PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

LITTLE COBBOSSEE LAKE

Kennebec County, Maine

Little Cobbossee Lake PCAP-TMDL Report

Maine DEPLW 2005 - 0692

Maine Department of Environmental Protection

Cobbossee Watershed District and

Maine Association of Conservation Districts

Final EPA Approval - March 16, 2005

Little Cobbossee Lake

Phosphorus Control Action Plan (PCAP)

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LITTLE COBBOSSEE LAKE

Total Maximum Daily (Annual Phosphorus) Load

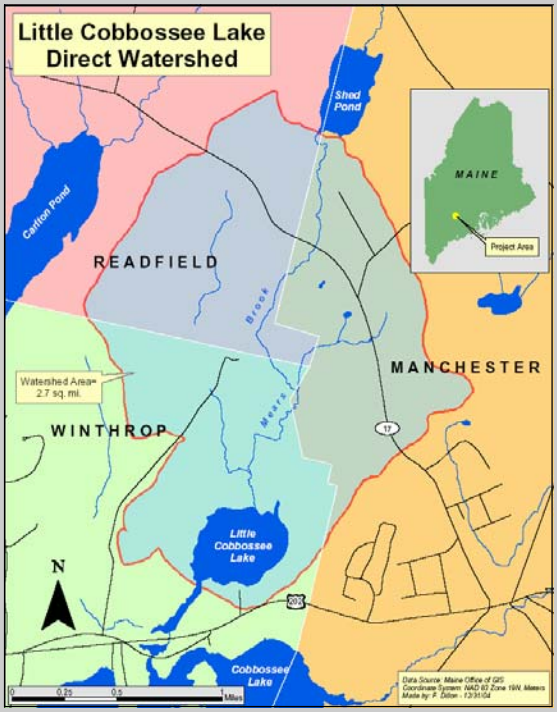
ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA New England Region I staff, the following individuals, groups and agencies were instrumental in the preparation of this combined Little Cobbossee Lake Phosphorus Control Action Plan-Total Maximum Daily Load report: Cobbossee Watershed District (Bill Monagle, Wendy Dennis); Maine Association of Conservation Districts (MACD) staff (Jodi Michaud Federle, Forrest Bell and Fred Dillon); Town of Winthrop (Office staff); Kennebec County Soil & Water Conservation District (Nate Sylvester); Maine Department of Agriculture (David Rocque); Maine Department of Inland Fisheries & Wildlife, Region B, Sidney (Bill Woodward) and Maine Department of Conservation - Forest Service (Chris Martin).

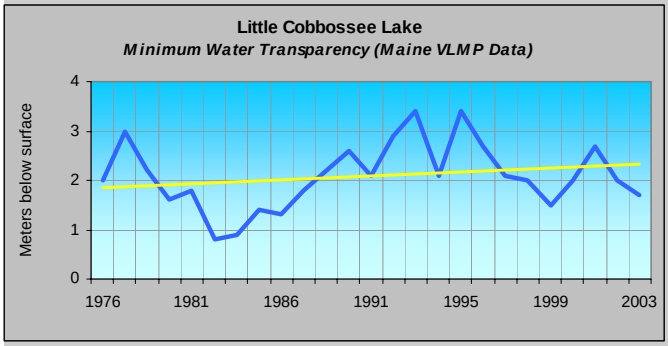
LITTLE COBBOSSEE LAKE PHOSPHORUS CONTROL ACTION PLAN
SUMMARY FACT SHEET

Background

LITTLE COBBOSSEE LAKE is a 79-acre waterbody located within the town of Winthrop in Kennebec County, Maine. Little Cobbossee Lake has a direct **watershed** area (see map) of 2.7 square miles; a maximum depth of 33 feet, a mean depth of 10 feet; and a **flushing rate** of 4.6 times/yr.



Little Cobbossee Lake has a history of supporting excessive amounts of algae in the late summer-early fall, due in large part to the contribution of **phosphorus** that is prevalent in area soils and has eroded and historically accumulated in the pond bottom sediments. Soil erosion in the watershed can have far-reaching consequences, as soil particles effectively transport phosphorus, which serves to "fertilize" the lake and decreases water clarity (see chart below). Excess phosphorus can also harm fish habitat and lead to nuisance algae blooms—floating mats of green scum—or dead and dying algae. Studies have shown that as lake water clarity decreases, lakeshore property values also decline.

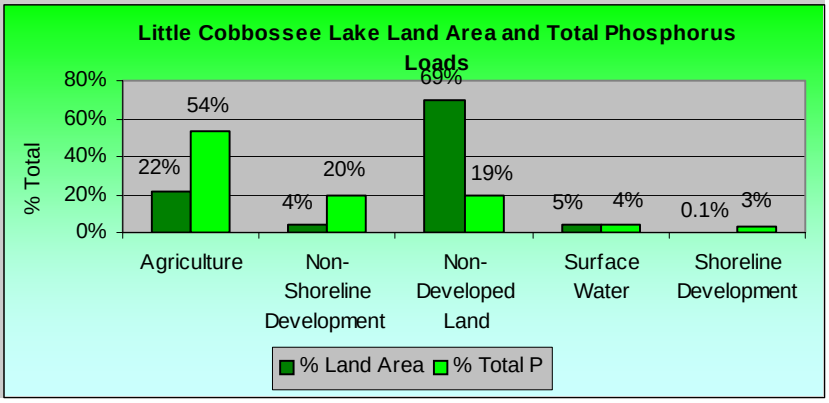


Stakeholder Involvement

Federal, state, county, and local groups have been working together to effectively address this nonpoint source water pollution problem. In 2003-04, the Maine Department of Environmental Protection funded a project in cooperation with the Cobbossee Watershed District (CWD), the Maine Association of Conservation Districts (MACD) and the Kennebec County Soil and Water Conservation District (KC-SWCD) to identify and quantify the potential sources of phosphorus and identify the **Best Management Practices** needed to be installed in the watershed. A final report, completed in the early winter of 2005, is entitled "Little Cobbossee Lake Phosphorus Control Action Plan" and doubles as a **TMDL** report, to be submitted to the U.S. Environmental Protection Agency, New England Region, for their final review and approval.

