PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

MOUSAM LAKE

York County

Mousam Lake PCAP-TMDL Report

Maine DEPLW 2002 - 0529

Maine Department of Environmental Protection

and Maine Association of Conservation Districts

FINAL EPA REVIEW DOCUMENT

September 24, 2003

<u>MOUSAM Lake</u> Phosphorus Control Action Plan

<u>Table of Contents</u>

APPENDICES

<u>MOUSAM LAKE</u>

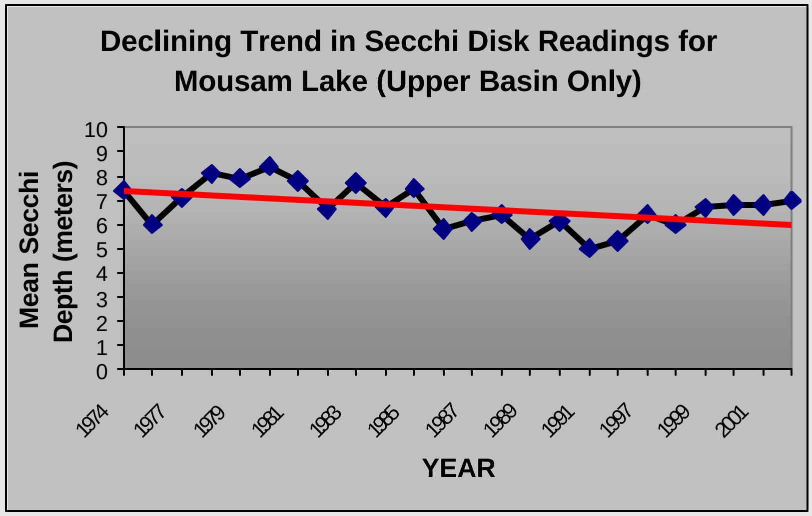
Total Maximum Daily (<u>Annual Phosphorus</u>) Load

ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA New England Region I staff, the following individuals and groups were instrumental in the preparation of this <u>Mousam Lake Phosphorus Control Action Plan-Total Maximum Daily (Annual Phosphorus) Load</u> report: MACD staff (Forrest Bell, Jodi Michaud Federle and Tim Bennett), York County Soil and Water Conservation District (Deb St. Pierre, Abe Rushing, Duane Snyder); the entire Mousam Lake Region Association (including VLMP monitor Pat Baldwin), town officials and office staff in Acton and Shapleigh; Maine Forest Service (Morten Moesswilde); Maine Department of Agriculture (David Rocque); Maine Department of Inland Fisheries and Wildlife (John Boland and Francis Brautimgam).

Mousam Lake Phosphorus Control Action Plan Summary Fact Sheet

Background

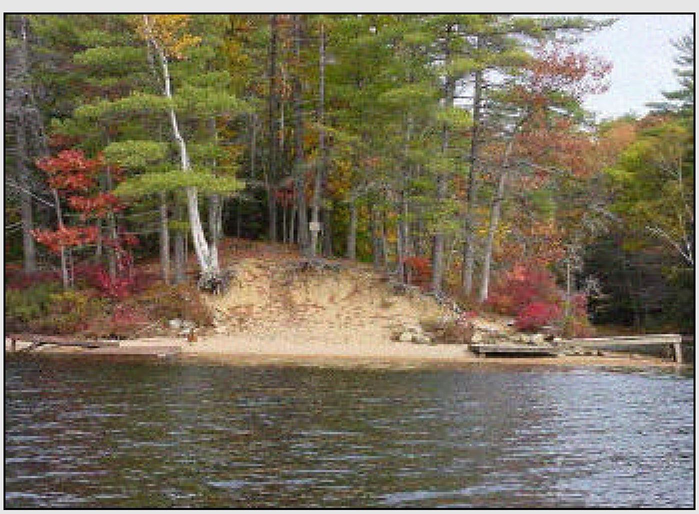


MOUSAM LAKE is a dual-basin 863-acre waterbody located within the towns of Shapleigh and Acton in York County, southwestern Maine. Mousam Lake has a total combined **watershed** area of 20 square miles, inclusive of the associated Goose and Loon pond watersheds; The lake has a maximum depth of 82 feet and mean depth of 17 feet. The larger, upper basin of Mousam Lake has a relatively slow, near average **flushing rate** of 1.3 times per year. In direct contrast, the smaller and shallower lower basin of Mousam Lake has a much faster flushing rate of nearly 18 times per year. Only the upper basin of Mousam Lake is currently 303 (d) listed, however, the TMDL developed in the final report for the upper basin will ensure that water quality standards are maintained in the lower receiving basin as well.

Although far from experiencing typical nuisance algae blooms, the upper basin of Mousam Lake has shown an overall declining trend in water clarity (see graph, above) during the past 28 years. Average annual Secchi disk readings (measures of water clarity) have, however, shown some improvement over the past 4-5 years. The historical decline in water clarity was due, in large part, to the runoff export of **phosphorus** that is prevalent in area soils (particularly lakeshore septic systems) and effectively transported via groundwater discharge. Excessive soil erosion in lake watersheds can also have far-reaching consequences (see photo example of Mousam Lake erosion, below). Soil particles transport the phosphorus, which essentially "fertilizes" the lake and decreases water clarity. Excessive phosphorus loads can also harm fish habitat and may ultimately lead to nuisance algae blooms. Studies have shown that as lake water clarity decreases, lakeshore property values also decline.

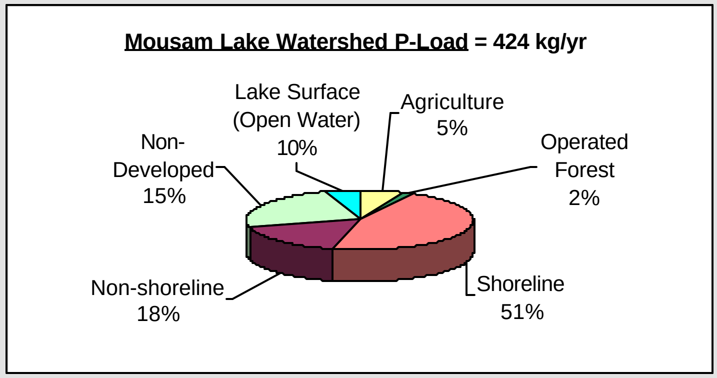
Stakeholder Involvement

Federal, state, county, and local groups have been working together to address this water quality problem. In 2001, the Maine Department of Environmental Protection (Maine DEP) funded a project in cooperation with the Maine Association of Conservation Districts and the York County Soil and Water Conservation District (YC-SWCD) to identify and quantify the potential sources of phosphorus and to recommend **Best Management Practices** to be installed in the watershed. A final report, completed in the spring of 2003, is entitled "Mousam Lake Phosphorus Control Action Plan" and doubles as an official **TMDL** report, to be submitted to the U.S. Environmental Protection Agency for their final review and approval.



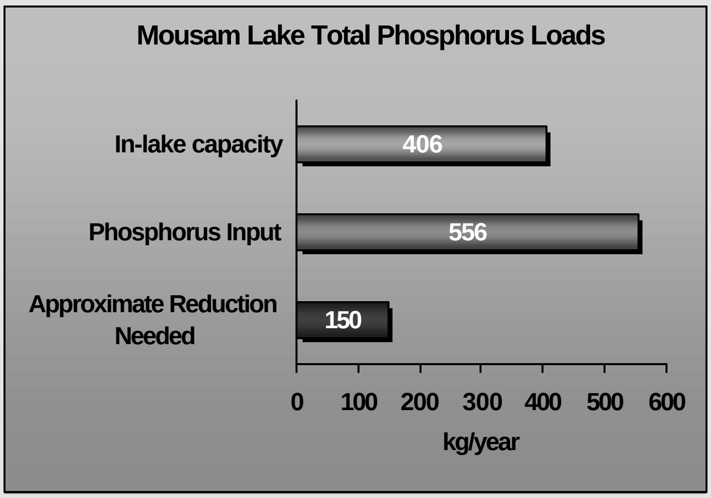
What We Learned

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



An estimated 424 kilograms (kg) of total phosphorus per year is exported to Mousam Lake (upper basin) directly from the external watershed. The pie chart (top right) shows the breakdown of the phosphorus load for open water and representative land uses.

The bar graph below depicts the estimated direct phosphorus load (424 kg/yr + indirect 82 kg/yr + 50 kg/yr future development = 556 kg/yr), which exceeds Mousam Lake's (upper basin) modeled capacity (406 kg) to effectively process phosphorus, leaving the remaining external watershed load (150 kg/yr) as the minimum amount needed to be reduced on an annual basis to ensure that Mousam Lake (both upper and lower basins) will continue to remain free of nuisance summer algal blooms.



What You Can Do To Help!

As a watershed resident (both upper and lower basins) there are many things you can do to protect the water quality of Mousam Lake. Lakeshore owners can use phosphorus-free fertilizers and maintain natural vegetation (trees and shrubs) adjacent to the lake. Agricultural and commercial land users can consult the York County Soil and Water Conservation District (YC-SWCD) or Maine Department of Environmental Protection (Maine DEP) for information regarding Best Management Practices (BMPs) for the effective reduction of phosphorus. Watershed residents can become further involved by volunteering to help the Mousam Lake Region Association (MLRA) and participating in YC-SWCD and MLRA sponsored events. All stakeholders and watershed residents can learn more about their lake and the many resources available by reviewing of the Mousam Lake PCAP-TMDL report. Following EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work, will be available online at http://www.state.me.us/dep/blwq/docmonitoring/tmdl2.htm or can be viewed and copied (at cost) at Maine DEP offices in Augusta (Bureau of Land & Water Quality, Ray Building, AMHI Campus).

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 generally present in small amounts and limits the plant growth in lakes. Generally, as phosphorus increases, the amount of algae also increases.*
- ***Best Management Practices*** *are techniques to reduce sources of polluted runoff and their impacts. BMP's are low cost, common sense approaches to reduce storm runoff and velocity to keep soil out of lakes and tributaries.*
- ***TMDL*** *is an acronym for Total Maximum Daily Load which represents the total amount of a pollutant (e.g., phosphorus) that a waterbody can receive and still meet acceptable water quality standards.*

Project Premise

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

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

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

Secondly, watershed survey work, including a shoreline and septic survey evaluation, was conducted by the MACD project team to help identify the need for ***total phosphorus*** reduction techniques that would be beneficial for the Mousam Lake watershed (inclusive of both upper and lower basins). Watershed survey work included assessing direct drainage ***nonpoint source (NPS) pollution*** sites that were not identified during the Mousam Lake Watershed Nonpoint Source Pollution Survey conducted in 1997. The results of this assessment includes recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Mousam Lake. **Note:** *In order to protect the confidentiality of landowners in the watershed, site-specific information is not provided as part of this report.*

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.*

This Phosphorus Control Action Plan (PCAP) project compiles and refines land use data derived from various sources, including the water-shed municipalities of Acton and Shapleigh, the Mousam Lake Region Association (MLRA), and the York County Soil and Water Conservation District (YC-SWCD). Local citizens, involved watershed organizations, and conservation agencies should benefit from this compilation of data as well as the watershed assessment and Best Management Practice (BMP) recommendations. Above all, this document is directly intended to help Mousam Lake stakeholder groups to effectively prioritize future BMP work in order to obtain the resources necessary for implementation of NPS pollution mitigation work in their watersheds.

Study Methodology

Mousam Lake watershed background information was obtained by several methods, including a review of previous studies of the watershed areas; water quality monitoring data provided by the Maine DEP supported Volunteer Lake Monitoring Program (VLMP); 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** combine layers of information about a place to give you a better understanding of that place. The information is often represented as computer generated maps.*

Land use data were determined using several methods, including (1) ***Geographic Information System (GIS)*** map analysis, (2) analysis of topographic maps, (3) analysis of town property tax maps and tax data, (4) analysis of aerial photographs (US-FSA 1998) and (5) field visits. Much of the undeveloped land use area (i.e., forest, wetland, grassland) was determined using GIS maps utilizing data from the 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.

