpoint source load (US-EPA 1999). There are no known point sources of pollutants to Long Lake.

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. This water quality assessment uses historic documented conditions as the primary basis for comparison. Given the context of "impaired use and enjoyment," along with a realistic interpretation of Maine's goal-oriented Water Quality Standards (WQS), Maine DEP has determined that episodic, non-cyanobacteria based algae blooms (e.g. diatoms), limited to the fall or spring periods only, are in WQS attainment for GPA waters. Currently, Long Lake does not meet water quality standards due to excessive historical watershed phosphorus loading leading to severe dissolved oxygen (DO) depletion in deep areas of the lake and increasing trophic state.

Designated Uses and Anti-degradation Policy: Long 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 Long Lake is to halt its current trend of increasing trophic state so that it can attain Maine DEP standards of stable or decreasing trophic state. The numeric (in-lake) water quality target for Long Lake, to meet this goal, is conservatively set at 6 ppb total phosphorus (1,923 kg TP/yr). Since numeric criteria for phosphorus do not exist in Maine's 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 phosphorus concentration that would attain the narrative water quality standard. Spring-time (early May) epilimnion core total phosphorus levels in Long Lake measure 5 - 7 ppb, while summer-time (July through September) in-lake epilimnion core total phosphorus levels measure 6 - 8 ppb. In summary, the numeric water quality target goal of 6 ppb for total phosphorus in Long Lake was based on observed late spring – early summer mixed water column data, corresponding to continued maintenance of non-bloom conditions, as reflected in suitable (water quality attainment) measures of both Secchi disk transparency (> 2.0 meters) and chlorophyll-a (< 8.0 ppb).

ESTIMATED PHOSPHORUS EXPORT BY LAND USE CLASS

Table 3 details the numerical data used to determine external phosphorus loading for the Long Lake watershed. The key below explains the columns and the narrative that follows the table (pages 28-29) relative to each of the representative land use classes.

Key for Columns in Table 3

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

Land Area in 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 the land use.

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

TP Coeff. Value kg TP/ha: The selected coefficient for each land use category. The total phosphorus coefficient is determined from previous research – usually the median value, if listed by the author. The coefficient is often adjusted using best professional judgment based on conditions including soil type, slope, and best management practices (BMPs) installed.

Land Area in Hectares: Conversion, 1.0 acre = 0.404 hectares

TP Export Load kg TP: Total hectares x applicable total phosphorus coefficient for each land use

GIS adjusted kg TP: Total hectares x land use coefficient x slope coefficient x soils coefficient (See Appendix A)