What We Learned

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



An estimated 145 kilograms (kg) of phosphorus is exported on an annual basis to Little Cobbossee Lake from the direct watershed. The indirect total phosphorus contribution from upstream Shed Pond was estimated at 18 kg/yr. Over the past two decades the amount of phosphorus being recycled internally (30 kg TP/year) from the bottom sediments of Little Cobbossee Lake during the summertime is about one-fourth of Little Cobbossee Lake's natural capacity (115 kg TP annually) for in-lake phosphorus assimilation.

Phosphorus Reduction Needed

The natural capacity of Little Cobbossee Lake to effectively process 115 kg of TP on an annual basis without harming water quality equals an in-lake phosphorus concentration of 15 ppb. Little Cobbossee Lake's average summertime TP concentration averages 28 ppb - which is equivalent to 214 kg. Accounting for a 4 kg allocation for future development, the total amount of phosphorus reduction needed to meet water quality standards (nuisance algal bloom-free conditions) in Little Cobbossee Lake approximates 103 kg (218-115).

What You Can Do To Help

As a watershed resident, there are many things you can do to protect the water quality of Little Cobbossee Lake. Lakeshore owners can use phosphorus-free fertilizers and maintain natural vegetation adjacent to the lake. Agricultural and commercial land users can consult the Cobbossee Watershed District or the Kennebec County Soil and Water Conservation District or Maine Department of Environmental Protection for information regarding Best Management Practices (BMPs) for reducing phosphorus loads. Watershed residents can always become involved by volunteering to help the Cobbossee Watershed District and by participating in events sponsored by Friends of the Cobbossee Watershed.

The estimated phosphorus loading to the lake originates from both shoreline and non-shoreline areas (see graph, below) so everyone must take ownership of lake restoration. All stakeholders and watershed residents can learn more about their lake and the many resources available, including review of the Little Cobbossee Lake Phosphorus Control Action Plan (PCAP). Following final EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work, will be available online at www.state.me.us/dep/blwq/docmonitoring/tmdl2.htm, or can be viewed and/or copied (at cost) at Maine DEP offices in Augusta (Bureau of Land and Water Quality, Ray Building, Hospital Street AMHI Complex).

Key Terms

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

Project Premise

This project, funded through a Clean Water Act Section 319-grant from the United States Environmental Protection Agency (EPA), was directed and administered by the Maine Department of Environmental Protection (Maine DEP) under contract with the Cobbossee Watershed District (CWD) and the Maine Association of Conservation Districts (MACD), from 2002 through the early winter of 2005.

The objectives of this project were twofold: First, a comprehensive land use inventory was undertaken to assist Maine DEP in developing a Phosphorus Control Action Plan (PCAP) and a Total Maximum Daily Load (TMDL) report for the Little Cobbossee Lake watershed. Simply stated, a TMDL is the total amount of phosphorus that a lake can receive without harming water quality. Maine DEP, with assistance from the MACD Project Team, will address and incorporate public comments before final submission to the US EPA.

Secondly, watershed survey work, including a shoreline and septic survey evaluation, was conducted by the Cobbossee Watershed District to help assess **total phosphorus** reduction techniques that would be beneficial for the Little Cobbossee Lake watershed. Watershed survey work included assessing direct drainage **nonpoint source (NPS) pollution** sites, inclusive of recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Little Cobbossee Lake. **Note:** *To protect the confidentiality of land owners in the Little Cobbossee Lake watershed, site-specific information has not been provided in this PCAP-TMDL report.*

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.*

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) report compiles and refines land use data derived from various sources, including the Cobbossee Watershed District, the Maine Office of GIS and the Kennebec County Soil & Water Conservation District (KC-SWCD). Local citizens, watershed organizations, and conservation agencies should benefit from this compilation of data as well as the watershed assessment and the non-point source best management practice (NPS-BMP) recommendations. Above all, this document is intended to help Little Cobbossee Lake watershed stakeholder groups to effectively prioritize future BMP work in order to obtain the funding resources necessary for further NPS pollution mitigation work in their watershed.

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

Study Methodology

Little Cobbossee Lake background information was obtained using several methods, including a review of previous studies of the lake and watershed (Monagle-CWD 1995, Maine DEP 1999). Numerous phone conversations and personal interviews with municipal officials, regional organizations and state agencies, and several field tours of the watershed were made - including boat reconnaissance of the lake and shoreline area.

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 infra-red photographs (NAPP 1991 and 1992) and (5) ground-truthing. Much of the undeveloped land use area (i.e., forest, wetland, grassland) was determined using GIS land cover mapping (1995/96 Coastal Change Analysis Program), created by the Kennebec County Soil and Water Conservation District. The developed land use areas were obtained using the best possible information available through analysis of methods 2 through 5 listed above.