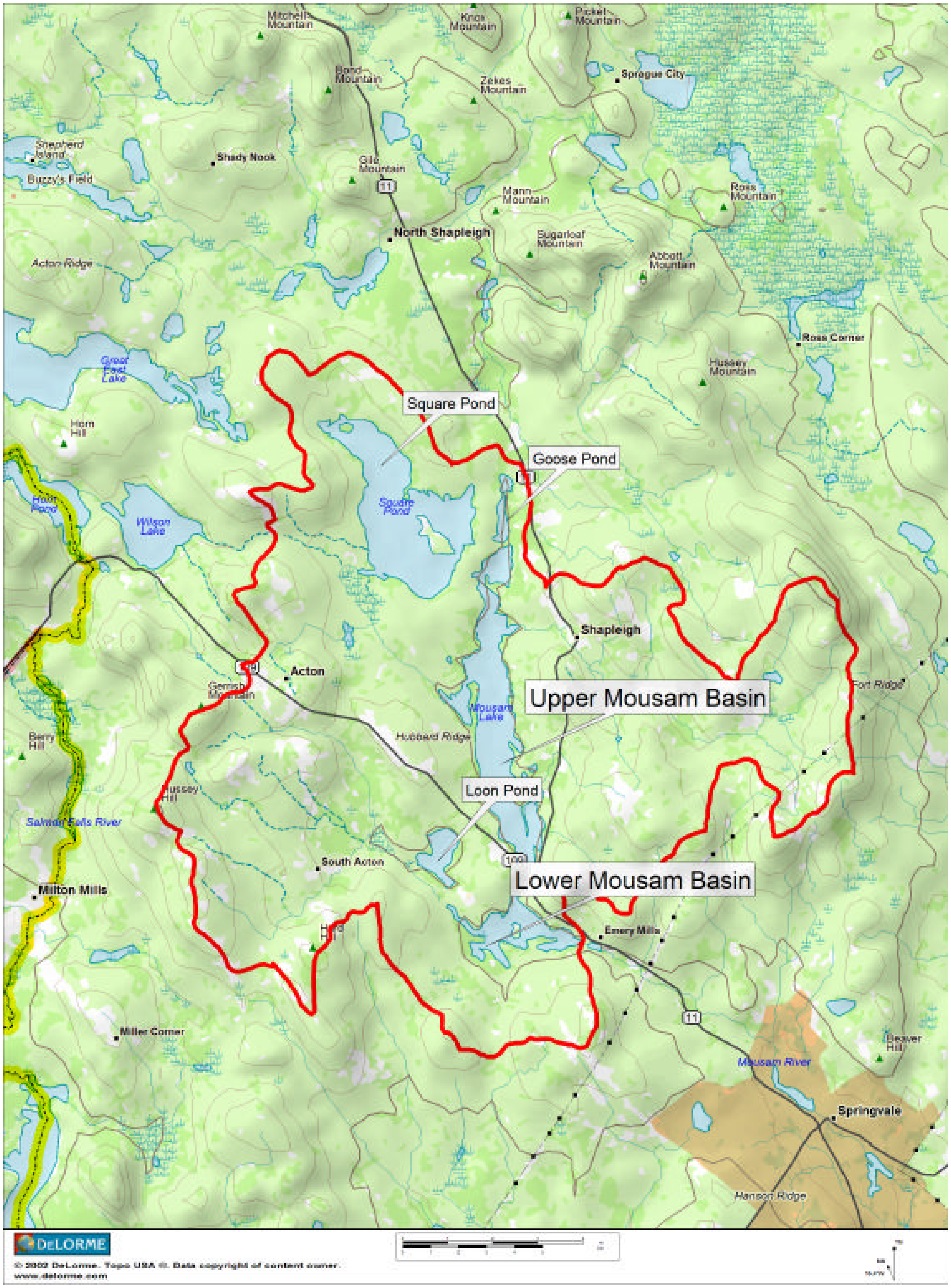
Roadway data were gathered by taking actual road width measurements of the various types of roads (state, town, private/camp) in the watershed. The roads were measured between the two outer edges of the roadside ditches or berms. An average width was used for each of the three road types. Final measurements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

Additional land use data (i.e. residential, institutional) were determined using GIS cover mapping, aerial photos, topographic and property tax maps as well as personal consultation and, when necessary, field visits. Agricultural information within the Mousam Lake Watershed was provided by the York County Soil and Water Conservation District (YC-SWCD). Information regarding forestry harvesting operations was provided by the Maine Forest Service, Department of Conservation.

Study Limitations

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

Figure 1. Map of Mousam Lake (Basins 1-2) and Watershed.



MOUSAM LAKE Phosphorus Control Action Plan

DESCRIPTION of WATERBODY and WATERSHED

MOUSAM LAKE is a dual-basin 863 acre drainage lake located within the towns of Shapleigh and Acton in York County in southwestern Maine. Mousam Lake has a **direct watershed** area of 12,518 acres, or 19.6 square miles, with a maximum depth of 82 feet and an overall mean depth of 17 feet in the deeper northern basin. The larger, upper basin of Mousam Lake has a relatively slow flushing rate of only 1.3 times per year, while the smaller, relatively shallow lower receiving basin has a much faster flushing rate of 18 times per year. The total Mousam Lake watershed drainage area, inclusive of the associated Goose and Loon pond watersheds is 13,354 acres (ca. 21 square miles).

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

Drainage System – Mousam Lake (lower basin) is drained at its outlet by the 303(d) listed Mousam River, which flows in a southeastern direction through the town of Kennebunk and out to the Atlantic Ocean. The Emery Mills outlet dam is under the control and management of the nearby town of Sanford. Two lesser ponds (Square and Goose) are associated with the upper basin of Mousam Lake. Square Pond now drains into Goose Pond and Goose Pond drains directly into the upper basin of Mousam Lake. Loon Pond drains into the lower basin only.

This PCAP has been developed for both basins, however, since the two basins of Mousam Lake are significantly different in terms of lake morphology (size and depth), flushing rate, and **trophic state**, the TMDL study is limited to the upper basin only.

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

Water Quality Information

Mousam Lake is listed on the U.S. EPA /Maine Department of Environmental Protection's 303(d) list of lakes that do not meet the State's water quality standards as well as the State's **Nonpoint Source Priority Watersheds** list. Hence, a Phosphorus Control Action Plan (and TMDL) was developed in 2001-2003.

*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.*

Water quality data for Mousam Lake's upper basin has been collected through Maine DEP and VLMP since 1974, while water quality data for the lower basin has been collected for only the past 5 years. Based on **Secchi disk transparencies** and measures of total phosphorus and **chlorophyll-a**, the water quality of Mousam Lake is considered to be good, however a significant decline in water transparency trends has been observed. The potential for nuisance algae blooms in Mousam Lake is low in the upper basin and moderate in the lower basin (Maine DEP 2001).

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

Nonpoint source (NPS) pollution (including septic system contributions) is the main reason for declining water quality in Mousam Lake. During and after storm events, nutrients (e.g. phosphorus) - naturally found in Maine soils – drain from the surrounding watershed by way of streams and overland flow.

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

Phosphorus can be thought of as a fertilizer—a primary food for plants, including algae. Phosphorus is naturally limited in lakes and when lakes receive excess phosphorus in the form of NPS pollution, it “fertilizes” the lake by feeding the algae. Too much phosphorus can result in nuisance blue-green algae blooms, which can damage the ecology and aesthetics of a lake, as well as the economic well-being of the entire community.

Unique Drainage Feature - Watershed Soil Characteristics - An outstanding feature of Mousam Lake in general is the abundance of excessively drained soils, especially along the shoreline. Nearly 95% of Mousam Lake’s shoreline is comprised of hydrologic soil group “A” soil types. The types of soils series along shoreline areas (branching outward from shore at least 300 feet) are predominantly Adams, Colton, and Hermon. These soils are deep, nearly level to steep, excessively drained soils formed in material deposited by glacial meltwater (USDA Soil Survey, 1982). Water is removed from these soils very rapidly and the rate of permeability is usually greater than 20 inches per hour. Hence, the surface runoff on the Adams, Colton, and Hermon soils would be minimal and surface (overland) phosphorus loading from these soils would be much less than the phosphorus loading from less porous soil types (Personal Conversation, Jeff Dennis, Maine DEP).

Given the porous nature of the soils bordering the shoreline of Mousam Lake, it would seem possible that phosphorus infiltration rates and leaching via groundwater transport may be a contributing phosphorus loading factor. John Hopeck (Maine DEP hydrogeologist - personal communication) has reviewed this possibility and has concluded that "the actual total phosphorus contribution from on-site groundwater discharge remains highly speculative at this time".

Upland areas of the Mousam Lake Watershed contain a variety of soils. Soil types more than 300 feet from the shoreline include “A” soil groups (Adams, Colton, Hermon), and “C” soil groups (Brayton, Lyman, Becket, Skerry). In general, the group “C” soils have slow infiltration rates when thoroughly wet. However, of the four predominant “C” soil types, only the Brayton soils are classified as “poorly drained”. The Lyman, Becket, and Skerry series are fine sandy loam soils formed in glacial till and are generally classified as “well drained”. The percent coverage of soils in the drainage basins by hydrologic soil type A to D is shown in Table 1 (below). Soil coverage acreages were mapped using USDA soil survey maps with the Mousam Lake Watershed overlain. Soil class acreages were determined using USDA Acreage Calculating Grids for 1:20,000 scale soil maps.

Table 1. Mousam Lake Watershed Soil Group Coverage

Soil Type	Class A	Class B	Class C	Class D
Upper Basin	39%	<1%	59%	<1%
Lower Basin	49.5%	<1%	50%	<1%
Goose Pond	94%	0%	0%	6%
Loon Pond	63%	0%	37%	0%

Principle Uses: The dominant human uses of the Mousam Lake shoreline are residential (both seasonal and year-round occupancy) and recreational—boating, fishing and swimming/beach use. There are no commercial camps on Mousam Lake; however, a large private campground is located in the northwestern part of the watershed near Hubbard Ridge within the Town of Acton. A recently built Maine DIFW state-operated public boat launch is located on the east side of the lower basin off Route 11. Also, a Boy Scout Camp is located on the shore of Goose Pond, within the Town of Shapleigh.

Human Development: Both upper and lower Mousam Lake basins are highly developed along the shoreline. Of the 947 shoreline lots in the entire watershed, only 63 lots (7%) are undeveloped. There are more than 1,200 housing units within the direct watershed, with a total of 674 lakeshore housing units (78% seasonal and 22% year-round). The upper Mousam Lake (north) basin has 388 (85%) seasonal and 67 (15%) year-round homes. In contrast, the lower Mousam Lake (south) basin has 138 seasonal (63%) and 81 (37%) year-round dwellings (MACD Project Staff 2001).

A total of 2,145 and 2,217 people currently reside within the towns of Acton and Shapleigh, respectively (2001 Maine Municipal Directory estimates), for a total human population of 4,362 - the majority of which live within the Mousam Lake watershed boundaries. Summer population in these two towns is estimated to exceed 10,050 people (SMRP 1987). The growth rate in Acton has ranged from a 76% increase during the 1970s to a 39% increase during the 1980s. The growth rate in Shapleigh has ranged from a 145% increase in the 1970s to a 52% increase during the 1980s. Some of the population increase in both towns that has occurred during this time period involves conversions from seasonal to year-round residences on Mousam Lake, Loon Pond, Goose Pond and other lakes outside the watershed. (Personal communication – Ruth Ham, Shapleigh Selectperson). It is estimated that as many as ten of these seasonal-to-year-round conversions take place on Mousam Lake each year (Steve McDonough, Shapleigh CEO, personal communication).

An example of a fairly well-maintained naturally vegetated and stable buffer on the shoreline of Mousam Lake.

<u>Fish Assemblage and Anadromous Fish Restoration</u>

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) and past conversations with John Boland and Francis Brautigam (Region A, Gray Maine DIFW office), Mousam Lake (towns of Shapleigh and Acton, Mousam River - Gulf of Maine) is currently managed as a mixed warmwater and coldwater fishery and was last surveyed in 1996. A total of **20** <u>fish species</u> are listed, including: **10** <u>native indigenous fishes</u> (American eel, Golden shiner, Fallfish, White sucker, Brown bullhead, Chain pickerel, Banded killifish, Pumpkinseed, Redbreast sunfish, and Yellow perch); **6** <u>stocked-managed</u> fish species (sea-run Alewife - Maine DMF **anadromous** fish restoration program, landlocked Rainbow smelt and Atlantic salmon, Brook trout, Lake trout, and Brown trout - Maine DIFW); <u>**3** introduced fishes of uncertain origin</u> (White perch, Smallmouth bass, and Largemouth bass); and **1** <u>illegally introduced</u> species (Black crappie – 10-15 years ago). Landlocked Rainbow smelt and Alewives have naturally self-sustaining populations, while Brook and Brown trout, and landlocked Atlantic salmon are stocked annually. Lake trout were last stocked in 1995, however, a modest togue fishery still exists. Principal <u>warmwater fisheries</u> include smallmouth and largemouth bass, chain pickerel, and black crappie.

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

Historically, Mousam Lake had excellent water quality for **salmonids**, with a large volume of cold, oxygenated water present from about 22 feet (6.6 meters) to the bottom in the larger and deeper upper or northern basin of the lake. Today, due to increasing nutrient levels, and the subsequent decomposition of organic matter in the sediments, oxygen depletion (below 5 parts per million **dissolved oxygen**) is apparent within 25% of the water column (59-79 feet; 18-24 meters) in the upper basin and 50% of the water column (16-32 feet; 5-10 meters) in the lower (southern) basin of Mousam Lake. In-lake oxygen levels below 5 parts per million stress coldwater fish and a persistent loss of oxygen may eliminate suitable habitat for sensitive coldwater fish species.

> *Fish in the **salmonid** family include salmons, trouts, char, and whitefishe.*

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

Improving (stable) water transparencies and overall acceptable water quality conditions in Mousam Lake, including restoration of suitable dissolved oxygen conditions (greater than 5 parts per million), will serve to enhance and/or support the continued maintenance of existing coldwater fisheries, particularly in the deeper upper basin of Mousam Lake. At this time, the apparent water quality of Mousam Lake (upper basin) is fairly stable and coldwater fishery conditions are on the rebound (personal conversation, Francis Brautigam, Maine DIFW, Region A, Gray).

Land Use Inventory

The results of the Mousam Lake watershed land use inventory are depicted in Tables 2 and 3 on the following pages. The various land uses are categorized by developed (culturally impacted) land vs. non-developed (naturally occurring) land. Developed land area comprises approximately 68% of the watershed and the non-developed land and surface area of Mousam Lake comprise the remaining 32%. These numbers may be used to help make future planning and conservation decisions relating to the Mousam Lake Watershed. The information in these tables will also be used by the Maine DEP for preparation of the Total Maximum Daily (Annual Phosphorus) Load Report (see Appendices).