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

Table 3. Long Lake Direct Watershed - Phosphorus Export by Land Use Class

LAND USE CLASS	Land Area Acres	Land Area %	TP Coeff. Range kg TP/ha	TP Coeff. Value kg TP/ha	Land Area Hectares	TP Export Load kg TP	GIS Adjusted* kg TP	TP Export Total %
Agricultural and Forested Land								
Operated Forest Land	5,819	25%	0.04 - 0.10	0.08	2,356	188	205	8.6%
Low Intensity Hayland	658	3%	0.35 - 1.35	0.64	266	171	189	8.0%
Livestock Areas	32	0%	0.14 - 4.90	0.81	13	11	11	0.5%
Orchard	51	0%	0.06 - 0.75	0.4	21	8	9	0.4%
Cultivated Cropland	8	0%	0.26 - 18.6	2.24	3	7	8	0.3%
Farm Buildings	3	0%	0.77 - 4.18	1.5	1	2	2	0.1%
Sub-Totals	**6,571**	**29%**	**-**	**-**	**2,660**	**387**	**424**	**17.8%**
Shoreline Development								
Septic Systems		**Long**	**Lake**	**Septic**	**Model**	144	144	6.1%
Medium Density Residential	472	2%	0.40 - 2.20	1.0	191	191	210	8.8%
Private/Camp Roads	43	0%	0.60 - 10.0	2.0	17	35	36	1.5%
Low Density Residential	157	1%	0.25 - 1.75	0.5	64	32	34	1.4%
Campgrounds	51	0%	0.56 - 2.70	0.7	21	14	15	0.6%
High Density Residential	17	0%	0.56 - 2.70	1.4	7	9	8	0.3%
Boys and Girls Camps	15	0%	0.4 - 2.20	0.5	6	3	4	0.2%
Commercial	5	0%	0.77 - 4.18	1.5	2	3	2	0.1%
Institutional Public	1	0%	0.77 - 4.18	1.5	0	1	1	0.0%
Parks and Cemeteries	1	0%	0.14 - 4.90	0.8	0	0	0	0.0%
Sub-Totals	**762**	**3%**	**-**	**-**	**309**	**432**	**454**	**19.1%**
Non-Shoreline Development								
Private and Public Roads	425	2%	0.60 - 10.0	1.5	172	258	275	11.6%
Low Density Residential	1,344	6%	0.25 -1.75	0.5	544	272	295	12.4%
Medium Density Residential	568	2%	0.40 - 2.20	1.0	230	230	240	10.1%
Institutional (Public)	98	0%	0.77- 4.18	1.5	40	59	62	2.6%
Commercial	62	0%	0.77 - 4.18	1.5	25	38	38	1.6%
Campgrounds	111	0%	0.56 - 2.70	0.7	45	32	33	1.4%
Industrial	46	0%	0.77-4.18	1.5	19	28	28	1.2%
Boys and Girls Camps	86	0%	0.4 - 2.20	0.5	35	17	17	0.7%
High Density Residential	45	0%	0.56 - 2.70	1.4	18	26	23	1.0%
Parks and Cemeteries	22	0%	0.14 - 4.90	0.8	9	7	6	0.3%
Utilities	20	0%	0.10- 0.20	0.2	8	2	2	0.1%
Landfill	8	0%	0.35 - 1.35	0.64	3	2	2	0.1%
Gravel Pits	38	0%	0.00-0.00	0	15	0	0	0.0%
Sub-Totals	**2,873**	**13%**	**-**	**-**	**1,163**	**971**	**1,021**	**43.0%**
Total: DEVELOPED LAND	**10,206**	**45%**	**-**	**-**	**4,132**	**1,790**	**1,899**	**79.9%**
Non-Developed Land								
Inactive/Passively Managed Forest	6,222	27%	0.01 - 0.04	0.04	2,519	101	111	4.7%
Reverting Fields	199	1%	0.10 - 0.20	0.2	81	16	17	0.7%
Islands	29	0%	0.01 - 0.04	0.04	12	1	1	0.0%
Other waters	15	0%	0.11 - 0.21	0.16	6	1	1	0.0%
Wetlands	821	4%	0.00 - 0.05	0	332	0	0	0.0%
Total: NON-DEVELOPED Land	**7,286**	**32%**	**-**	**-**	**2,950**	**119**	**130**	**5.5%**
Total: Surface Water (Atmospheric)	**5,358**	**23%**	**0.11 - 0.21**	**0.16**	**2,169**	**347**	**347**	**14.6%**
TOTAL: DIRECT WATERSHED	**22,850**	**100%**	**-**	**-**	**9,251**	**2,256**	**2,376**	**100.0%**

Total Phosphorus Land Use Loads

Estimates of total phosphorus export from different land uses found in the Long Lake are presented in Table 3, representing the extent of the current direct watershed phosphorus loading to the lake (2,376 kg TP/yr). Total phosphorus loading from the associated upstream sources (750 kg TP/yr) accounts for loading from the indirect watershed, determined on the basis of *flushing rate x volume x TP concentration (ppb),* representing typical area gauged streamflow calculations. The six waterbodies (Bear Pond, Little Moose Pond, Crystal Lake, 303(d) listed Highland Lake, Otter Pond, and Woods Pond) that are most immediate in the chain of flow to Long Lake are utilized in this model (Jeff Dennis, Maine DEP).

Total phosphorus loading measures are provided as a range of values to reflect the degree of uncertainty generally associated with such relative estimates (Walker 2000). The watershed total phosphorus loading values were primarily determined using literature and locally-derived export coefficients as found in Schroeder (1979), Reckhow et al. (1980), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for residential properties, roadways, agriculture and other types of land uses (e.g., recreational, commercial).