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

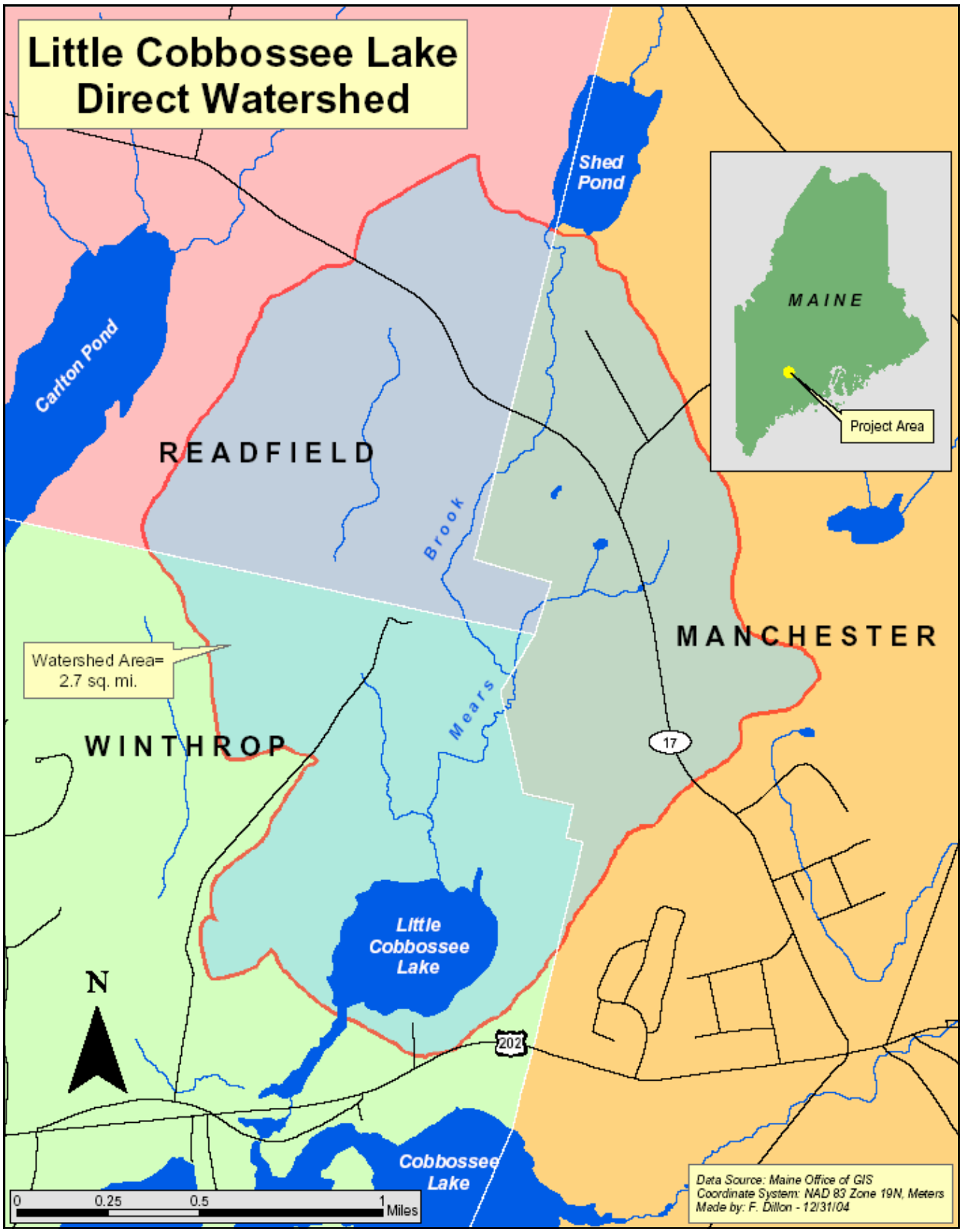
Roadway data were gathered by taking actual road width measurements of the various types of roads (state, town, private/camp) in the watershed. Roads were measured between the two outer edges of the roadside ditches or berms. An average width was used for each of the three road types. Final measurements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

Agricultural and orchard land use information within the Little Cobbossee Lake watershed was gathered by the CWD by way of personal interviews, analysis of aerial photos and ground-truthing.

Study Limitations

Land use data gathered for the Little Cobbossee Lake watershed is as accurate as possible given available information and resources utilized. However, the final numbers for the watershed land use analysis and phosphorus loading numbers are approximate, and should be viewed as carefully researched estimates only.

Figure 1. Map of the Little Cobbossee Lake Direct Watershed



LITTLE COBBOSSEE LAKE Phosphorus Control Action Plan

DESCRIPTION of WATERBODY (MIDAS Number 8065) and WATERSHED

LITTLE COBBOSSEE LAKE is a 79-acre single-basin waterbody (32 hectares), located entirely within the Town of Winthrop (DeLorme Atlas, Map 12), within Kennebec County in central Maine. Little Cobbossee has a **direct watershed** area (see Figure 1) of 1,724 acres (2.7 square miles) including lake surface area. The Little Cobbossee Lake watershed is located within the towns of Winthrop, Readfield, and Manchester. Little Cobbossee Lake has a maximum depth of 33 feet, overall mean depth of 12 feet, and a flushing rate of 4.6 times per year.

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

Drainage System – Along the northernmost portion of the lake, the lone tributary, Mears Brook, empties to the lake. At this juncture, Mears Brook is the product of the confluence of an unnamed stream and the main channel of the brook, which originates at the outlet of Shed Pond, the only upstream lake in the watershed. Shed Pond is a relatively small (47 acres), shallow pond.

Little Cobbossee Lake shares the same water level elevation as 303(d) listed Cobbossee Lake, which lies immediately downstream. These two lakes are hydraulically connected via a large culvert beneath US Route 202.

Water Quality Information

Little Cobbossee Lake is listed on the Maine DEP's 303(d) list of lakes that do not meet state water quality standards as well as Maine's Nonpoint Source Priority Watersheds list. Hence, the preparation of a Phosphorus Control Action Plan (and TMDL) was prepared and publicly reviewed in the early winter of 2005.

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

Based on **Secchi disk transparencies,** measures of both TP and **chlorophyll-a**, the water quality of Little Cobbossee Lake is considered to be poor and the potential for nuisance summertime algae blooms is high (Maine VLMP 2004). Together, these data document a trend of increasing **trophic state,** in direct violation of the Maine DEP Class GPA water quality criteria requiring a stable or decreasing trophic state.

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

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

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

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

Principle Uses: The dominant human uses of the Little Cobbossee Lake shoreline are residential (both seasonal and year-round occupancy) and recreational – including very low intensity boating, fishing, and swimming. A privately owned boat launch is located along the east side of the outlet channel from the lake and is limited to carry-in access only. The access site is located along Route 202 in the Town of Winthrop. There are no public access facilities on the lake.