Descriptive Land Use and Phosphorus Export Estimates

Agriculture and Operated Forest Lands: The amount of land used for agricultural and silvicultural purposes in the Mousam Lake watershed is minimal when directly compared to other land uses. Acreages were measured using 1989 air photos with follow-up field visits throughout the entire watershed to confirm (ground-truth) the current use of fields and woodlots. It appears that many grassland areas in the watershed have been converted to residential properties during the past 12 years. Only four small working farms are currently present in the watershed (Geoff Coombs, NRCS, personal communication, 2001). The largest of these farms, an apple orchard, is located on Hubbard Ridge in Acton.

In the upper basin, agriculture and forestry combine to account for only 3% of the total land area of the watershed and 6% of the phosphorus loading. In the lower basin, agriculture and forestry account for 4% of the total land area of the watershed and 11% of the phosphorus loading. Hayland is estimated to contribute the most phosphorus, with managed forest woodlots, orchard, and pasture contributing the remaining phosphorus load. The hayland category was determined (through field observation and consultation with York County USDA Natural Resources Conservation Service staff) to be "low intensity" - meaning that the land is minimally fertilized and cut only once or twice a year.

Shoreline Residential (House and Camp Lots): A shoreline survey was completed in the summer and fall of 2001 by Maine DEP, MACD project staff, and York County Soil and Water Conservation District (YC-SWCD) staff. The survey was conducted from a boat, approximately 50 feet from the shoreline. The survey results provide a shoreline structure tally as well as subjective determinations of the impact of each lot in regard to phosphorus loading. There are an estimated 674 homes and cottages on the lakeshores and another 41 homes within the shoreland zone (within 250 feet of the high water line) on Mousam (upper and lower basins) Lake. The shoreline count estimates 388 seasonal (85%) and 67 year-round (15%) dwellings along the shore of the upper basin and 138 seasonal (63%) and 87 year-round (37%) dwellings along the shore of the lower basin of Mousam Lake (MACD 2001).

To determine phosphorus loading estimates, each developed shoreline lot was assigned an NPS pollution impact rating using best professional judgment. The ratings range from 1 to 5, with 1 being very low impact (natural - best case scenario) and 5 being high impact (unnatural – worst case scenario). Lots receiving a rating of 1 have a full naturally vegetated buffer. Conversely, a lot given a score of 5 would have little or no vegetative buffer and support bare (eroding) soil – a visible source of phosphorus input to the lake. A grass covered mowed lawn leading down to a rip-rapped shoreline or

Table 2. UPPER Mousam Lake Direct Watershed—Land Use Inventory and P-Loads

LAND USE CATEGORY	Total Land Area Acres	Total Land Area %	TP Export Total %
	UPPER Mousam Lake		
Agricultural & Operated Forest Land			
Low-Intensity Hayland	59	0.9	3.6
Orchard	18	0.3	0.7
Pasture/Barnyard	3	0.0	0.2
Operated Forest Land	108	1.6	2.1
Sub-Totals	**187 acres**	**3%**	**7%**
Shoreline Development	UPPER Mousam Lake		
Low Impact Residential	40	0.6	1.0
Medium Impact Residential	206	3.0	7.8
High Impact Residential	84	1.2	4.5
Residential Septic Systems	0	0.0	29.4
Camp and Private Roads	43	0.6	8.1
Sub-Totals	**372 acres**	**5%**	**51%**
Non-Shoreline Development	UPPER Mousam Lake		
State Roads	41	0.6	2.3
Town Roads	97	1.4	5.6
Low Density Residential	105	1.6	2.5
Medium Density Residential	35	0.5	1.3
High Density Residential	13	0.2	0.7
Commercial	18	0.3	2.6
Parks	25	0.4	1.2
Cemeteries	6	0.1	0.8
Institutional	6	0.1	2.4
Sub-Totals	**346 acres**	**5%**	**18%**
Total: DEVELOPED Land	**905 acres**	**13%**	**75%**
Non-Developed Land	UPPER Mousam Lake		
Inactive/Passively Managed Forest	4,485	66.2	8.6
Wetlands	342	5.0	0.7
Scrub Shrub	45	0.7	0.4
Grasslands/Reverting Fields	353	5.2	5.0
Total: NON-DEVELOPED Land	**5,225** UPPER	**77%** Mousam	**15%**
Total: Surface Water (Atmospheric)	**643 acres**	**9%**	**10%**
TOTAL: DIRECT WATERSHED	**6,773** UPPER	**100%** Mousam	**100%**

Table 3. LOWER Mousam Lake Direct Watershed—Land Use Inventory and P-Loads

LAND USE CATEGORY	Total Land Area Acres	Total Land Area %	TP-Export Total %
Agricultural & Operated Forest Land	**LOWER Mousam Lake**		
Low-Intensity Hayland	84	1.5	6.8
Orchard	92	1.6	4.7
Pasture/Barnyard	27	0.5	2.7
Operated Forest Land	12	0.2	0.3
Sub-Totals	**214 acres**	**4%**	**14%**
Shoreline Development	**LOWER Mousam Lake**		
Low Impact Residential	47	0.8	1.5
Medium Impact Residential	59	1.0	3.0
High Impact Residential	36	0.6	2.6
Residential Septic Systems	0	0.0	24.1
Camp and Private Roads	26	0.5	6.7
Sub-Totals	**167 acres**	**3%**	**38%**
Non-Shoreline Development	**LOWER Mousam Lake**		
State Roads	16	0.3	1.2
Town Roads	57	1.0	4.4
Low Density Residential	68	1.2	2.2
Medium Density Residential	7	0.1	0.4
High Density Residential	16	0.3	1.1
Cemeteries	4	0.1	0.4
Parks	5	0.1	0.5
Commercial	13	0.2	2.5
Institutional	6	0.4	1.1
Sub-Totals	**192 acres**	**3%**	**14%**
Total: DEVELOPED Land	**573 acres**	**10%**	**66%**
Non-Developed Land	**LOWER Mousam Lake**		
Inactive/Passively Managed Forest	3,575	62.2	12.7
Wetlands	300	5.2	0.5
Scrub Shrub	158	2.7	1.4
Grasslands/Reverting Fields	920	16.0	16.3
Total: NON-DEVELOPED Land	**4,952** **LOWER**	**86%** **Mousam**	**29%**
Total: Surface Water (Atmospheric)	**220 acres**	**4%**	**4%**
TOTAL: DIRECT WATERSHED	**5,745** **LOWER**	**100%** **Mousam**	**100%**

Table 4. COMBINED Mousam Lake Direct Watershed - Land Use and P- Loads

LAND USE CATEGORY	Total Land Area Acres	Total Land Area %	TP Export Total %
Agricultural & Operated Forest Land		**COMBINED Mousam Lake**	
Low-Intensity Hayland	142	1.1	5.0
Orchard	110	0.9	2.4
Pasture/Barnyard	29	0.2	1.3
Operated Forest Land	120	1.0	1.3
Sub-Totals	**401 acres**	**3%**	**10%**
Shoreline Development		**COMBINED Mousam Lake**	
Low Impact Residential	86	0.7	1.2
Medium Impact Residential	264	2.1	5.8
High Impact Residential	120	1.0	3.6
Residential Septic Systems	0	0.0	27.1
Camp and Private Roads	69	0.6	7.5
Sub-Totals	**539 acres**	**4%**	**45%**
Non-Shoreline Development		**COMBINED Mousam Lake**	
State Roads	57	0.5	1.9
Town Roads	154	1.2	5.1
Low Density Residential	173	1.4	2.4
Medium Density Residential	42	0.3	0.9
High Density Residential	29	0.2	0.9
Commercial	31	0.2	2.5
Parks	30	0.2	1.3
Cemeteries	10	0.1	0.4
Institutional	11	0.1	0.9
Sub-Totals	**537 acres**	**4%**	**16%**
Total: DEVELOPED Land	**1,478 acres**	**12%**	**72%**
Non-Developed Land		**COMBINED Mousam Lake**	
Inactive/Passively Managed Forest	8,059	64.4	8.8
Wetlands	642	5.1	0.7
Scrub Shrub	203	1.6	1.1
Grassland/Reverting Fields	1,272	10.2	10.4
Total: NON-DEVELOPED Land	**10,177 COMBINED**	**81%**	**Mousam 21%**
Total: Surface Water (Atmospheric)	**863 acres**	**7%**	**8%**
TOTAL: DIRECT WATERSHED	**12,518 COMBINED**	**100%**	**Mousam 100%**

beach would receive a rating of 4 – but, only if there was no evidence of bare soil, in which case a rating of 5 would be assigned. In addition to the impact rating, project staff estimated the residency status of the dwelling (seasonal vs. year-round), the distance of the dwelling to the lake, the percent slope of the lot, the presence or lack of vegetated buffers, presence of bare soils, existing rip rap, and other notable features such as retaining walls or boat launches. Table 3 (below) summarizes the findings of the survey on both the upper and lower Mousam Lake basins.

Relevant findings of the shoreline residential survey include a high percentage (65%) of inadequate shoreline buffers on lakefront lots, particularly on shoreline developments on the lower basin. There are a relatively high percentage of steep slopes along the shoreline (34%) and a high percentage of dwellings less than 100 feet from the lake (88% average) within both upper and lower Mousam Lake basins.

In addition to completion of the shoreline survey, more than 900 property tax files were reviewed at the Acton and Shapleigh town offices. For the upper and lower Mousam Lake basins, these files were used to confirm the determination of seasonal vs. year-round properties, lot sizes, as well as to gather septic system information.

Phosphorus loading from Mousam Lake shoreline residential areas is categorized into low, medium, and high impact ratings. These ratings are derived directly from the shoreline visual survey impact ratings. The lot sizes have been calculated for each of the three impact ratings and an average lot size is used and multiplied by the total phosphorus loading coefficient recommended by Reckhow (1980). For the upper basin of Mousam Lake, all shoreline residential sites are estimated to contribute 13% (56 kg) of the total watershed (external) phosphorus load. Low impact sites contribute only 1% of the TP-load, medium impact sites contribute 7.8%, and high impact sites (which comprise only 1.2% of the total land area within the watershed) contribute 4.5% of the external, watershed derived TP-load to the upper basin of Mousam Lake. For the lower basin of Mousam Lake, shoreline residential sites are estimated to contribute 7% (22 kg) of the total watershed (external) phosphorus load – 1.5% from low impact sites, 3% from medium impact sites, and 2.6% from high impact sites.

Table 5. Results of 2001 Mousam Lake Shoreline Survey

Variable	Upper Mousam	Lower Mousam
Total number of lots surveyed	481	254
Number of developed lots	455	219
Average impact rating	3.1	3.2
Dwellings less than 100’ from lake	87%	89%
Lot on steep slope of more than 20%	34%	34%
Inadequate shoreline buffer	41%	65%
Bare soil evident	21%	20%
Existing shoreline riprap evident	1%	12%
Adequate natural vegetation	25%	20%

Shoreline Septic Systems: It is important to consider the potential for total phosphorus loading from septic systems due to the combination of compounding factors present: (1) high percent of homes in close proximity to the lakes; (2) high percent of homes built on relatively steep slopes; and (3) the uniquely sandy, highly permeable glacial outwash soils of western York County. Over 90% of Mousam Lake's shoreline exceeds 8% slope (SMRPC, 1988) and approximately one-third of the shoreline lots exceed 20% slope (MACD Project Team 2001). These steep areas are dominated by loose sandy soils which provide a poor and often inadequate filter (low phosphorus retention rate) for septic system effluent (SCS/NRCS 1982).

In order to estimate total phosphorus loading from shoreline septic systems, a general model was used based on the following attributes: seasonal or year-round occupancy; estimated age of the system; estimated distance of the system to the lake; and the number of people per dwelling (assumed to be 3). These attribute values were determined by shoreline survey and town records.

Based on this septic system model, total phosphorus loads from residential septic systems within the Mousam Lake watershed is estimated at 124.7 kg/yr for the upper basin (29.4% of the total external P-load) and 76.5 kg/yr for the lower basin (24.1% of the total external P-load).

Private/Camp Roadways: There are approximately 29 miles of camp/private roads within the entire Mousam Lake watershed. Camp roads contribute an estimated 8.1% (35 kg) of the phosphorus load to the upper basin while comprising 0.6% of the land area. In the lower basin, camp roads contribute 6.7% (21 kg) of the total phosphorus load while comprising 0.5% of the total land area.

Overall, shoreline development in the upper Mousam Lake basin comprises only 5% of the total watershed area, however contributes 216 kg of phosphorus annually, approximating 51% of the estimated total phosphorus load. In contrast, shoreline development in the lower Mousam Lake basin comprises only 3% of the total watershed area, while contributing 120 kg of total phosphorus annually, approximating 38% of the estimated total phosphorus load.

Other Development and Land Uses

Non-Shoreline Development: Consists of all lands outside the immediate shoreline of Mousam Lake, including state and town roadways, low-density non-shoreline residential areas and other land uses such as institutional (public) areas, commercial and recreational areas. These land use areas were calculated using GIS land use coverage provided by the Maine DEP.

Public Roadways: The total loading for state roads – 16.5 kg of phosphorus and town roads – 39.3 kg of phosphorus combine to total 9% of the total phosphorus load to the upper basin. In the lower basin, total loading for state roads – 3.9 kg of phosphorus and town roads – 13.9 kg of phosphorus, combine to contribute 5% of the total phosphorus load.