Agricultural and Operational Forest Lands: Phosphorus loading coefficients as applied to agricultural land uses were adopted, in part, from Reckhow et. al. 1980: livestock areas/pasture (0.81 kg TP/ha/yr), row crops/tillage/cultivation (2.24 kg TP/ha/yr) the Annabessacook Lake Model 1977: orchard (0.40 kg TP/ha/yr) Dennis and Sage 1981: low-intensity hayland (0.64 kg TP/ha/yr); and from past Maine DEP 1982 studies: farm buildings (used commercial-industrial coefficient) (1.5 kg TP/ha/yr).

The phosphorus loading coefficient applied to operated forestlands (0.08 kg TP/ha/yr) was changed from previous PCAP-TMDL reports after consulting with LEA and Maine Forest Service staff. The rationale for this change is based on the fact that properly managed harvest areas will generally act as phosphorus sinks during periods of regeneration. According to the Maine Forest Service, nearly 3,500 water quality inspections conducted throughout the state in 2003, approximately 7% of the harvested sites posed "unacceptable" risks to water quality. Previous lake PCAP-TMDL reports identified a "worst case" upper limit phosphorus loading coefficient of 0.6 kg TP/ha/yr for operated forestland. We applied this "worst case" value to 7% of the 2,356 operated forestland hectares (165 ha) identified in the Long Lake watershed. The "best case" passively managed forestland coefficient (0.04 kg TP/ha/yr) was then applied (per Jeff Dennis, Maine DEP and Chris Martin, Maine Forest Service) to the remaining 93% (2,191 hectares) of operated forestland - assuming that it had all been properly managed. The calculations to arrive at an average operated forestland coefficient of 0.08 kg TP/ha/yr are as follows:

Worst case operated forestland: 2,356 ha x 7% = 165 ha x 0.60 kg TP/ha/yr = 99 kg TP/ha/yr

Best case operated forestland: 2,356 ha - 165 ha = 2,191 ha x 0.04 kg TP/ha/yr = 88kg TP/ha/yr

New phosphorus loading coefficient for operated forestland: 187 kg TP / 2,356 ha= 0.08

Residential Lots (House and Camp): The range of phosphorus loading coefficients used (0.25 – 2.70 kg TP/ha/yr) were developed using information on residential lot stormwater export of phosphorus as derived from Dennis et al (1992). low density residential Development (0.50 kg TP/ha/yr), medium density residential development (1.0 kg TP/ha/yr), and high density residential development (1.40 kg TP/ha/yr).

Private and Public Roads: The total phosphorus loading coefficient for private and public roads (2.0 TP/ha/yr for private and 1.50 kg TP/ha/yr for public) was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997) and phosphorus research by Jeff Dennis (Maine DEP).

Other Developed Land Uses: Research from Wagner-Mitchell-Monagle 1989: parks and cemeteries (0.80 kg TP/ha/yr), from the original Cobbossee Lake TMDL (Monagle 1995) and total phosphorus recommendations by Jeff Dennis: institutional public (1.50 kg TP/ha/yr), commercial (1.50 kg TP/ha/yr), industrial (1.50 kg TP/ha/yr), gravel pits (0 kg TP/ha/yr), campgrounds (0.70 kg TP/ha/yr), boys and girls camps (used low density residential coefficient) from Bouchard 1995 utilities lines (used grasslands/reverting fields coefficient) (0.20 kg TP/ha/yr) from Dennis, Sage 1981; Annabessacook Lake 1990; and Reckhow et al 1980 landfill (used low intensity hayland coefficient) (0.64 kg TP/ha/yr)

Total Developed Lands Phosphorus Loading: A total of 79.9% (1,899 kg) of the phosphorus loading to Long Lake is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture and forestry (17.8% - 424 kg); non-shoreline development (43% - 1021 kg) and shoreline development (19.1% - 454 kg), including septic systems (6.1% - 144 kg) as depicted in Table 3.