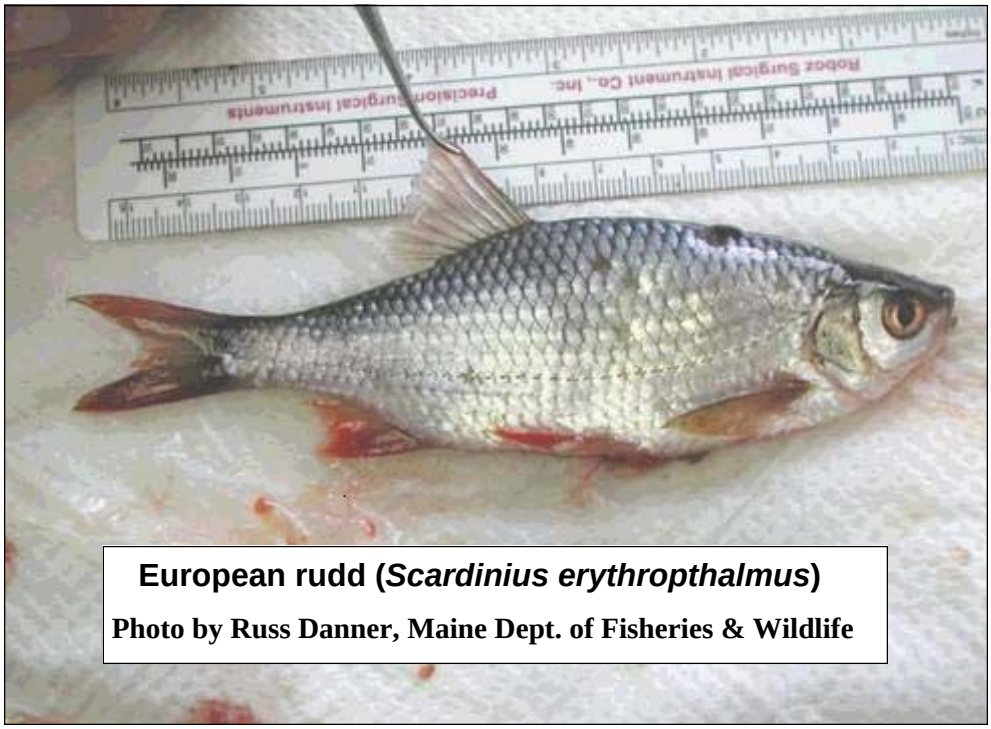
Human Development: The shoreline of Little Cobbossee Lake is very lightly developed compared to other regional lakes and ponds within the Cobbossee Watershed District. Shoreline development is limited to the southeast shore of the lake, where there are only 11 structures located along the approximate 1.3-mile shoreline. Of these, four (36%) are seasonal camps and seven (64%) are year-round dwellings (CWD 2002). The majority of the Little Cobbossee Lake shoreline, approximately 75 percent, is dominated by dense emergent wetland vegetation.

Little Cobbossee Lake is on the State's **Nonpoint Source Priority Watersheds** list due primarily to algal blooms and other factors. In addition to NPS pollution, high population growth rates are a concern for the watershed. The watershed lies within the towns of Winthrop (41%), Readfield (34%), and Manchester (25%). Notably, for the 1990-2000 time frame, Manchester and Readfield experienced a 17% and 16% population increase, respectively (www.KVCOG.org). Population growth and increased land use activities within the watershed have most likely contributed to increased runoff to Little Cobbossee Lake with a resultant increase of algae growth. The population of Little Cobbossee Lake direct watershed approximates 230 people (CWD 2004).

*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.*

Little Cobbossee Lake Fish Assemblage - Fisheries Assessment

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) and a recent conversation with fish biologist William (Bill) Woodward (Region B, Sidney DIFW office), **Little Cobbossee Lake** (town of Winthrop, Cobbossee Lake - Kennebec River drainage) is currently managed as a warmwater fishery (black bass, white perch, chain pickerel) and was last surveyed in 1971 (revised 12-20-04). A total of **16** fish species are listed, including: **10** native indigenous fishes (American eel, golden shiner, white sucker, brown bullhead, chain pickerel, banded killifish, fourspine stickleback, pumpkinseed, redbreast sunfish and yellow perch); **3** introduced fishes (white perch, smallmouth and largemouth bass); and **3** unauthorized (illegally) stocked fish species (European rudd, northern pike and rainbow smelt). Introduced rudd, an exotic minnow species closely resembling golden shiner - with which it is capable of hybridizing, have been recorded from Cobbossee Stream and also reside in Little Cobbossee Lake. Rudd are commonly utilized as a baitfish species in other parts of the United States, but are prohibited from sale in Maine (along with all non-Maine propagated or harvested baitfish species).



European rudd (*Scardinius erythropthalmus*)

Photo by Russ Danner, Maine Dept. of Fisheries & Wildlife

Little Cobbossee Lake has been historically plagued with the annual occurrence of nuisance summertime algal blooms. Working on the premise that reducing algal productivity will help restore/maintain suitable water quality conditions and fishery habitat conditions, then a significant reduction (103 kg TP/year) in the external (watershed) loading of total phosphorus to Little Cobbossee Lake may lead to maintaining in-lake nutrient levels - within the assimilative capability of this lake (115 kg TP) to effectively process available total phosphorus and enhance and/or protect the continued maintenance of the existing warm-water fisheries.

General Soils Description (Source: USDA SCS 1978):

The Little Cobbossee Lake watershed is characterized by the following general soil associations:

The majority of the eastern, western, and northern portion of the Little Cobbossee Lake watershed falls within the Hollis-Paxton-Charlton-Woodbridge soil association. These soils are shallow and deep, somewhat excessively drained to moderately well drained soils. A majority of the shoreline areas fall within the Paxton-Charlton soil series which can have limitations for septic system placement.

A portion of the watershed in southern Manchester falls within the Buxton-Scio-Scantic soil association. Many of the soils specific to this area of the watershed, including the areas adjacent to Mears Brook, are very poorly drained and have severe limitations for septic tank absorption fields.

Shoreline areas of Little Cobbossee Lake are comprised of a variety of soils including Scarborough Mucky Peat and Togus Fibrous Peat along the northern and southern shorelines. These soils have a very high water table and severe septic limitations. The eastern shoreline areas of the lake are dominated by Hollis Fine Sandy Loam soils, which also have severe septic limitations.

Land Use Inventory

The results of the Little Cobbossee Lake watershed land use inventory are depicted in Table 1 (following page). The various land uses are categorized by developed land vs. non-developed land. The developed land area comprises approximately 26% of the watershed and the non-developed land including the water surface area of Little Cobbossee Lake, comprise the remaining 74% of the watershed. These numbers may be used to help make future planning and resource conservation decisions relating to the Little Cobbossee Lake watershed. The information in Table 1 was also used as a basis for preparing the Total Maximum Daily (Annual Phosphorus) Load report (see Appendices).