Non-Shoreline Residential area categories include 'low impact residential', 'medium impact residential', and 'high impact residential'. In the upper basin, non-shoreline residential land uses contribute 19 kg and 4.5% of the total phosphorus load, while in the lower basin, non-shoreline residential land uses contribute 12 kg and 3.7% of the total phosphorus load.

Commercial: Commercial areas - including boat marinas, stores, and restaurants – were determined by field survey and evaluation and contribute an estimated 11 kg/yr of TP (2.6% of the total phosphorus load) to the upper basin and 8 kg kg/yr of TP (2.5%) to the lower basin.

Other: The remaining land uses include several cemeteries, Acton Fairgrounds, and various institutional (public) areas - which contribute 13 kg/yr or 3% of the total phosphorus loading to the upper basin and 6 kg/yr or 2% of the total phosphorus loading to the lower basin of Mousam Lake.

Overall, all developed lands in the upper basin comprised 13% of the watershed area and contribute 320 kg of phosphorus annually, approximating 75% of the estimated externally (watershed) generated phosphorus load. Total developed lands in the lower basin comprised 10% of the watershed area and contributes 232 kg of phosphorus annually, approximating 66% of the estimated externally (watershed) generated phosphorus load.

Phosphorus Loading from Non-Developed Lands

Non-Developed Land Areas comprise 77% of the total land area in the upper basin watershed and 86% of the total land area in the lower basin watershed. This includes forested areas, wetlands, grassland and unused open fields, and scrub shrub or reverting fields. An estimated 15% (62 kg/yr) of the total phosphorus load to the upper basin and 29% (94 kg/yr) of the total phosphorus load to the lower basin of Mousam lake is derived from these non-developed sources.

Atmospheric Deposition (Open Water) is estimated to account for 10% (42 kg/yr) of the total phosphorus load to the upper basin and 4% (14 kg/yr) of the total phosphorus load to the lower basin.

Figures 2 & 3 depict the percentage of total land area covered by representative land uses within the upper and lower basins of the Mousam Lake watershed.

Figure 2. Total Land Use for Upper Basin

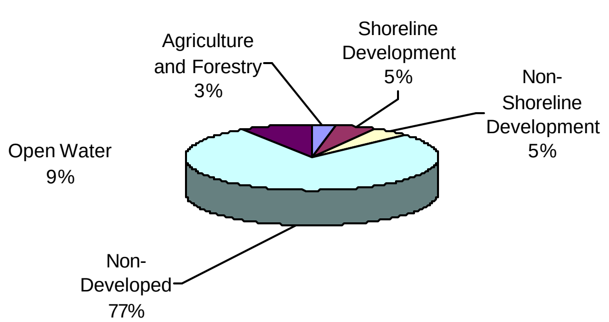
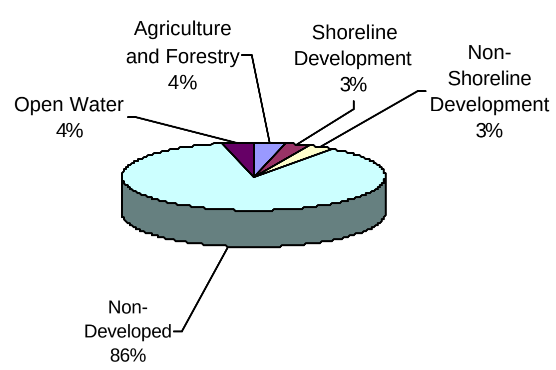


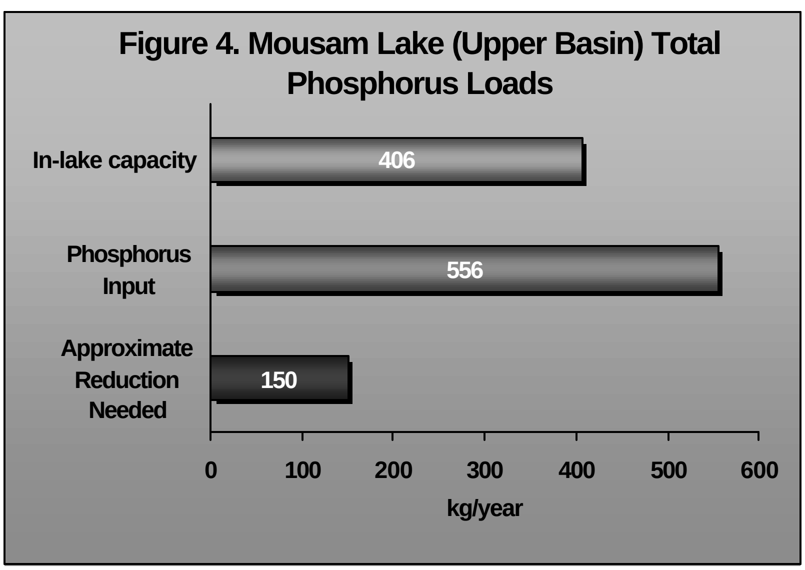
Figure 3. Total Land Use for Lower Basin



PHOSPHORUS LOADS – Watershed, Sediment and In-Lake Capacity

Supporting documentation for the phosphorus loading analysis includes the following: water quality monitoring data from the Maine DEP and the Volunteer Lake Monitoring Program and development of a phosphorus retention model (see Appendices for detailed information).

- External total phosphorus loadings to Mousam Lake originate from a combination of direct (watershed) and indirect (Square-Goose ponds) sources of total phosphorus (TP). Mousam Lake DIRECT watershed TP sources annually approximating 424 kg in the upper basin - have been identified and accounted for by existing land uses.
- Total phosphorus loading to Mousam Lake from the associated Square-Goose ponds accounts for external loading from the INDIRECT watershed of annual totals of 82 kg for the upper basin - determined on the basis of *flushing rate x volume x TP concentration,* taking into consideration typical area gauged streamflow measures (Maine DEP Watershed Data Files - Jeff Dennis, Project Manager).
- The relative contribution of INTERNAL sources of total phosphorus within Mousam Lake is negligible at this time - either basin showed little evidence of sediment phosphorus recycling.
- The annual phosphorus contribution to account for FUTURE DEVELOPMENT for Mousam Lake is an additional 50 kg for the upper basin, for a total phosphorus load (direct and indirect + future development) of 556 kg in the upper basin.
- The annual phosphorus load allocation (lake assimilative capacity) for all existing and future non-point pollution sources for Mousam Lake is 406 kg for the upper basin, based on a water quality target goal of 8 parts per billion (Figure 4).
- Total phosphorus external (direct and indirect watershed) approximate LOAD REDUCTIONS of a minimum of 50 (upwards to 150) kg in the upper basin are required to account for impacts of future development and to ensure acceptable water quality in future years.



MOUSAM LAKE (Upper and Lower Basins)

PHOSPHORUS CONTROL ACTION PLAN

Mousam Lake is a waterbody that has impaired water quality due mostly to nonpoint source (NPS) pollution resulting in excessive amounts of phosphorus being contributed from its watershed. In light of recent and current efforts addressing watershed restoration, identified Best Management Practices (BMPs) and specific actions to reduce watershed derived phosphorus loadings to improve water quality conditions in Mousam Lake (combined watersheds) are as follows:

Recent and Current NPS/BMP Efforts

A Maine DEP funded and YC-SWCD/Mousam Lake Region Association (MLRA) sponsored watershed survey was completed during April 1997. It is estimated that the survey effort covered roughly 50% of the lower Mousam shoreline, 30% of the upper Mousam shoreline and approximately 70% of the Goose Pond shoreline. This is a small percentage of the entire Mousam Lake watershed. Fourteen volunteers conducted the survey in groups of two or three over five sectors. The survey identified 115 sites with a high, medium, or low priority ranking. A large number of sites (42%) were grouped in the residential category. State and town roads accounted for another 7% while private roads accounted for 28% of sites. Twenty-five sites received a “high priority” ranking. The YC-SWCD also completed a 1999 319 BMP demonstration grant with the assistance of a hydrogeologist (John Rand). This grant ($21,184 in federal funds) funded the implementation of six demonstration sites in the watershed.

In the Spring of 2001 the MACD project team conducted additional field work in the watershed. Project partners from the YC-SWCD, US EPA, and Mousam Youth Conservation Corps (YCC) participated with the survey work. Twenty-two additional sites were located. **Note:** As a result of the MACD field work, three sites have been added to the current YC-SWCD 319 implementation project. One of these sites will be a large-scale project at the intersection of Route 109 and 11 on the Acton/ Shapleigh town line. This project will include additional funding from the Maine Department of Transportation.

An additional $100,000 was awarded in 2001 through Maine DEP Watershed Improvement Financial Assistance Partnership, which provides funds for Maine’s Soil and Water Conservation Districts to control nonpoint source pollution in threatened or polluted waterbodies. The program is funded by the Maine Department of Agriculture and U.S. Environmental Protection Agency. BMPs were installed at twenty sites under the auspices of this grant and another 60 sites were provided with technical assistance from the YC-SWCD and Mousam Lake Youth Conservation Corps.

Recommendations for Future Work

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

1) Watershed Management: There are many resources available to watershed stakeholders. An important step in lake restoration efforts was taken when Mousam Lake Region Association joined forces with the YC-SWCD beginning in 1997. The YC-SWCD provides education and outreach, offers free technical assistance to landowners for NPS BMP recommendations as well as free labor and potential cost-share funding for BMP implementation. The Southern Maine Lake Coordinator (currently Tamara Pinard) also offers free technical assistance and potential grant project oversight and coordination. Continued interagency cooperation between the Mousam Lakes Region Association the YC-SWCD, the Maine DEP and Acton and Shapleigh will help to maximize resources and efforts dedicated to protecting and enhancing the water quality of Mousam Lake. This Mousam Lake Leadership Team can help achieve locally supported watershed management programs to facilitate widespread implementation of BMPs or other management measures in order to reduce or eliminate NPS pollution in Mousam Lake.

Action Item # 1: Coordinate Existing Watershed Management Efforts		
Activity	**Participants**	**Schedule & Cost**
Develop a Mousam Lake Leadership Team	MLRA, YC-SWCD, Maine DEP, municipalities, local business, watershed citizens	Annual Roundtable Meetings beginning in 2003—**minimal cost**

2) Shoreline Residential: Numerous sites have been identified as having a potential to negatively impact the water quality of Mousam Lake. The 1996 watershed survey identified 48 problem residential sites in the watershed and the MACD shoreline survey and field reconnaissance identified another 275 potential problem sites (114 on lower Mousam and 161 on Upper Mousam). The cumulative impact of all of these problematic residential sites can significantly add to existing total phosphorus levels in Mousam Lake. In order to improve the current problems on shoreline residential lots, efforts need to continue and be implemented on an even larger and broader scale. Large-scale buffer campaigns should be implemented for shoreline lots and educational efforts should be aimed at all landowners and land users on the shoreline of Mousam Lake and associated waterbodies.

Action Item # 2: Implement a Buffer Awareness and Planting Campaign		
Activity	**Participants**	**Schedule & Cost**
Develop a Buffer Awareness Campaign for Watershed Citizens	MLRA, YC-SWCD, ME-DEP, watershed citizens, local nurseries	Annually beginning in 2003 **$5,000/yr**

3) Septic Systems: Older, poorly designed and installed septic systems within the shoreland zone may contribute significantly to water quality problems, adding to the cumulative phosphorus load to Mousam Lake. MACD staff worked with the towns of Acton and Shapleigh to analyze the current state of septic systems in the shoreland zone of Mousam Lake, and Loon and Goose ponds.

While Mousam Lake septic systems – when properly sited, constructed, maintained, and set back from the water – should not affect water quality, many septic systems do not meet all of these criteria and thus have the potential to contribute phosphorus and other contaminants to lake water. Septic systems around Mousam Lake that are sited in coarse, sandy soils with minimal filtering capacity are especially likely to contribute nutrients to lake waters, as are older septic systems which pre-date Maine's 1974 Plumbing Code.

Recommendations for reducing existing phosphorus inputs to lakes include replacement of pre-Plumbing Code septic systems and other poorly functioning systems within the shoreland zone of Mousam Lake. Identification of potential problem systems can be accomplished through town records and sanitary surveys. Lakeshore residents who believe they may have problems with their septic systems are encouraged to contact their town office for possible technical and/or financial assistance. In some cases, a revolving (Maine DEP) loan fund could be established to assist in the replacement of malfunctioning septic systems. Above all, educational efforts should make residents aware of impending problems and possible cost-effective solutions.

Action Item # 3: Encourage Updating Septic Systems for Mousam Lake Shoreline Properties		
Activity	**Participants**	**Schedule & Cost**
Seek replacement of pre-Plumbing code (1974) septic systems and other poorly functioning systems	MLRA, YC-SWCD, watershed municipalities and watershed citizens	Annually beginning in 2003 **Cost will vary**

4) Roadways: The 1996 Mousam Lake watershed survey identified eight problem sites on state and town roads and 32 problem sites on camp and private roads. In addition, MACD road survey work during 2001 identified 15 state and town road sites and seven camp and private road sites. While these sites are generally more complex and costly to repair than residential home sites, the long-term savings to the town and landowners are substantial. It is not unthinkable to treat all potential problem sites on state and town roads located in the lake watershed. Camp and private roads offer more of a challenge, due to the overall lack of road associations in the watershed. Note: The YC-SWCD is working to assist with the organization and formation of camp road associations in the watershed. The installation of typical roadside BMPs (reshaping of ditches, culvert maintenance, proper crowning of roads, and installing plunge pools and turn-outs) is needed in several areas of the Mousam Lake watershed.