Non-Developed Lands Phosphorus Loading: The phosphorus export coefficient for forested land and islands (0.04 kg TP/ha/yr) is based on a New England regional study (Likens et al 1977) and phosphorus availability recommendation by Jeff Dennis. The phosphorus export coefficient for reverting fields is based on research by Bouchard in 1995 (0.20 kg TP/ha/yr). The export coefficient for wetlands is based on research by Bouchard 1995, and Monagle 1995 (0.0 kg TP/ha/yr). The phosphorus loading coefficient chosen for surface waters (atmospheric deposition) was (0.16 kg TP/ha) and was originally used in the China Lake TMDL (Kennebec County).

Shoreline Erosion: Undeveloped areas of the lake shoreline that may be eroding due to natural causes (i.e., wind, wave and ice action) are not included as a source of phosphorus due to the difficulty in quantifying impact area and assigning suitable phosphorus loading coefficients.

Phosphorus Load Summary

It is our professional opinion that the selected export coefficients are appropriate for the Long Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external nonpoint source nutrient pollution (direct and indirect drainages) approximates 3,126 kg TP/yr.

LINKING WATER QUALITY and POLLUTANT SOURCES

Assimilative Loading Capacity: The Long 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 and justifiable to express the Long Lake TMDL as an annual load because the lake basin has an annual flushing rate of 0.94 flushes, one-third less than the 1.50 average flushing rate for Maine lakes.

The Long Lake basin lake assimilative capacity is capped at 1,923 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 6 ppb. This value reflects the modeled annual phosphorus loading responsible for current trophic state conditions, based on a long term goal of maintaining average summertime phosphorus concentrations at or below 6 ppb.

Future Development: In order to effectively meet the stated goal of maintaining current trophic state conditions, further reductions in existing watershed phosphorus loading is necessary for two important reasons. First, Long Lake has a flushing rate of only 0.94 times per year and is a well-mixed waterbody. 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 P-load over the past 5 years (Jeff Dennis, Maine DEP).

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 used 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 non-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 projected amount is a conservative estimate, since most of the development during this period (1999-2003) did in fact incorporate measures to mitigate phosphorus export from the Long Lake watershed. The second reason for the need to further reduce existing watershed P-loads is that growth will, no doubt, continue to occur in the Long Lake watershed, contributing new sources of phosphorus to the lake. Previously unaccounted P-loading from anticipated future development on the Long Lake watershed is 240 kg (1 ppb change in trophic state = 320 kg x 0.75). Hence, existing phosphorus source loads must be reduced by at least 240 kg/yr to allow for anticipated new sources of phosphorus to Long Lake. Reductions already underway in non-point source total phosphorus loadings are expected from the continued implementation of best management practices - primarily from improvements to roadways and residential shoreline vegetative buffer plantings (see NPS/BMP Implementation Plan and PCAP Summary, pp. 23-26).

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Long Lake - in terms of sediment TP recycling - were analyzed (using lake volume-weighted mass differences between early and late summer) and estimated on the basis of water column TP data from 2002 to 2004. Estimated internal sediment TP loads for this 3-year period ranged from 270 to 323 kg with an average annual value of 300 kg. The amount of phosphorus being released from the sediments of Long Lake, during the summer period, has been fairly regular during this time period. This value is not calculated into the model to determine the target goal for Long Lake.

Linking Pollutant Loading to a Numeric Target: The basin loading assimilative capacity for Long Lake was set at 1,923 kg/yr of total phosphorus to meet the numeric water quality target of 6 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data (3 year springtime average, 2002 -2004), was used to link phosphorus loading to a numeric target.

Supporting Documentation for the Long 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 retention coefficients.

<u>Total Phosphorus Retention Model</u> (after Dillon and Rigler 1974 and others)

L = P (A z p) / (1-R) where: (1 ppb change = **320** kg)

1,923 = **L** = in-lake total phosphorus load capacity (kg TP/year)

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

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

7.7 = **z** = mean depth of lake basin (m) **A z p = 157**

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

0.49 = **1- R** = phosphorus retention coefficient, where:

0.51 = **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, and China Lake TMDLs (2000-2001), and Long, Webber-Threemile-Threecornered pond complex, Mousam, Annabessacook, Pleasant Pond, Unity, and Upper Narrows pond PCAP-TMDLs (Maine DEP 2003-2005) have shown this approach to be effective in linking watershed total phosphorus (external) loadings to existing in-lake phosphorus concentrations.