Descriptive Land Use and Phosphorus Export Estimates

Agriculture: The Cobbossee Watershed District has been working with various farmers in the Little Cobbossee Lake watershed since the 1970s. In the Little Cobbossee Lake watershed, agriculture is primarily limited to a large apple orchard in association with a retail store, a modest beef cattle operation and associated hay fields and pasture, as well as other isolated haylands. The orchards total about 161 acres. The apple orchard operation recently received the 2004 Conservation Award from the Kennebec County office of the Soil and Water Conservation District (SWCD). The beef cattle operation is a seasonal (4 to 5 months) activity that involves between 25 and 35 beef cows and calves grazing on about 80 acres of pasture. The small herd size is insufficient to graze this area completely, thereby requiring mechanical harvesting methods. Manure storage on this farm is not required (less than 50 animals).

The extent of land used for agricultural purposes in the Little Cobbossee Lake watershed is relatively large when compared to other culturally based land uses, accounting for 22% of the total direct watershed area and 54% of the total phosphorus loading to the lake. Within the various agricultural practices, hayland are estimated to contribute the most phosphorus (27%), with pasture contributing 18% to the remainder of the annual total phosphorus load. The single large apple orchard was found to contribute 9% of the phosphorus load, based on low level P-loads - taking into account past and present implementation of best management practices.

Table 1. LITTLE COBBOSSEE LAKE Direct Watershed Land Use Inventory and Phosphorus Loads.

LAND USE CLASS	Land Area Acres	Land Area %	TP Export Total %
Agricultural Land			
Hayland (manured)	17.0	1.0%	5.9%
Hayland (non-manured)	116.0	6.7%	20.7%
Pasture	80.0	4.6%	18.0%
Orchard	161.0	9.3%	9.0%
Little Cobbossee Sub-Totals	**374**	**22%**	**54%**
Shoreline Development			
Low Impact residential	0.2	0.0%	0.1%
Medium Impact residential	0.9	0.1%	0.4%
Shoreline Septic Systems	**Little Cobbossee Lake Septic Model**		2.5%
Private/Camp Roads	0.7	0.0%	0.4%
Little Cobbossee Sub-Totals	**2**	**0.1%**	**3%**
Non-Shoreline Development			
Low Density Residential	41.8	2.4%	5.8%
State Roads	9.0	0.5%	3.8%
Town Roads	4.3	0.2%	1.8%
Unimproved Roads	4.0	0.2%	2.2%
Cemeteries	1.2	0.1%	0.3%
Golf Course	11.6	0.7%	5.2%
Commercial	3.0	0.2%	1.2%
Little Cobbossee Sub-Totals	**75**	**4%**	**20%**
Total: DEVELOPED LAND	**451**	**26%**	**77%**
Undisturbed/Unmanaged Forest	929.2	53.9%	10.3%
Scrub-Shrub	115.0	6.7%	3.2%
Grassland/Reverting Fields	101.0	5.9%	5.6%
Wetlands	49.1	2.8%	0.3%
Total: NON-DEVELOPED LAND	**1,194**	**69%**	**19%**
Total: Surface Water (Atmospheric)	**79**	**5%**	**4%**
TOTAL: DIRECT WATERSHED	**1,724**	**100%**	**100%**

Shoreline Residential (House and Camp Lots): Shoreline lake residences can have a comparatively large estimated impact, in terms of total phosphorus loading to lakes, in comparison to their relatively small percentage of the total land area in the watershed. This does not hold true for Little Cobbossee Lake, where the developed shoreline area accounts for less than 1% of the land area and is estimated to contribute only 3% of the total phosphorus load to the lake.

The shoreline of the 79-acre lake supports 11 single family dwellings. And, consistent with its relatively small percentage of the total land area in the watershed (0.1%), the relative total phosphorus loading contribution to the lake from the occupied shoreland zone remains of little significance on a watershed-wide basis

In order to evaluate the impact of these lake shoreline homes, CWD project staff conducted a shoreline residential survey in the fall of 2002. This visual survey was carried out while observing the Little Cobbossee Lake shoreline from a boat and the results are based on subjective determinations of potential impact ratings using best professional judgment. The visual survey included a residential structure tally along with estimating a potential NPS pollution impact rating based on the following components: presence or lack of vegetated buffers, distance of dwelling from shoreline, shoreline erosion, presence of bare/exposed soil and percent slope of the lot. In addition to the impact rating, project staff estimated the residency status of the dwelling (seasonal vs. year-round) and notable features such as retaining walls or boat launches.

The NPS pollution impact rating ranges from 1 to 5, with 1 being low and 5 being high. A residential lot assigned a rating of 1 would likely have minimal disturbance, limited developed area, or have full natural vegetation. Conversely, a rating of 5 would indicate little or no vegetative buffer and/or exposed soil on the parcel, or other visible source of phosphorus input to the lake. A similar rating system for vegetated buffer status was established. A summary of the findings of the survey on Little Cobbossee Lake appears below:

Table 2. Little Cobbossee Lake Shoreline Survey Results (2002)

Rank	Vegetated Buffers (Number of Lots within each rank)	NPS Pollution Impact Severity (Number of Lots within each rank)
1 = low impact	0	2
2	2	6
3	4	3
4	2	0
5 = high impact	3	0

Relevant findings of the shoreline survey include the moderate to high percentage of inadequate shoreline buffers on lakefront lots and fewer lots than expected with a high NPS pollution impact. The reason for no lots receiving an NPS severity rating of high (i.e., 4 to 5) is that

those lots with minimal buffers exhibited little to no shoreline erosion, were located at greater distances from the shore, and were located on low-relief terrain. Around the nearly 1.3-mile long shoreline, there were no discernable extended areas of shoreline considered to be either moderate or severely eroded. Of the 11 dwellings, it is estimated that seven are year-round residences and four are seasonal.

To estimate the phosphorus load to the lake from shoreline dwellings, each lot was subjectively assigned a phosphorus export coefficient corresponding to a residential lot with clearing limits of 10,000 square feet and situated on HSG-C soils as presented in *PHOSPHORUS CONTROL IN LAKE WATERSHEDS: A Technical Guide to Evaluating New Development* (Maine DEP 1992).

In total, shoreline residential sites (exclusive of septic systems) are estimated to contribute 0.7 kg of the total phosphorus load into Little Cobbossee Lake. Low impact sites contribute 14% of this total and medium impact sites contribute 86% of the TP loading to Little Cobbossee Lake from shorefront properties.