The YC-SWCD has worked extensively on two large-scale roadside BMP projects on Pump Box Brook/Route 11 and Goose Pond Road/Goose Pond Outlet. In addition to these complex sites, MACD project staff has recommended the mitigation of a complex roadside/beach site at the intersection of Route 11 and 109 and the south end of the upper Mousam basin. The York County SWCD is working cooperatively with both Maine DEP and the Maine Department of Transportation to install BMPs at this site (Deb St. Pierre, personal communication). Also, a Camp Road Study committee has been established in the Town of Acton to consider the issues relating to camp roads. This committee is addressing issues related to the summer and winter maintenance of camp roads. Committee members have physically measured each road, noting whether paved or gravel, observed drainage conditions, counted homes and estimated year-round residents, rated road conditions and checked for turnaround availability (MLRA Newsletter Spring 2001). The results of this survey should be used by conservation partners to help prioritize and implement BMPs on all Acton residential camp roads.

Action Item # 4: Implement Camp Road Best Management Practices		
Activity	**Participants**	**Schedule & Cost**
Continue to Implement Roadside BMPs watershed-wide	MLRA, YC-SWCD, Maine DEP, watershed road associations	Annually beginning in 2003 **$10,000/yr**

5) Agriculture and Forestry: The 1996 Mousam Lake Watershed Survey did not list any agriculture or forest harvesting sites as problem areas. MACD project staff field reconnaissance efforts revealed that there are no existing commercial livestock operations in the watershed. Some small farms exist with 5-15 animals, but no significant water pollution problems were observed. Apple orchards in the watershed are generally well maintained and sited away from receiving waters. BMP recommendations for agricultural land uses include providing education on conservation practices and planning, as available, from the YC-SWCD and Natural Resources Conservation Service offices located in Alfred. There are some forest harvesting operations in the watershed, particularly in the western part of the lower Mousam basin watershed. No significant problems were observed in the 1996 Watershed Survey or during the MACD project staff field analysis. Individuals working in the watershed should seek BMP guidance for wood lot management that can be provided by the Maine Forest Service District Forester in Alfred or by contacting the MFS at (1-800-367-0223).

Action Item # 5: Conduct Workshops for Agriculture and Forestry Operators		
Activity	**Participants**	**Schedule & Cost**
Conduct workshops encouraging the use of phosphorus control measures	YC-SWCD, NRCS, MFS, forestry and agriculture community	Annually beginning in 2003 **$1,000/yr**

6) Non-shoreline Residential and Commercial: These properties should also be considered as potential problem areas, especially areas adjacent to watershed brooks and streams. Commercial areas should be included in education and outreach campaigns as many of them can directly benefit from maintaining suitable water quality in Mousam Lake and its associated waterbodies.

Action Item # 6: Develop Stewardship Initiatives for Mousam Lake Tributaries		
Activity	**Participants**	**Schedule & Cost**
"Adopt" local streams to promote stewardship efforts including education and water quality monitoring	MRLA, YC-SWCD, Maine DEP Stream Team, local schools, and watershed citizens	Annually beginning in 2003 **$500/yr**

7) Individual Action: By watershed residents should be encouraged through continued education and outreach efforts, including: retention or planting of natural vegetation of buffer strips, use of non-phosphate cleaning detergents, elimination of phosphorus-containing fertilizers, adequate maintenance of septic systems.

Action Item # 7: Expand Watershed-Wide Homeowner Education		
Activity	**Participants**	**Schedule & Cost**
Increase outreach and education efforts to watershed citizens, including technical assistance	MRLA, YCSWCD, Maine DEP	Annually beginning in 2003 **$1,500/yr includes printing of educational materials**

8) Municipal Actions: Towns should include ensuring public compliance with local and state water quality laws and ordinances (Shoreland Zoning, Erosion and Sedimentation Control Law, plumbing code) through education and enforcement action only when necessary.

WATER QUALITY MONITORING PLAN

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

PCAP Closing Statement

The current level of watershed and lakeshore restoration work in the Mousam Lake region is a very promising feature. As a result of these efforts, there is an existing framework of organizations in place able to handle future grant administration and funding (YC-SWCD, Town of Acton, Town of Shapleigh, MLRA). The 1999 Mousam Lake 319 Project began emphasizing the need for Best Management Practices with modest goals for NPS reduction and has evolved into a wide-scale watershed effort focused on NPS remediation and long-term watershed management. The continued strong support from the two watershed towns, Acton and Shapleigh (who have fully funded the Youth Conservation Corps during the summer of 2001), is vital to the long-term preservation and restoration of Mousam Lake. Future post PCAP-TMDL funding should be directed to lake/watershed stakeholders to further support and build upon existing, successful projects and programs.

APPENDICES

MOUSAM LAKE

Total Maximum Daily (Annual Phosphorus) Load

Introduction to Maine Lake TMDLs - Total Maximum Daily (Annual Phosphorus) Load and Phosphorus Control Action Plans (PCAPs)

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

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

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

The first Maine lake TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. PCAP-TMDLs have been approved by US-EPA for Madawaska Lake (Aroostook County), Sebasticook Lake, East Pond (Belgrade Lakes), China Lake, and Highland (Duck) Lake (Cumberland County). 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 Webber, Threemile, and Threecornered Pond in Kennebec County. Ongoing PCAP-TMDL lake studies include: Long and Highland lakes (Bridgton); Annabessacook and Little Cobbossee lakes and Pleasant and Upper Narrows Ponds - the latter two under separate contract with CWD. A PCAP-TMDL for Unity Pond (Waldo County) has also been drafted, with the assistance of Unity College staff. PCAP-TMDL studies have been initiated for Sabattus, Togus, and Lovejoy ponds.

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. They are primarily designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to address the problem. Landowners and watershed groups are eligible to receive technical and financial assistance from state and federal natural resource agencies to reduce watershed total phosphorus loadings to the lake. **Note:** *for non-stormwater regulated lake watersheds (e.g., Mousam Lake), the development of phosphorus-based lake PCAP-TMDLs are not intended by Maine DEP to be used for regulatory purposes.*

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

Water Quality Monitoring: Data for Mousam Lake has been collected from the upper (northern) basin deep hole since 1974. Semi-continuous Secchi disk transparency (SDT) measures have been obtained from 1976 through 1992 and 1997 to the present (Maine VLMP 2001). During this 28-year period, 9 years of basic chemical information was collected by Maine DEP, in addition to SDT (water clarity) measures. Water quality in the lower (southern) basin of Mousam Lake has been monitored for only 5 years - in 1992 and 1997 and over the past three years (1999-2001), during which 4 years of basic chemical information was collected.

Water Quality Measures: The water quality in Mousam Lake differs considerably between the generally mesotrophic upper northern basin (01) and the more eutrophic, lower southern basin (05). Mousam Lake is a non-colored waterbody, with average color measures ranging from 14 to 22 SPU's between the upper and lower basins, respectively. Average minimum summer water column transparencies vary from 3.9 to 3.5 meters, while mean SDT's vary from 6.7 to 5.1 meters between the two basins. The range of water column (epilimnion core vs. bottom grab) TP for Mousam Lake is 4 - 8 parts per billion (ppb) vs. 4 -12 ppb in the northern basin and 6 -10 vs. 11-12 ppb in the lower basin. Chl-a measures range from: 1.3 - 9.1 ppb in the northern basin and 2.9 - 6.5 ppb in the lower basin. Recent dissolved oxygen (DO) profiles show significant levels of DO depletion in deep areas of the lake: below 5 parts per million (ppm) in 25% of water column (18-24+ m) in upper basin and below 5 ppm in 50% of water column (5-10 m) in the lower basin of Mousam Lake. Oxygen levels below 5 ppm stress coldwater fish and a persistent loss of oxygen may eliminate habitat for sensitive cold-water species (Maine DEP 2000). The potential for TP to leave the bottom sediments and become available to algae in the water column (internal loading) is low in the deeper upper basin and somewhat greater in the shallower lower basin (Maine DEP 2000).

Priority Ranking, Pollutant of Concern and Algae Bloom History: Mousam Lake (upper basin) is a very popular and well-developed lakeshore which has historically supported a significant coldwater (salmonid) fishery. Today, its water clarity is generally good, however a significant historical decline in water quality trends has been observed. Hypolimnetic dissolved oxygen levels have declined over the past several years and water quality standards are not being generally met. At this time, there are no prevalent nuisance algal blooms (aka 'China Lake Syndrome'); however, the lower (southern) basin may be showing signs of cultural eutrophication. Mousam Lake is on the State's 303(d) listing of lakes in non-attainment of water quality standards (Maine DEP 1998) by virtue of a significant declining trend in water transparency over the past decade (Maine DEP-VLMP 2002). Mousam Lake is also on the Maine DEP's list of Lakes Most-At-Risk From Development due to rapid population growth rates in the surrounding towns and the sensitive nature of the waterbody. At this time, the potential for nuisance algae blooms in Mousam Lake is judged to be low in the upper basin and moderate in the lower basin (Maine DEP 2000).

Natural Environmental Background Levels: Were not separated, for Mousam Lake, 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).

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. Mousam Lake is a non-colored lake (average color 14 - 22 SPUs), with relatively high late summer minimal SDT readings (overall average of 3.5 - 3.9 meters), in association with fairly low chlorophyll a levels (3.6 - 4.1 ppb). Currently, Mousam Lake does not meet water quality standards due to a significant decline in water transparency trends over time, combined with monitored annual summertime hypolimnetic dissolved oxygen deficiencies. This water quality assessment uses historic documented in-lake conditions as the primary basis for comparison.

Designated Uses and Antidegradation Policy: Mousam 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 numeric (in-lake) water quality target for Mousam Lake (upper basin) is conservatively set at 8 ppb total phosphorus (406 kg TP/yr). Since numeric criteria for phosphorus do not exist in Maine's state water quality regulations - and would be less accurate targets than those derived from this study - we employed best professional judgment to select a target in-lake total phosphorus concentration that would attain the narrative water quality standard. Spring-time total phosphorus levels in Mousam Lake averaged 8 ppb during 2001-02, while in-lake (epilimnion core) total phosphorus summer-time (June through August) measures ranged from 5-9 ppb (non-bloom conditions). In summary, the numeric water quality target goal of 8 ppb for total phosphorus in Mousam Lake was based on available water quality data (average epilimnion grab/ core samples) 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).

The table below describes the column variables found in Tables 6-7 on following pages.

Key for Columns in Tables 6 and 7

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

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

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

TP Coeff. Range kg TP/ha: The range of the coefficient values listed in the various 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 it is listed by the author. The coefficient is often adjusted using best professional judgment based on conditions including soil type, slope, and BMPs installed.

Land Area Hectares: (conversion) 1.0 acre = .404 hectares

TP Export Load kg TP: = total hectares x selected TP coefficient

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

Table 6. Mousam Lake (Upper Basin) - 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	TP Export Total %
Agricultural and Forested Land			**ML Upper**	**Basin**			
Low Intensity Hayland	59	0.9%	0.35 - 1.35	0.64	23.7	15.2	3.6%
Orchard	18	0.3%	0.06 - 0.75	0.40	7.2	2.9	0.7%
Pasture	3	0.0%	0.14 - 4.90	0.81	1.2	1.0	0.2%
Operated Forest Land	108	1.6%	0.20 - 0.60	0.2	43.7	8.7	2.1%
Sub-Totals	**187**	**3%**	**ML Upper**	**Basin**	**76**	**28**	**7%**
Shoreline Development							
Low Impact Residential	40	0.6%	0.25 - 1.75	0.25	16.1	4.0	1.0%
Medium Impact Residential	206	3.0%	0.40 - 2.20	0.40	83.2	33.3	7.8%
High Impact Residential	84	1.2%	0.56 - 2.70	0.56	33.9	19.0	4.5%
Residential Septic Systems	**Mousam**	0.0%	**Lake**	**Septic**	**Model**	124.7	29.4%
Camp and Private Roads	43	0.6%	0.60 - 10.0	2.00	17.3	34.6	8.1%
Sub-Totals	**372**	**5%**	**ML Upper**	**Basin**	**151**	**216**	**51%**
Non-Shoreline Development							
State Roads	41	0.6%	0.60 - 10.0	0.60	16.5	9.9	2.3%
Town Roads	97	1.4%	0.60 - 10.0	0.60	39.3	23.6	5.6%
Low Density Residential	105	1.6%	0.25 - 1.75	0.25	42.5	10.6	2.5%
Medium Density Residential	35	0.5%	0.40 - 2.20	0.40	14.2	5.7	1.3%
High Density Residential	13	0.2%	0.56 - 2.70	0.56	5.3	2.9	0.7%
Commercial	18	0.3%	0.77 - 4.18	1.50	7.3	10.9	2.6%
Institutional	6	0.1%	0.77 - 4.18	1.50	2.2	3.3	0.8%
Parks/Fairgrounds/Cemeteries	31	0.5%	0.14 - 4.90	0.80	12.5	10.0	2.4%
Sub-Totals	**345**	**5%**	**ML Upper**	**Basin**	**140**	**77**	**18%**
Total: DEVELOPED LAND	**905**	**13%**	**ML Upper**	**Basin**	**367**	**320**	**75%**
Non-Developed Land							
Inactive/Passively Managed Forest	4,485	66.2%	0.01 - 0.04	0.02	1,815.0	36.3	8.6%
Wetlands	342	5.0%	0.00 - 0.05	0.02	138.4	2.8	0.7%
Scrub Shrub	45	0.7%	0.10 - 0.20	0.10	18.4	1.8	0.4%
Grassland/Reverting Fields	353	5.2%	0.10 - 0.20	0.15	142.9	21.4	5.0%
Total: NON-DEVELOPED Land	**5,225**	**77%**	**ML Upper**	**Basin**	**2,115**	**62**	**15%**
Total: Surface Water (Atmospheric)	**643**	**9%**	0.11 - 0.21	0.16	**260**	**42**	**10%**
TOTAL: DIRECT WATERSHED	**6,773**	**100%**	**ML Upper**	**Basin**	**2,741**	**424**	**100%**