Strengths and Weaknesses in the Overall TMDL Analytical Process: The Long Lake TMDL was developed using existing lake 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-New England) 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.

Critical Conditions - Occur in Long Lake during the summertime, when the dissolved oxygen depletion in the bottom hypolimnetic waters is most pronounced. The lake target loading capacity of 6 ppb total phosphorus during this critical time period, will provide adequate seasonal protection, and will result in gradual water quality improvement over future years (see Seasonal Variation).

LOAD ALLOCATIONS (LA's) The annual load allocation for Long Lake equals 1,923 kg TP and represents, in part, that portion of the lake's assimilative capacity allocated to non-point (overland) sources of phosphorus (from Table 3). Direct external TP sources (totaling 2,376 kg/yr - GIS adjusted) have been identified and accounted for in the land-use breakdown portrayed in Table 3. Further reductions in non-point source phosphorus loadings are expected from the continued implementation of NPS best management practices (see PCAP pages 23 –26). As previously mentioned, it was not possible to separate natural background from non-point pollution sources in this watershed because of the limited and general nature of the available information. As in other Maine TMDL lakes (see Sebasticook Lake, East Pond, China Lake and Webber-Threemile-Threecorner, Annabessacook, Pleasant, and Unity pond TMDLs), in-lake nutrient (phosphorus) loadings in Long Lake originate from a combination of direct and indirect external (watershed + six associated sub-watersheds) and an accumulation of internal (sediment) sources of phosphorus.

WASTE LOAD ALLOCATIONS (WLA's): There are no known existing point sources of pollution (including regulated storm-water sources) in the Long Lake watershed, hence, the waste load allocation for all existing and future point sources is set at 0 (zero) kg/year of total phosphorus.

MARGIN OF SAFETY (MOS): An implicit margin of safety was incorporated into the Long Lake TMDL through the conservative selection of the numeric water quality target, as well as the selection of relatively conservative phosphorus export loading coefficients for cultural pollution sources (Table 3). Based on both the Long Lake historical records and a summary of statewide Maine lakes water quality data for non-colored (< 26 SPU lakes) - the target of 6 ppb (1,923 kg TP/yr in Long Lake) represents a highly 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 non-colored Maine lakes indicate 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.

SEASONAL VARIATION: This Long 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 macrophytes. With an average flushing rate of 0.94 flushes/year, the average annual phosphorus loading is most critical to the water quality in Long Lake. Maine DEP lake biologists, as a general rule, use more than six flushes annually (bi-monthly) as the cutoff for considering seasonal variation as a major factor (to distinguish lakes vs. rivers) in the evaluation of total phosphorus loadings in aquatic environments in Maine. Nonpoint source best management practices (BMPs) proposed for the Long Lake watershed have been designed to address total phosphorus loading during all seasons.

PUBLIC PARTICIPATION: Adequate ('full and meaningful') public participation in the Long Lake TMDL development process was ensured - during which land use and phosphorus load reductions were discussed - through the following avenues from summer 2002 through winter 2005:

1. Town of Bridgton Comprehensive Plan Committee meetings
2. Consultations with Bridgton, Harrison and Naples CEOs
3. Consultations with members of the Long Lake Water Level Committee
4. Land use interpretation and correction from the Naples Comprehensive Planning Committee

5. Draft reports were given to town officials in Bridgton, Naples and Harrison
6. Long Lake watershed stakeholder meetings
7. Extensive Long Lake water quality monitoring with shorefront volunteers
8. Clean Lake Checkup Program Property Consultations with shorefront owners
9. Lakes Environmental Association sponsored public presentations
10. Maine DEP, LEA and MACD Long Lake watershed and shoreline survey
11. Arial photo interpretation with Long Lake watershed residents

LONG LAKE STAKEHOLDER REVIEW

A stakeholder review document was distributed electronically on 31 January 2005 to the following organizations or individuals that participated in the field work and/or development of the document: Roy Bouchard, and Jeff Dennis (Maine DEP), Oxford and Cumberland County SWCD's, Tamara Lee Pinard (Southern Maine Lakes Coordinator) and CC-SWCD Board of Supervisors, Colin Holme and Peter Lowell (LEA), Chris Martin (Maine Forest Service), David Rocque (Maine Department of Agriculture), and Francis Brautigam (Maine DIFW).