Shoreline Septic Systems: It is important to consider the potential for phosphorus loading from septic systems around the immediate vicinity of Little Cobbossee Lake. Export coefficients were taken from Dennis and McPhedran (1991), and applied to this recent shoreline survey. These include an estimate of 2.7 persons per household and export coefficients of 0.05 and 0.15 kg/TP per capita for seasonal and year-round residences, respectively. Based on these estimates, residential shoreline septic system loadings contribute an average total phosphorus export of approximately 2.5% or 3.6 kg TP annually.

Private/Camp Roadways are analyzed within the shoreline development category and were measured using GIS land use data and field measurements. The average road width for private roads in the Little Cobbossee Lake watershed is 17 feet. When multiplied by the average road width, camp and private roads cover less than 1 acre in the direct watershed. Camp roads contribute an estimated 0.4% (0.5 kg/yr) of TP to the total phosphorus load in the direct watershed.

NPS pollution associated with roads can vary widely, depending upon road type, slope and proximity to a resource. All 11 shorefront homes are in close proximity to US Route 202 along the southeastern shore of the lake. There were no major problems found to be associated with camp roads in the watershed. Little Cobbossee Road, the most extensive camp road in the watershed is a paved road with no sign of improper design with regard to water drainage. The other smaller camp roads exhibit signs of minor problems that include erosion of the road surface, insufficient road crown, and presence of shoulder berms.

Overall, shoreline development comprises less than 1% of the total watershed area and contributes an average of 5 kg of total phosphorus annually, which approximates 3% of the estimated phosphorus load to Little Cobbossee Lake.

Other Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreline of Little Cobbossee Lake - including residential areas, state and town roads, and other land uses such as commercial areas, cemeteries and a portion of a local golf course. These land use areas were calculated using GIS land use coverage, aerial photos and ground-truthing.

Non-Shoreline Roadways were measured using GIS land use data and field measurements. When multiplied by the average road width, state, town, and other unimproved roadways cover 17 acres in the direct watershed. The major contributor from the road category is loading from Route 17, the only state road in the watershed. Overall, roads contribute an estimated 11 kg of TP to the direct watershed, which approximates 8% of the total phosphorus load to Little Cobbossee Lake.

Low-Density Residential Homes: Residential areas in the Little Cobbossee Lake watershed were calculated using GIS land use maps provided by the Kennebec County SWCD in combination with ground-truthing and aerial photographs. This land use is characterized by dispersed, low-density, single-family homes. Non-shoreline residential areas account for an estimated 42 acres and 6% of the total phosphorus load to Little Cobbossee Lake.

Other: The remaining non-shoreline land uses include a portion (11.6 acres) of a local golf course; a small portion of the apple orchard (3 acres) dedicated to commercial use, and a small cemetery (1.2 acres). The total phosphorus loading from these other uses is estimated at 9.6 kg/yr or approximately 7% of the total phosphorus loading to Little Cobbossee Lake.

Overall, non-shoreline development accounts for 4% of the total land area and contributes approximately 20% of the total phosphorus load to Little Cobbossee Lake.

Phosphorus Loading from Non-Developed Lands

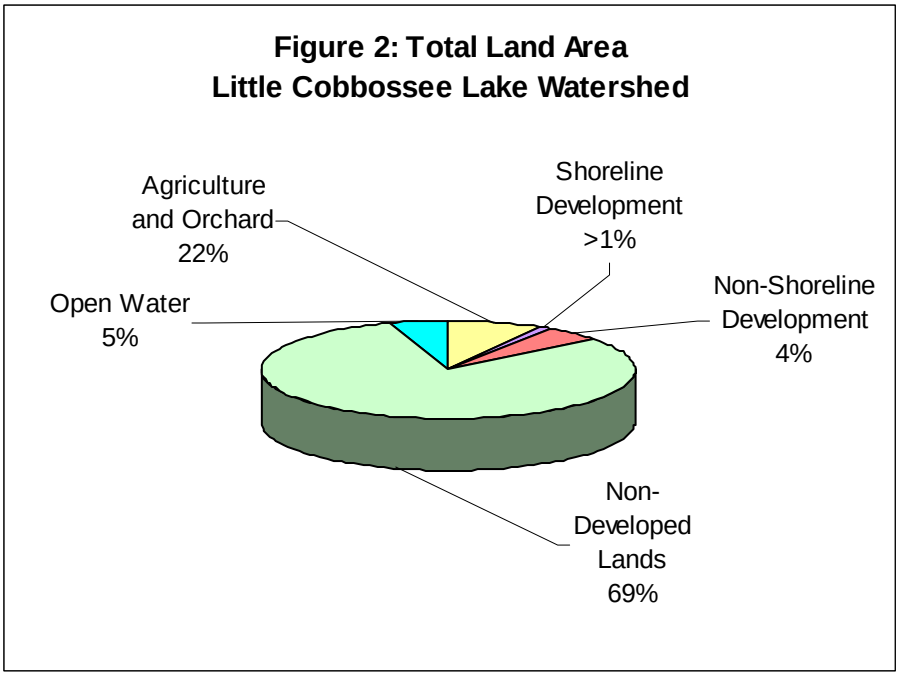
Forests: Of the total land area within the Little Cobbossee Lake watershed, 929 acres are forested, characterized by privately-owned non-managed deciduous and mixed forest plots. Approximately 10% of the phosphorus load is estimated to be derived from non-commercial forested areas within Little Cobbossee Lake's direct drainage area.

Other Non-Developed Land Areas: Combined wetlands, grassland/reverting fields and old field scrub-shrub account for the remaining 15% of the land area and 13.3 kg TP annually, approximating 9% of the total phosphorus export load.