Table 7. Mousam Lake (Lower Basin) – 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	TP Export Total %
Agricultural and Forested Land			**ML Lower**	**Basin**			
Low Intensity Hayland	84	1.5%	0.35 - 1.35	0.64	34.0	21.8	6.8%
Orchard	92	1.6%	0.06 - 0.75	0.40	37.2	14.9	4.7%
Pasture	27	0.5%	0.14 - 4.90	0.81	10.8	8.7	2.7%
Operated Forest Land	12	0.2%	0.20 - 0.60	0.2	4.7	0.9	0.3%
Sub-Totals	**214**	**4%**	**ML Lower**	**Basin**	**87**	**46**	**15%**
Shoreline Development							
Low Impact Residential	47	0.8%	0.25 - 1.75	0.25	18.8	4.7	1.5%
Medium Impact Residential	59	1.0%	0.40 - 2.20	0.40	23.7	9.5	3.0%
High Impact Residential	36	0.6%	0.56 - 2.70	0.56	14.5	8.1	2.6%
Residential Septic Systems	**Mousam**	0.0%	**Lake**	**Septic**	**Model**	76.5	24.1%
Camp and Private Roads	26	0.5%	0.60 - 10.0	2.00	10.7	21.4	6.7%
Sub-Totals	**167**	**3%**	**ML Lower**	**Basin**	**68**	**120**	**38%**
Non-Shoreline Development							
State Roads	16	0.3%	0.60 - 10.0	0.60	6.5	3.9	1.2%
Town Roads	57	1.0%	0.60 - 10.0	0.60	23.2	13.9	4.4%
Low Density Residential	68	1.2%	0.25 - 1.75	0.25	27.5	6.9	2.2%
Medium Density Residential	7	0.1%	0.40 - 2.20	0.40	2.8	1.1	0.4%
High Density Residential	16	0.3%	0.56 - 2.70	0.56	6.5	3.6	1.1%
Commercial	13	0.2%	0.77 - 4.18	1.50	5.3	7.9	2.5%
Institutional	6	0.1%	0.77 - 4.18	1.50	2.2	3.3	1.1%
Parks/Fairgrounds/Cemeteries	9	0.2%	0.14 - 4.90	0.80	3.6	2.9	0.9%
Sub-Totals	**192**	**3%**	**ML Lower**	**Basin**	**78**	**44**	**14%**
Total: DEVELOPED LAND	**573**	**10%**	**ML Lower**	**Basin**	**232**	**210**	**66%**
Non-Developed Land							
Inactive/Passively Managed Forest	3,575	62.2%	0.01 - 0.04	0.02	1,446.7	28.9	9.1%
Wetlands	300	5.2%	0.00 - 0.05	0.02	121.4	2.4	0.8%
Scrub Shrub	158	2.7%	0.10 - 0.20	0.10	63.7	6.4	2.0%
Grassland/Reverting Fields	920	16.0%	0.10 - 0.20	0.15	372.2	55.8	17.6%
Total: NON-DEVELOPED Land	**4,952**	**86%**	**ML Lower**	**Basin**	**2,004**	**94**	**29%**
Total: Surface Water (Atmospheric)	**220**	**4%**	0.11 - 0.21	0.16	**89**	**14**	**4%**
TOTAL: DIRECT WATERSHED	**5,745**	**100%**	**ML Lower**	**Basin**	**2,325**	**318**	**100%**

TOTAL PHOSPHORUS LAND USE LOADS

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

Selected phosphorus loading coefficients (primarily roads and shoreline residential) were reduced to account for the estimated bioavailability of urban runoff sources according to available literature (Lee et al. 1980 and Sonzogni et al. 1982) and to better account for algal available-P export values as reflected in Dennis et al. (1992). These adjustments account not only for the readily available SRP (soluble-reactive-phosphorus) in the runoff, but also a substantial portion of the particulate inorganic component, particularly the P which is weakly adsorbed on the surface of soil particles (relative to discussion in Chapra 1997, pg. 524). **Note:** *These adjustments in P-load coefficients did not alter the overall conclusions and final recommendations of the Mousam Lake PCAP-TMDL report for identified needs and NPS/BMP implementation plans for the Mousam Lake watershed.*

Agricultural/Forest Operational Practices: Total phosphorus loading coefficients, as applied to agricultural practices, were adopted, in part, from Reckhow et al. 1980: pasture 0.81 kg TP/ha; and Dennis and Sage 1981: low-intensity hayland 0.64 kg TP/ha; and from past Maine DEP (1989) studies (row crops 1.50 kg/TP/ha). The phosphorus loading coefficient applied to operated forest lands (0.20 kg/TP/ha) was derived (low estimate) directly from the original Cobbossee Lake TMDL report (Monagle 1995).

Shoreline Residential (House and Camp Lots): The range of phosphorus loading coefficients used (0.25 – 2.70 kg/ha/yr) were developed using information on residential lot stormwater export of algal available phosphorus from Dennis et al. (1992).

Private Camp Roads: Total phosphorus loading coefficients for private camp roads (2.00 kg/TP/ha) were chosen, in part, on the basis of previous studies from rural Maine highways (Dudley et al. 1997).

Public Roadways: Town and state roadways (92 ha) were assigned a total phosphorus loading rate of 0.60 kg per hectare per year. This (low end of range due to soil types) coefficient was chosen, in part, on the basis of previous studies of rural Maine highways (Dudley et al. 1997).

Non-Shoreline Development: Non-shoreline residential areas in the watershed are characterized as low, medium, and high density residential - as reflected in the variable P-loading coefficients

Total Cultural Phosphorus Loading: A total of 75% (320 kg) of the total phosphorus loading to the upper basin and 66% (210 kg) for the lower basin of the Mousam Lake watershed is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture and forestry (upper: 7%-28 kg; lower: 15%-46 kg); roadways (upper: 8%-33 kg; lower: 6%-18 kg), non-shoreline development (upper: 18%-77 kg; lower: 14%-44 kg) and shoreline development (upper: 51%-216 kg; lower: 38%-120 kg), including septic systems (upper: 29%-125 kg; lower: 24%-77 kg) and camp/private roads (upper: 8%-35 kg; lower: 7%-21 kg) – as depicted in Tables 6-7.

Non-Cultural Phosphorus Loading: The phosphorus export coefficient for non-managed forested land (0.02) is based on the low end range (due to soil type) of a regional study (Likens et al 1977). The lower total phosphorus loading coefficient chosen for atmospheric deposition (0.16 kg/P/ha) is similar to that used for the China Lake TMDL (Kennebec County), while the upper range (0.21 kg/P/ha) generally reflects a watershed that is 50 percent forested, combined with agricultural areas interspersed with urban/suburban land uses (Reckhow et al. 1980). **Other** Non-Cultural Land Uses: combined wetlands, and old field scrub shrub accounts for the remaining 6% (26 kg) of the non-cultural phosphorus export load in the upper basin and 20% (68 kg) for the lower basin of Mousam Lake.

Atmospheric Deposition and Surface Waters: Mousam Lake surface waters (upper basin) comprise 9.5% (260 ha) of the watershed area (2,741 ha) and account for an estimated 42 kg of total phosphorus, representing 10% of the total phosphorus load entering Mousam Lake. Lower basin numbers approximate 4% (89 ha) by area (2,325) and 14 kg (4% of the P-load in lower basin).

Phosphorus Load Summary

It is our professional opinion that the selected low-range phosphorus export coefficients are appropriate for the Mousam Lake watershed primarily due to the permeable nature of the prevalent characteristic sandy shoreline soils (see previous PCAP discussion). Results of this land use study indicate that a best estimate of the present total phosphorus loading from both direct and indirect external (watershed generated) nonpoint source pollution, plus allocations to account for future developmental rates (see discussion below), approximates 556 kg TP/year in the upper basin of Mousam Lake. This annual external watershed generated loading to the upper basin of Mousam Lake equates to a phosphorus loading modeled at 11 ppb (559 kg TP/year) - approximately 150 kg above the TMDL target goal of 8 ppb (406 kg TP/year). Comparative numbers for the lower basin of Mousam Lake equates to a P-loading modeled at 12 ppb (708 kg TP/year).

LINKING WATER QUALITY & POLLUTANT SOURCES

Assimilative Loading Capacity: The Mousam Lake TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity, or other appropriate measures. It is thought appropriate to express the Mousam Lake TMDL as an annual load, in part because the upper lake basin has a relatively long flushing rate of 1.3 flushes per year). Notably, the lower (southern) basin has a much greater flushing rate of approximately 18 flushes per year. The lake assimilative capacity for all existing and future non-point pollution sources for Mousam Lake (upper basin) is capped at 406 kg TP/yr - as derived from the empirical phosphorus retention model based on a target (springtime P-concentration) goal of 8 ppb. This value generally reflects the annual phosphorus load that yields the upper basin's current trophic state.

Future Development: In order to effectively meet the stated goal of maintaining current trophic state, further reductions in existing watershed phosphorus loading is necessary for two important reasons. First, Mousam Lake (upper basin) has a flushing rate of only 1.3 times per year and is a well-mixed waterbody. Hence, much of the phosphorus laden water in the lake entered from 2 to 5 years ago. Some development has occurred in the watershed over the past 5 years, no doubt resulting in an increase in annual phosphorus loading from the watershed. Given the lag time in lake response to this additional P-load, existing annual watershed phosphorus loads should be reduced by at least the amount of increase in load over the past 5 years. The unmitigated rate of increase in Mousam Lake's annual phosphorus load due to new development approximates 2.5 kg TP/yr, or 12.5 kg TP over a 5 year period (Dennis et al. 1992 application). This amount is a conservative estimate, since most of the development during this period (1998-2002) did in fact incorporate measures to mitigate non-regulated stormwater phosphorus export from the Mousam Lake watershed. The second reason for needing to reduce existing watershed phosphorus loading is that growth will continue to occur in the watershed, contributing new sources of phosphorus to the lake - even with the incorporation of strict phosphorus export controls. Hence, existing phosphorus load sources must be further reduced to effectively allow for anticipated new sources of phosphorus to the lake. The Maine DEP water quality goal of maintaining a stable trophic state includes a reduction of current P-loading which accounts for both recent P-loading as well as potential future development in the watershed. The methods use by Maine DEP to estimate future growth (Dennis et al. 1992) are inherently conservative, as they provide for relatively high-end regional growth estimates and largely un-mitigated P-export from new development. This provides an additional non-quantified margin of safety to ensure the attainment of state water quality goals.

Based on the above discussion, the trend of increasing trophic state in Mousam Lake can be halted and the trophic state maintained at current levels, well into the future - if (1) the Towns of Acton and Shapleigh and the state implement local ordinances and state law, and (2) if the existing watershed phosphorus loading (upper basin) is reduced by at least 50 kg TP/yr (12.5 kg + 38 kg). The figure of 38 kg is = 0.75 ppb X 51 kg, with 0.75 ppb as the allowable future increase in total phosphorus concentration for a high level of protection on a moderate-sensitive lake and the 51 kg is the phosphorus load that will result in a 1.00 ppb increase in lake phosphorus concentration in the upper basin of Mousam Lake. Reductions already underway in nonpoint source phosphorus loadings are expected from the continued implementation of best management practices - primarily from improvements to camp roads and shoreline septic systems (see PCAP Summary). The goal is to limit net increases in phosphorus loading from future development for the upper basin to 38 kg (equivalent to 0.75 ppb in the lake). This can be most effectively accomplished by limiting total phosphorus export from regulated new development based on Maine DEP's phosphorus allocation method (Dennis et al. 1992) as described in "Phosphorus Control in Lake Watersheds: a technical guide for evaluating new development".

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Mousam Lake - in terms of sediment 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 2001 - the only year for which adequate lake profile TP concentration measures were available to derive reliable estimates of internal lake mass. Given the relatively low levels of phosphorus in the water column and in the absence of nuisance algae blooms, it was expected that internal sediment derived phosphorus mass would not be a problem in Mousam Lake. Indeed, internal total phosphorus mass estimates, for the combined Mousam Lake basins actually declined from average highs of 451 kg (May-July) to 351 kg (July-August) to 272 (August - September). The lower, more fertile basin of Mousam Lake did have slightly higher water column TP values, however, there was still no evidence of sediment derived phosphorus mass, even when calculated as separate basins. In the absence of internal TP mass, Mousam Lake external and indirect total phosphorus loads approximate 506 kg annually - less the 406 from in-lake processing capacity, which equals 100 kg as the amount of TP needed to be reduced to attain suitable water quality based on existing water quality standards. This reduction in phosphorus may be attained given additional reductions in watershed derived phosphorus loads into Mousam Lake.

Linking Pollutant Loading to a Numeric Target - The pollutant loading capacity for Mousam Lake (upper basin) was set at 406 kg/yr of total phosphorus to meet the numeric water quality target of 8 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to the numeric target.