The stakeholder review period was extended for another two weeks at the request of Cumberland County SWCD (through February 23rd).

Peter Lowell (LEA) provided several editorial comments and wording changes that were addressed in the public review document.

Chris Martin (MFS) provided clarification on forestry practices in the watershed and suggested several wording changes relating to forest land, which were incorporated into the public review document.

Tamara Lee Pinard and the Cumberland County SWCD Board of Supervisors provided editorial comments and wording changes that were fully addressed in the public review document. Substantive comments were also provided and discussed at a meeting with LEA and MACD on Wednesday, February 23. Maine DEP approved changes were then incorporated into the final public review document.

PUBLIC REVIEW PROCESS

The public review process began on February 25, 2005 and ran through March 25, 2005. All stakeholder review participants were provided electronic versions of the public review document. In addition, Bridgton Planning Board members, Bridgton Selectmen, the Bridgton CEO, Harrison Conservation Commission, Harrison Planning Board, the Harrison CEO, Naples Conservation Commission, Naples Planning Board, and the Naples CEO were provided printed copies of the public review documents. In addition, a standard Maine Lakes PCAP-TMDL the following 'legal' advertisement was placed in the *Bridgton News*, *Advertiser Democrat* (Norway), *Portland Press Herald*, and *Kennebec Journal* during week-end editions in mid-March of 2005.

LONG LAKE (Cumberland-Oxford Counties)
Watershed/Lake Nutrient Control/Management Report (PCAP-TMDL)

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 combined **Phosphorus Control Action Plan (PCAP)** and **Total Maximum Daily Load (TMDL)** nutrient report for the **Long Lake** (DEPLW 2005-0691) watershed, located within the towns of Bridgton, Harrison and Naples. This **PCAP-TMDL** report identifies and provides best estimates of non-point source phosphorus loads for all representative land use classes in the **Long Lake** watershed and the total phosphorus reductions required to restore and maintain acceptable water quality conditions. A Public Review draft of this report may be viewed at Maine DEP Central Offices in Augusta (Ray Building, Hospital Street - Route 9, Land & Water Bureau) or on-line: http://www.maine.gov/dep/blwq/comment.htm. Please send all comments, in writing - by March 28, 2005, to Dave Halliwell, Lakes TMDL Program Manager, Maine DEP, State House Station #17, Augusta, ME 04333. e-mail: david.halliwell@maine.gov.

Further public review responses were provided by Tamara Lee Pinard, Lakes Program Manager with the Cumberland County Soil and Water Conservation District - primarily addressing the need for establishing a reduced "interim phosphorus reduction goal" which would allow watershed managers to develop (short-term effective NPS-BMP) implementation plans which be reasonably achieved, in terms of cost and effort. In consultation with Roy Bouchard (DEA Lakes Assessment Section) and Jeff Dennis (Watershed Management Division), we have modified this PCAP-TMDL report to take into account these concerns (see also pages 5 and 22). This phosphorus loading modification (interim goal) may also be applicable to four other similar 303(d) listed mesotrophic-type Maine lakes (e.g., Highland lakes - Falmouth and Bridgton, Mousam Lake, and Upper Narrows Pond), but not directly applicable to the remaining 28 more eutrophic-type 303-d listed Maine lakes.

March 25, 2005

Dave Halliwell
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Dear Dave:

The following are comments submitted on behalf of the Cumberland County Soil and Water Conservation District (CCSWCD) for the public review draft of the Long Lake TMDL report.