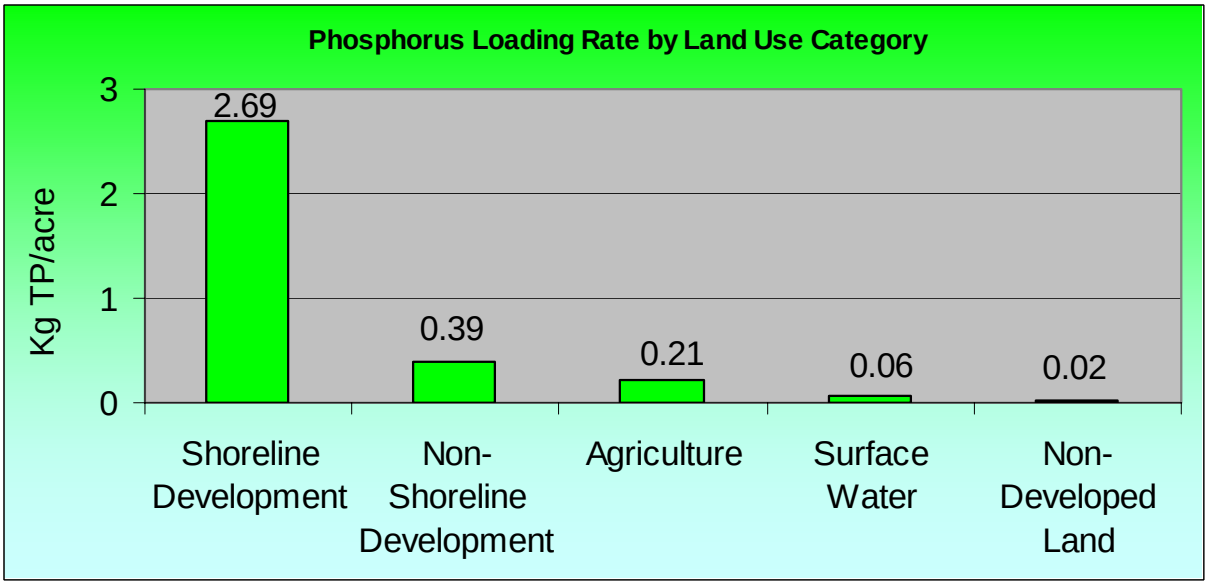
Atmospheric Deposition (Open Water): Little Cobbossee Lake surface waters (79 acres) comprise 5% of the total watershed area and account for an estimated 5 kg of total phosphorus, representing 4% of the total direct watershed load entering Little Cobbossee Lake.

The lower total phosphorus loading coefficient chosen (0.16 kg TP/ha) is similar to that used for nearby central Maine lakes in 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).

<u>Figure 2a</u> depicts the percentage of total land area covered by land uses.



<u>Figure 2b</u> TP Loading Rates by Land Use Class



PHOSPHORUS LOADS – Watershed, Sediment and In-Lake Capacity

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

- Total phosphorus loadings to Little Cobbossee Lake originate from a combination of direct external (watershed) and internal (pond sediment) sources. External (direct) watershed TP sources, totaling 145 kg annually have been identified and accounted for by land use.

- Total phosphorus loading from the associated upstream Shed Pond accounts for external loading from the indirect watershed of 18 kg annually, determined on the basis of (*flushing rate x volume x TP concentration),* and typical area gauged stream flow calculations. In lieu of water quality data specific to Shed Pond, estimates on the pond's phosphorus export were based on the statewide mean epilimnetic concentration of 12 ppb (VLMP 2002 Annual Report). Based on estimates (Maine DEP) of pond volume and flushing rate, Shed Pond is estimated to contribute approximately 18 kg of total phosphorus to Little Cobbossee Lake on an annual basis.

- The contribution of bottom sediment (internal) sources of total phosphorus within Little Cobbossee Lake approximates 30 kg, as modeled by the Cobbossee Watershed District for the spring-summer-fall period of 2002.

- The load allocation (lake assimilative capacity) for all existing and future non-point pollution sources for Little Cobbossee Lake is 115 kg of total phosphorus per year, based on a non-algal bloom target goal of 15 ppb.

- A change of 1 ppb in phosphorus concentration in Little Cobbossee Lake is equivalent to 8 kg. The difference between the target goal of 15 ppb (115 kg) and the average summertime total phosphorus concentration (28 ppb = 214 kg) is 99 kg.

- The annual contribution to account for future development for Little Cobbossee Lake is 4 kg.

- Given a 4 kg allocation for future development (0.5 x 8), the total amount of phosphorus needed to be reduced to maintain water quality standards in Little Cobbossee Lake is estimated to be 103 kg (99 + 4).

LITTLE COBBOSSEE LAKE

PHOSPHORUS CONTROL ACTION PLAN

Recent and Current Efforts

The earliest survey of the Little Cobbossee Lake watershed was performed in the mid-1970's. That survey was part of a collaborative effort between the CWD and the Southern Kennebec Regional Planning Commission as part of a region-wide Section 208 planning grant. Since that time, land use in the watershed was updated as part of the Cobbossee Lake TMDL (Monagle 1995) as the drainage area and pond were considered a sub-watershed of Cobbossee Lake. Land use data were then further updated for this current Little Cobbossee Lake PCAP-TMDL report.

Recommendations for Future Work

Little Cobbossee Lake is a waterbody that has impaired water quality due mostly to nonpoint source (NPS) pollution and resultant internal sediment recycling of phosphorus. Specific recommendations regarding Best Management Practices (BMPs) and actions to reduce external watershed total phosphorus loadings in order to improve water quality conditions in Little Cobbossee Lake are as follows:

Shoreline Residential areas have the potential to negatively impact the lake's water quality. Because of the few shoreline residential sites (11) on Little Cobbossee Lake, they have been determined to have a low impact on water quality. In order to mitigate phosphorus export from shoreline residential lots, landowners should implement BMPs and adopt more responsible watershed behavior where these BMPs are warranted. An effort should be undertaken to encourage landowners to establish adequate and effective vegetated buffers along the shoreline. For a copy of The Buffer Handbook, contact the Maine DEP's Bureau of Land and Water Quality in Augusta (287-2112) or for technical assistance regarding buffers, or contact the Cobbossee Watershed District (377-2234).

Action Item # 1: Educate watershed residents about shoreline buffers		
Activity	**Participants**	**Schedule & Cost**
Develop a buffer awareness campaign for watershed residents	*Friends*, KC-SWCD, CWD, Maine DEP, municipalities, watershed citizens	Begin immediately $1,500/year

Roadways: Camp/private roadways surrounding Little Cobbossee Lake are well maintained by private road owners and pose a limited threat to water quality when compared to other similar road networks. Other unimproved roads in the watershed that have not been surveyed may present a water quality threat and the owners of these roads should be encouraged to adopt appropriate BMPs such as proper crowning, ditch turnouts, dust management, etc.