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

Total Phosphorus Retention Model (after Dillon and Rigler 1974 and others)

Upper Mousam Lake Basin (01)

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

406 = **L** = external total phosphorus load capacity (kg TP/year)
8.0 = **P** = spring overturn total phosphorus concentration (ppb)
2.6 = **A** = lake basin surface area (km^2)
8.2 = **z** = mean depth of lake basin (m) **A z p = 26.9**
1.26 = **p** = annual flushing rate (flushes/year)
0.53 = **1- R** = phosphorus retention coefficient, where:
0.47 = **R = 1 / (1+ sq.rt. p)** (Larsen and Mercier 1976)

Total Phosphorus Retention Model (after Dillon and Rigler 1974 and others)

Lower Mousam Lake Basin (05)

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

472 = **L** = external total phosphorus load capacity (kg TP/year)
8.0 = **P** = spring overturn total phosphorus concentration (ppb)
0.9 = **A** = lake basin surface area (km^2)
3.0 = **z** = mean depth of lake basin (m) **A z p = 47.8**
17.92 = **p** = annual flushing rate (flushes/year)
0.81 = **1- R** = phosphorus retention coefficient, where:
0.19 = **R = 1 / (1+ sq.rt. p)** (Larsen and Mercier 1976)

Previous use of the Vollenwieder (Dillon and Rigler 1974) type empirical model for Maine lakes, e.g., Cobbossee, Madawaska, Sebasticook, East Pond, China Lake, and Highland (Duck) Lake TMDLs (ME-DEP 2000-2003) has shown this approach to be effective in linking watershed total phosphorus (external) loadings to existing in-lake total phosphorus concentrations.

Strengths and Weaknesses in the Overall TMDL Analytical Process: The Mousam 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-NES) provides a more accurate model for northeastern regional lakes.

Strengths:

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

Weaknesses:

- Inherent uncertainty of TP load estimates (Reckhow 1979, Walker 2000) and associated variability and generality of TP loading coefficients.

Critical Conditions: Occur in Mousam Lake during the summertime, when the potential (frequency and occurrence) of nuisance algae blooms are greatest. The loading capacity of 8 ppb of total phosphorus was set to achieve desired water quality standards during this critical time period, and will also provide adequate protection throughout the year (see Seasonal Variation).

LOAD ALLOCATIONS (LA's): The load allocation (lake capacity) for all existing and future non-point pollution sources for Mousam Lake (upper basin) is 406 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 8 ppb (see Loading Capacity discussion). Reductions in nonpoint source phosphorus loadings are expected from the continued implementation of best management practices from camp roads and shoreline septic systems.

WASTE LOAD ALLOCATIONS (WLA's): As there are no known existing point sources of pollution in the Mousam Lake watershed, 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 Mousam 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. Based on both Mousam Lake historical records and a summary of statewide Maine lakes water quality data for non-colored (< 26 SPU lakes) - the target of 8 ppb (406 kg TP/yr in the upper basin of Mousam 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. The statewide data base for uncolored 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. The difference between the in-lake target of 8 ppb and 17 ppb represents a 53% implicit margin of safety for Mousam Lake.

SEASONAL VARIATION: The Mousam Lake TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year – during the summer, when conditions most favor the growth of algae and aquatic plants. With annual flushing rates of 1.3, the annual phosphorus loading is most critical to the water quality in Mousam Lake. However, the best management practices (BMPs) and implementation plan proposed for the Mousam Lake watershed have been designed to address total phosphorus loading during all seasons.

PUBLIC PARTICIPATION: Adequate ("full and meaningful") public participation in the Mousam Lake PCAP-TMDL development process was ensured through the following avenues:

1. Southern Maine Lakes Coordinator, Wendy Garland, presented general Mousam Lake TMDL information prepared for her by MACD Project Manager (Forrest Bell) to about 100 participants at the 2000 Mousam Lake Region Association Annual Meeting.

2. MACD Project Manager (Forrest Bell), spoke at the 2001 Mousam Lake Region Association Annual Meeting, which was attended by about 150 residents. A detailed presentation was given regarding the TMDL process, what was to be done on Mousam Lake, and the opportunity for public involvement. Since this date, more than a dozen residents have contacted Forrest with specific issues relating to Mousam Lake.

3. MACD Project Manager, Forrest Bell, attended York County SWCD Board Meetings (January 11, 2001 and November 8, 2001) to present information regarding the Mousam Lake TMDL. The District Board Supervisors as well as Associate Supervisors attended each meeting; Pat Baldwin of the Mousam Lake Region Association attended the first meeting.

4. During the fall of 2000 and spring, summer and fall of 2001, MACD Project Staff Forrest Bell and Jodi Michaud made numerous (approximately 15) visits to the watershed to meet with York County SWCD representatives, observe conditions in the watershed, conduct road and shoreline surveys, talk with officials from the Town of Acton and Town of Shapleigh and speak to area residents.

5. Maine DEP and MACD Project staff attended the YCC Project Tour on October 16, 2001 to observe BMPs installed in the watershed. Various federal, state, and local partners, watershed citizens, and other groups interested in funding a YCC Program for their lake also attended this Mousam Lake watershed tour.

STAKEHOLDER and PUBLIC REVIEW COMMENTS and RESPONSES

A preliminary review draft TMDL was prepared and distributed to Mousam Lake watershed stakeholder groups, inclusive of: Ruth Ham (Town of Shapleigh), Lorraine Yeaton (Town of Acton), Jean Noon and Deb St. Pierre (YC-SWCD), Geoff Coombs (YC-NRCS), Pat Baldwin (Mousam Lake Region Association), Tamara Pinard (So. ME. Lakes Coordinator), Wendy Garland (Maine DEP SMRO), former Mousam Lake resident Dave Landry (China Lake Association President), Peter Mosher (Maine Department of Agriculture, and Morten Moesswilde (Maine Department of Conservation, Forestry Service). Following the 2-week preliminary stakeholder review period, paper and electronic forms were made available of the Public Review draft TMDL report, including 'legal' advertising in local newspapers, posting on the Maine DEP Internet Web site, and through normal Maine DEP advertising procedures (information and education). The following ad was printed in the Kennebec Journal (Augusta) and Portland Press Herald (York County edition) on Sunday editions only, August 25 and September 15, as well as the weekly (Thursday) edition of the Sanford News (August 29th and Sept.12th). The U.S. Environmental Protection Agency (Region I) and interested public was provided a 30-day period to respond with draft comments (Thursday, August 22nd through Friday, September 20th, 2002).

> In accordance with Section 303(d) of the Clean Water Act, and implementation regulations in 40 CFR Part 130 - the Maine Department of Environmental Protection has prepared a **Total Maximum Daily (Annual) Load (TMDL)** nutrient report (DEPLW 2002-0529) for total phosphorus (TP) for the **Mousam Lake** watershed, located in the towns of Shapleigh and Acton - within York County. This TMDL report identifies and estimates non-point source TP loadings within land use classes of the Mousam Lake direct watershed and TP reductions required to establish and maintain acceptable water quality.
>
> **Note:** This MS-Publisher retrofitted, frontloaded PCAP-TMDL report format, complete with revised phosphorus loadings and allocations to account for the prevalence of sandy soils and future development, were reviewed by lake/watershed stakeholders and Maine DEP lakes/ watershed staff and found to be very user friendly, preferable, and a major improvement.

The preliminary stakeholder review involved electronic and mail distribution to thirteen individuals. Five of these individuals responded via phone or email.

Pat Baldwin, Mousam Lake Region Association, expressed concern relating to the high percentage of phosphorus originating from shoreline septic systems and indicated that she will be "working with the appropriate individuals in state and municipal government to properly address the issue and reduce phosphorus loading from septic systems".

Morten Moesswilde, Maine Forest Service, addressed specific issues related to the use of managed and unmanaged forest land as well as the use of P coefficients for these land uses. In response to his comments, the terminology was changed to "forest land" and "forest access/infrastructure". The MACD Project Team responded to Mr. Moesswilde's other comments regarding the selection of phosphorus coefficients via email (see attached).

David Rocque, Maine Department of Agriculture, relayed general comments relating to the model developed for Mousam Lake phosphorus loading through septic systems. Mr. Rocque's comments and recommendations will be reviewed and discussed by the MACD/Maine DEP project team in the upcoming lakes TMDL methodology meeting (Fall 2002).

Deborah St. Pierre, York County Soil and Water Conservation District, provided minor informational edits.

Gordon Stuart, retired USFS Hydrologist, addressed several issues relating to phosphorus coefficients. Some comments were addressed through minor edits and others were addressed separately to Mr. Stuart (see attached).

Public Review Comments

There were no subsequent comments received for the Mousam Lake TMDL report during the 30-day Public Review period. *Maine DEP/MACD response to comments appear in italics.*

-----Original Message-----
From: **Moesswilde, Morten** [mailto:Morten.Moesswilde@state.me.us]
Sent: Thursday, **August 15, 2002** 3:12 PM
To: 'fbenviro@maine.rr.com'
Cc: Halliwell, David; Mansius, Donald J.; Blanck, Jim; Ryder, Roger
Subject: Mousam Lake TMDL questions

Forrest,

Thanks for the opportunity to review the draft Mousam Lake TMDL. I have a few brief questions, centering on the forested acres.

How are the 119.5 acres of "Managed Forests" vs. 8000+ acres of "Unmanaged Forests" identified? It's not clear how these differ. By several measures, e.g. Tree Growth enrollment, Forest Operations Notifications, Landowner Reports, or Forest Stewardship Plans and similar programs, the amount of forest that is "managed" is much greater, in the thousands of acres.

At the same time, the TP Coefficient for "Managed Forests" is 0.4 kg/P/ha, equal to that of "Shoreline Medium Impact Residential" land use. "Unmanaged forests" have a co-efficient of 0.02 kg/P/ha. What's the basis for the order of magnitude difference?

Obviously the two questions are related. If the 119.5 acres reflects some particular use, e.g. forest roads and landings, then it might make sense to call it something else, such as "Forest Access Systems/Infrastructure". On the other hand, the higher coefficient might not make be appropriate and might need to be re-visited if it were applied to all the acres that might be called "Managed Forests" under a broader definition. (Maine Forest Service has offered in the past to help with acreage estimates of how forests are used/managed.)

I raised a similar question on the East Pond TMDL. It appeared that a different methodology was used for the China Lake TMDL, which treated all forests the same (but might have separated some forest roads).

I appreciate the reference to assistance from Maine Forest Service on BMPs for forestry (under specific recommendations, pg. 29). You might refer to the MFS District Forester in Alfred (rather than the "regional office"). You could also include our statewide number 1-800-367-0223.

Any clarification would be very helpful. Thanks again for the opportunity to look at this.

Morten Moesswilde
Water Resources Forester, Forest Policy and Management Division
Department of Conservation - Maine Forest Service
22 State House Station, Augusta, Maine 04333, tel: 207-287-8430

"Helping you make informed decisions about Maine's forests"

Morten,

Likewise - thank you for your comments and questions on the Mousam Lake TMDL. Please note that I also sent a copy of the report to a retired USFS hydrologist, Gordon Stuart, who volunteers for the same river monitoring group that I do. He expressed some similar concerns about the classification-categorization of forested lands in the watershed.

I just re-analyzed the 119.5 acres that we labeled "managed forests" in the watershed. This acreage includes clear cut areas (from GIS land use data) as well as some forest access systems and infrastructure (observed during watershed field work). We applied the coefficient of .4 kg/P/ha based on research done by Dennis and McPhedran for Annabessacook Lake in 1991.

The majority of this land is located on "C" hydrologic group soils which suggest that there is some surface runoff. Some of the forest access systems are located adjacent to watershed tributaries which we felt further justified using a TP coefficient that is equivalent to the TP coefficient used for "shoreline medium impact residential".

The use of .02 for "unmanaged forests" is the lowest number of the range for TP coefficients that we have found in the literature review.

I would like to change the term "managed forests" to something more appropriate - do you have any suggestions based on what I have explained? Also - maybe the term "unmanaged forests" should simply be labeled as "forested land"?

I will also refer to Dennis Brennan in Alfred as you have suggested and include the statewide number.

Finally, may I suggest that we meet with you at some point to get further suggestions on P coefficients or categorization of forested lands? We are constantly looking to improve upon our existing methodology and have been holding informal team meetings in Augusta to address various issues relating to the use of P coefficients.

Thanks again for your input,

Forrest Bell
16 Primrose Lane
Gorham, ME 04038
207-839-3511

-----Original Message-----
From: **Moesswilde, Morten** [mailto:Morten.Moesswilde@state.me.us]
Sent: Wednesday, **August 21, 2002** 9:14 AM
To: 'Forrest Bell'
Cc: Halliwell, David; 'Jodi Michaud'
Subject: RE: Mousam Lake TMDL questions

Forrest,

FYI, our records indicate there has been significant acreage (400+) in Acton and Shapleigh that was harvested to convert to another land use in the last three years. We have minimal reports of "silvicultural" clearcutting. It would take more digging to identify how much of that acreage is in the Mousam Lake watershed, or what the intended land use was.

If you can give me a better description of where the 119 acres you had identified are, and what your base year is, I might be able to learn more about those specific harvests. Or I can characterize the data we have more completely. Let me know.