These comments are based on our experience working with both the Windham/Falmouth Highland Lake and Bridgton Highland Lake PCAP/TMDL reports in order to develop watershed based plans for implementation of necessary BMPs. This experience has led us to look closely at the reduction goals, which we have found to be overstated for lakes that are not experiencing culturally induced algal blooms but have instead, water quality data that indicate a historical minor trend of increasing trophic state.

The Long Lake TMDL appears to ere on the side of requiring a greater reduction in phosphorus in order to ensure that water quality goals are met (see page 30, Numeric Water Quality Target, page 34, Future Development, and page 36, Margin of Safety, which all explain conservative approaches to setting these targets). While I appreciate this cautious approach, I feel strongly that we can have the same implementation goals without setting a phosphorus reduction goal that overcompensates for the modeling. As a reasonable compromise, setting an interim phosphorus reduction goal is an option worth exploring.

An interim phosphorus reduction goal would allow a watershed manager to develop an implementation plan that is reasonable in both price and effort. For example, first, take care of all the largest and most cost effective fixes in the impaired watershed and establish a mechanism for continued landowner education and BMP maintenance. Follow through with the water quality monitoring plan that will provide sufficient data to adequately track seasonal and inter-annual variation and long-term trends in water quality. Finally, reassess the phosphorus reduction goal based on the lake's water quality.

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
Cumberland County Soil and Water Conservation District

APPENDIX A - Steps in Creating the GIS Adjusted Total Phosphorus Export

To better quantify phosphorus export within the Long Lake Watershed, a GIS model was developed. The base for the model was a land use coverage created in 2004 by Lakes Environmental Association using earlier land use coverage, high-resolution aerial photographs and field verification. Each individual land use was assigned a phosphorus export coefficient. The land use coverage was then "unioned" with slope, soil type and proximity coverage. The phosphorus export from the initial land use coverage was then modified by these additional coverage's. The result of the model was an estimation of the kilograms of phosphorus export for each land use incorporating the effects of slope, soil type and proximity. The steps for creating this model are outlined below.

1. An initial land use coverage was created (the coverage included roads and wetlands) for the watershed.
2. A soils coverage was unioned into the land use coverage.
3. A slope coverage was unioned into the land use and soil coverage. Before unioning the slope coverage, all slope classes were categorized. Slopes less than 8% were a slope class 1, slopes between 8 and 30% were a slope class 2 and slopes greater than 30% were a slope class 3.
4. A proximity coverage was created that extended 250 feet from Long Lake . This coverage was then unioned into the land use/soils/slope coverage. All developmental land uses that were within close proximity to these lake were reclassified as "shoreline" land uses. For example, "medium density residential" development within 250 feet of Long Lake was now classified as "shoreline medium density residential". As a result of these unions, each original land use polygon was broken down into smaller polygons that reflected a change in soil type, slope and proximity to the lake.
5. The land use/soil/slope/proximity coverage was then joined with a phosphorus export coefficient table. This table matched each land use with its estimated corresponding phosphorus export coefficient.
6. An additional field was added to the land use/soil/slope/proximity coverage called "Soils Adjust". This field assigned the following modifying coefficients for each soil type:

   A = 0.7
   B = 0.9
   C = 1.1
   C/D = 1.2
   D = 1.3
   Unknown or Blank = 1

7. An additional field was added to the land use/soil/slope/proximity coverage called "Slope Adjusted". This field assigned the following modifying coefficients for each of the 3 slope classes:

   Class 1 = 1.0
   Class 2 = 1.1
   Class 3 = 1.3
   Unknown or Blank = 1

8. A field was added called "Phosphorus Export Rate" to the land use/soils/slope/proximity coverage. This field takes the original land use coefficient and multiplies it by the "slope adjust" and "soil adjust" factors. (The proximity coverage is already factored in based on "shoreline" code in the land use classes.)

9. The final step was adding a field called "Phosphorus Export" to the coverage. This field multiplies the hectares of each unique polygon by the corresponding Phosphorus Export Rate. This column displays the kilograms of phosphorus exported from a specific soil type, for a particular slope range on a designated land use.

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