Morten Moesswilde
Water Resources Forester, Forest Policy and Management Division
Department of Conservation - Maine Forest Service
22 State House Station
Augusta, Maine 04333
t: 207 287 8430
"Helping you make informed decisions about Maine's forests"

Morten,

Unfortunately the base year for the GIS info is 1995 so the clearing data in the last 3 years would not have been identified. The data are derived from a "hybrid" of USGS MRLC landuse classification and the Maine GAP landuse classification. As a field person who has ground-truthed many of the lake watersheds I am moving away from the use of this outdated and sometimes inaccurate GIS data. I am hoping to design a pilot study for Sabattus Pond (one of the upcoming TMDL lakes) in which we will attempt to use GIS data more effectively and will be ground-truthing to provide site-specific data which will be then be entered into GIS that will include an orthoquad layer. This will be challenging in such a large watershed but should provide a better model for future TMDLs.

In response to your comments below it would be very difficult to describe the precise location of the potential clearcut areas as I do not have the GIS data on my computer - it originates from Maine DEP. I could give you rough estimates of the locations but I don't know if you would have any information to check that against.

Finally, may I suggest that we work through you on the Sabattus project to help "ground truth" these types of land uses? It would be an exhaustive task to break down forested land but identifying clear cut and access areas would be helpful.

Thanks again for your comments and please contact me if you have further questions.

Forrest Bell
16 Primrose Lane
Gorham, ME 04038
207-839-3511

From: **Moesswilde, Morten**
Sent: Tuesday, **August 20, 2002** 5:36 PM
To: 'Forrest Bell'; Moesswilde, Morten
Cc: Halliwell, David; Jodi Michaud
Subject: RE: Mousam Lake TMDL questions

Forrest,

Thanks very much for your reply. I'd be happy to meet with you at your convenience. For now, I'd offer a few thoughts.

It's hard to know exactly what to call the 119 acres without knowing more about your GIS land use base information. If it's picking up some intensively harvested areas as well as some of the road systems, it would be of interest to know if the cutting was forest management, particularly aggressive harvesting or a precursor to development or some other change of land use. If it's development or conversion perhaps you could call it "New Development" or "Agricultural Conversion" or something like that. If it's silvicultural clearcutting or heavy harvesting, but no conversion of use, I'm not sure it can be lumped in with development since it will reforest naturally within a couple of years. I can look at some of our harvest or monitoring data to see if there was any indication of clearcutting or change of land use. What year are your data, or what's your timeframe of interest?

My guess is that most forested land is better characterized simply as "Forest". "Management" implies some type of planning and periodic harvesting, but under a broad definition could include just about anything. I suspect there's very little forest that, strictly speaking, could be called "unmanaged".

If there's a way to parse out access systems, including roads and landings, then these areas might meaningfully be treated the same as other secondary roads. You could call these "Forest Access Roads" or something similar. I gather that such roads especially in the southern part of the state get a fair bit of recreational use which sometimes causes more problems than the trucking. Also, I think that in the China Lake TMDL roads were broken down further depending on proximity to surface water and road type, which might be useful. I'd defer on your TP coefficients but it's a matter of where they're applied.

There are different ways of getting at the land use information (databases, monitoring data, field review, air photos), depending on the level of detail you are looking for. I know Gordon Stuart from other contexts as well and would be interested to hear his input. Please give me a call at your convenience if you'd like to discuss this further. We could likely devoted field time as well if that would be useful. Thanks again for your reply - hope this is helpful.

Morten Moesswilde
Water Resources Forester, Forest Policy and Management Division
Department of Conservation - Maine Forest Service
22 State House Station, Augusta, Maine 04333, tel: 287-430

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Gordon Stuart

Retired Hydrologist

Gordon,

Thanks again for your comments on the Mousam Lake TMDL. It is obvious that you have put some thought and research into P loading and coefficients which is why I requested your comments. Before addressing your comments I feel that it is necessary to explain that our analysis is not yet "site specific". In other words, in a large lake watershed it is very difficult to pinpoint sources of P for every hectare. We are working toward a goal of using more site specific data through field verification combined with air photo analysis and GIS interpretation. In fact, we are currently researching the MANAGE watershed assessment model used by the University of Rhode Island for determining P export in lake water-sheds. Our work is an evolving process and each TMDL analysis had utilized better methods than its predecessor. Please scroll down below to see my responses to some of your comments – I have requested responses from Dave Halliwell, the TMDL project manager and an aquatic biologist on some of the specific in-lake questions.

Forrest Bell
16 Primrose Lane
Gorham, ME 04038
207-839-3511

From: Gordon Stuart [mailto:gordonw@gpom.com]
Sent: Tuesday, August 20, 2002 8:56 AM
To: Forrest Bell
Subject: Re: Mousam ATPL edits

Mousam Lake TMDL for Phosphorus (Gordon Stuart, Hydrologist)

Through my involvement with the Hancock Pond Association I have been looking into guidance on phosphorus over the last few years. The TMDL process looks more logical than some of the guidance. Here are some suggested refinements.

Natural background

Some estimate needs to be made of the natural background because it is the human caused increases that cause the problem. The Clean Water Act defines pollution as human caused impairment. The TMDL process should focus on human caused changes. Where forest land dominates the watershed, it produces a large natural load that masks the human caused changes.

We believe the TMDL process does focus on human caused changes due to the fact that P loading estimates for human impact areas usually exceeds 80% of the total P load for a watershed based on our previous and current studies.

Dissolved oxygen

The percent of the water column below 5 ppm is reported. But when it comes to P release from sediments, isn't the issue depletion of oxygen at the bottom? Is oxygen depleted to the point P goes back into solution?

You are correct, however, our concerns are related to observed dissolved oxygen deficits which may potentially impact existing fish populations in Mousam Lake. See further discussion re. low-level/ measurable internal sediment P-Load in Mousam Lake.

Wetlands

The TP coefficient for wetlands is low. The low oxygen level in wetland soils causes poor retention on P in the same way P is released from bottom sediments. Richardson at Duke found upland soils were better at retaining P. Correll at the Smithsonian found increased concentrations of P in groundwater drainage from saturated soils. The coefficient for wetlands should be higher than that of undisturbed forest land.

We agree with your assertion here and will discuss this with our project team.

Forestry/agriculture

Forestry and agriculture should be kept separate because there are totally different issues and mechanisms involved in P loading.

Your response is noted but they have been kept separate with the exception of the pie charts. The simple reason is that the total loading from these sources was low and they are somewhat similar land uses as compared to other land uses thus allowing for grouping them together in the pie chart. We will discuss this with our project team.

Undisturbed Forest Land

Managed and un-managed are not the best terms. Managed forests may not be harvest for decades. Recent harvesting is the key factor. All the land has been cut over.

Good point which was also made by Morten Moesswilde, MFS, who was copied on this email. We have made changes to the land use table and terminology.

Undisturbed forest land is a better label. It means land that has not been cut over, grazed, burned, or otherwise disturbed in 5 years. Generally harvested forest land returns to its natural hydrology and chemistry in 5 years.

Morten suggested that we use just "forested land" and we have made the appropriate adjustments.

The TP coefficient of .02 may be low. The results I found indicate a coefficient of .08 may be the natural background level of undisturbed forest land.

It is at the low end of the range – but it is appropriate for a watershed dominated by glacial outwash soils.

Recent Harvest Area

Based on all the monitoring I did in ME and NH, and all the research from the northeast; harvesting does not increase P concentrations. However, harvesting increases stream flow. It is the increased flow that increases P loads even when the concentration does not change. Studies by Hornbeck in NH show more than 25% of the basal area on an entire watershed must be removed to make a measurable difference in stream flow. Since the increased P load is tied to increased flow, it is not be measurable on watersheds where recent cuts are less than 25% of the watershed.

Your response is noted and appreciated. The only harvesting consideration is for areas (119.5 ac) that have apparently been clearcut or for areas where there is forest access and infrastructure. These areas are within close proximity (less than 500') to a tributary.

In my monitoring I could not find downstream changes once the watershed size increase to where the recent cuts were less than 25% of the watershed. So harvesting at some distance from lakes would not have any impact.

Harvesting data from Maine indicated the average harvest area is about 70 acres. On small ownership, under 1,000 acres, the average harvest area is about 30 acres. Changes from a 30 acre harvest would be hard to measure on watersheds over 120 acres in size.

The loading coefficient of .4 kg/ha is high. A coefficient of .12 kg/ha for harvested acres would be a better number. This number needs to be reduced for harvest areas that are some distance from the lake.

This would be something that could be taken into account however any additional information that you could provide on this number (.12) would be greatly appreciated. The number 0.4 that is used is based on a study by Dennis and McPhedran for Annabessacook Lake in 1991.

Other factors

Small streams that are exposed to solar radiation have higher P loading. Karr at Illinois reported on work that found slight increases in water temperature above 20 C caused big increases in P release from sediments. Areas where land uses have permanently removed shade from small streams should have an increased loading coefficient. *We are aware of this factor but to date our data is not site specific enough to account for this.*

The amount of Total P that is available to algae verses what goes into sediments should be estimated. Much of the P in mineral soil and organic matter is not released to the water column.

Good suggestion, however, can you provide a good method for accom-plishing this that is within the scope of this (non-research) project?

Wetzel's Limnology book page 226, indicates disturbing the bottom in shallow areas by raking, running motors, pulling weeds, etc greatly increases P release from sediments. The extent of these activities should be estimated. ***OK, but how??***

Gordon Stuart, Retired Hydrologist

-----Original Message-----
From: **Rocque, David** [mailto:David.Rocque@state.me.us]
Sent: Tuesday, August 20, 2002 8:49 AM
To: 'Forrest Bell'
Subject: RE:

Hi Forrest. Here is a summary of our discussion yesterday

(*Roy Bouchard, Maine DEP responses are included in italics, as follows*).

Very good comments and right on the mark. Let's also consider the purpose and context of what was done here.

First: *The shoreline survey is intended to complement the whole notion of P loading based on land use inventory and using export coefficients. As such, I don't think would be appropriate to spend the time to do a lot by lot assessment. (that would be appropriate if we were scoping an implementation project) At that level, we can only get a general estimate of the loading form all sorts of land uses, including roads and septic systems.*

Second: *Since it is a rapid assessment method, the data are taken from a boat and parameters are estimated, including the age and position of a system, inferred from lot characteristics. A detailed lot by lot survey would surely give us a much better idea of system contributions... but we would still have to use somewhat arbitrary assignment of attenuation, etc.*

I questioned two attributes (page 19) for septic systems for the Mousam Lake TMDL. One was the setback distance coefficients from the lake. Why were there three categories? It would seem that 100 feet would be sufficient to attenuate the amount of phosphorous from a septic system in most cases.

The attenuation factors were assigned arbitrarily. I wanted to somehow integrate the effects of the assumed distance (estimated from the boat) on attenuation. In some cases 100 feet is probably not enough, but it's assumed that it should do a good job generally. I would not be comfortable with 100% attenuation, since there are bound to be some systems at 100+ feet that contribute enough to reduce the overall average. Systems that were intermediate in distance not only have less distance for attenuation, but also are more likely to have been installed with less soil capacity or have some other attribute (groundwater etc. etc). One can assume all sorts of attenuation actors,,, this was not set in stone. Give me better numbers and I'd use them.

You might consider type of system as a parameter. Cesspools and dry wells are no longer allowed and are generally deeper into the soil. A shallow trench or bed type system is far more effective at removing nutrients, even if closer to the lake than a cesspool or dry well.

That was blended into the age of the system. Since on a screening level, we could not determine what the system is (even talking to owners would increase the accuracy, but for reasons above was not done). We inferred the age that was blended into the assumed age of the system.

Age of system was also a question for me. *We inferred the age of the system from general lot characteristics. Very imprecise. However, in the aggregate, I think one can get some idea of the characteristic. For example, if the cottage was built several decades ago and shows no signs of recent modernization of site work indicative of a pumped system, etc.) we might infer that it is likely a pre-plumbing code installation and as such may be less than ideal. What we should use for attenuation factors is clearly up for grabs.*

Pre-1974 systems, particularly those close to the lake should be considered a major threat to the lake. I do not however, see the distinction between 1974-1985 systems as compared to post 1985 systems. The same design techniques were used in both sets of dates. The same separation distance from the bottom of the leach field and water table or bedrock was in use. In fact, newer systems have to use coarser fill material than could be used in pre-1985 systems.

A more important parameter might be soil parent material and/or depth of installation. Leach fields installed shallow so as to take advantage of the finer topsoil material, organic matter, micro-organisms and plant roots are far more effective at recycling nutrients that those installed into the "C" horizon of a sandy soil. Also, what fill material was used? Does it have any fines to which phosphorous can attach? Has a bio-mat formed or is effluent only being attenuated by dilution? These are important questions.

These are just the kinds of things we'd want to put to use if we were to do an implementation level approach... That is, if we were to go into a watershed and spend money and time to extensively remediate NPS, a more careful survey of the individual sites, including roads and septic systems etc., needs to be done. If the purpose is the TMDLs, as currently supplied to EPA, does not include watershed action springing directly form each study, then a lower level of information is called for. This is a program design question that I have raised with Don Witherill's group before, but we are not yet in the position to do these studies differently at this time (You should also know that EPA is pressuring the State for an accelerated TMDL process, which makes the more precise watershed evaluation infeasible.) There's also a tension between EPA requiring TMDL's on listed waters vs. where we think the 319 $$ can most effectively be spent. We need a sea-change in EPA attitudes on this matter before we can resolve the larger program question, perhaps.

I suggest researching what the Town of Vassalboro did through enacting an ordinance to lessen the threat of polluting waterbodies from septic systems.

This is a good consideration. How it is done, is important too. I'm not sure that how they required replacements was the best way even if the aim was justified.. as few questions need to be asked about how it was done....

I would be glad to discuss these issues or any others you might have.

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