State and Town roads were determined to represent non-point sources of phosphorus. One state road (Route 17) was deemed to represent a medium priority site based on its surface area relative to other roads and its proximity to the major tributary to the lake, Mears Brook. No significant problems have been identified that warrant attention at this time. The CWD has worked closely with the Maine DOT on several projects along Route 17 to prevent undue erosion and sedimentation problems.

In general**,** the CWD will continue to make available to local camp road associations and member municipalities technical advice on proper road design and maintenance. Specific recommendations generally include the installation of typical roadside BMPs such as reshaping of ditches, culvert maintenance, proper crowning of roads, and installing plunge pools and turnouts. The municipalities of the watershed, Winthrop in particular, have cooperated with the CWD in the past on town road-related problems as they become apparent. The CWD will continue to seek this cooperation when erosion or drainage related problems arise on town roads in the watershed**.**

Action Item # 2: Implement roadway best management practices		
Activity	**Participants**	**Schedule**
Continue to implement roadside BMPs watershed-wide	CWD, KC-SWCD, *Friends*, Maine DEP, watershed municipalities and road associations	Ongoing

Agricultural: The CWD has been in contact with the agricultural land users (i.e., non-orchard) in the watershed. At this point in time, it is not clear what changes, if any, would be warranted concerning farm operations. Excluding livestock from Mears Brook may provide some benefit. A small, seasonal, herd size is unlikely to cause major problems, but considering the diverse nature of NPS pollution and the magnitude of load reduction necessary to improve Little Cobbossee Lake, fencing the brook and providing a stream crossing should be strongly considered. Additional recommendations will be developed after further farm-specific information is gathered.

Current nutrient application practices employed on apple orchards in the watershed are limited to individual tree spiking, so it is questionable whether modifications to orchard maintenance would serve to further reduce phosphorus export to the lake.

BMP recommendations for agricultural land uses include providing education on conservation practices and planning, as available, from the CWD and Kennebec County Soil and Water Conservation offices located in Kennebec County. For free technical assistance, potential cost-

Action Item # 3: Evaluate applicable BMPs for agricultural land uses at landowners request		
Activity	**Participants**	**Schedule & Cost**
Evaluate current practices at landowners' request, recommend and provide incentives for BMPs.	CWD, KC-SWCD and agricultural operations	Begin in 2005 - **$1,000/yr**

share funds or for more information about proper agricultural BMPs, contact the CWD, or the KC-SWCD in Kennebec County (622-7847, Extension #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 Little Cobbossee Lake. While 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 Little Cobbossee Lake which are sited in coarse, sandy soils with minimal filtering capacity, and are situated in zones where groundwater in-seepage is significant, 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 seeking replacement of pre-Plumbing Code septic systems and other poorly functioning systems within the shoreland zone of Little Cobbossee Lake. Identification of potential problem systems can be accomplished through town records and property owner questionnaire surveys and/or formal sanitary surveys (e.g. dye testing). 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 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 # 4: Address potential problems with septic systems		
Activity	**Participants**	**Schedule & Cost**
Educate watershed residents about proper maintenance and provide incentives for remediation, when necessary	CWD, KC-SWCD, Maine DEP local municipalities, *Friends*	Beginning in 2005 Varies

Individual Action: An educational campaign conducted by the CWD in partnership with the *Friends of the Cobbossee Watershed* should be implemented and include a watershed-wide outreach program. Actions that should be encouraged include use of non-phosphate cleaning detergents, establishing or maintaining vegetated buffer strips down-gradient of developed areas, changing lawn practices to include the use of phosphorus-free fertilizer, adequate maintenance of septic systems, and practicing proper erosion control during any construction activities, however minor.

Municipal Action: 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, when necessary.

The CWD has historically offered technical assistance to the Planning Boards of District towns regarding the review of proposed subdivisions and commercial uses. The CWD frequently reviews development proposals for the Planning Boards of the Towns of Winthrop, Manchester, and Readfield to ensure that phosphorus control, on a watershed basis, is adequate.

Nutrient Inactivation: Internal loading from oxygen-depleted sediments occur during the summer months in Little Cobbossee Lake and may also represent a significant occurrence during winter stratification (ice cover). Reducing or eliminating this component could possibly require a nutrient inactivation project, whereby aluminum salts, specifically aluminum sulfate (alum) and sodium aluminate, are applied to those anoxic lake sediments from which total phosphorus is liberated in order to prevent or reduce phosphorus release. This type of treatment can provide effective relief, but should only be prescribed after other external sources are addressed and the lake is properly diagnosed to determine the proper project design as well as the overall efficacy of this approach in this specific case. Based on CWD water quality data, the extent of Little Cobbossee Lake sediments overlain by anoxic lake water is between 25 and 30 acres.

WATER QUALITY MONITORING PLAN

Historically, the water quality of Little Cobbossee Lake has been monitored monthly during open water periods by the CWD, as reported by the statewide VLMP (2003) since 1973. Continued long-term water quality monitoring of Little Cobbossee Lake will be conducted between the months of May to October through the continued efforts of the CWD. Under this planned, post-TMDL water quality-monitoring scenario, sufficient data will be acquired to adequately track seasonal and inter-annual variation and long-term trends in water quality in Little Cobbossee Lake.

PCAP CLOSING STATEMENT

The Cobbossee Watershed District (CWD) has worked diligently since the early to mid-1970's addressing nonpoint source pollution in the watershed of Little Cobbossee Lake. Technical assistance by the CWD is available to all participating towns to mitigate phosphorus export from existing NPS pollution sources and prevent excess loading from future sources through the CWD's technical advice to local planning boards. The towns of Winthrop, Manchester, and Readfield have long recognized the link between their water resources and the local economy and, as such, provide strong support to lake restoration and protection efforts. The above noted towns should be commended for their continued support and cooperation with the CWD in the pursuit of lake protection and improvement.

The CWD has also worked closely with the Friends of the Cobbossee Watershed - a watershed made up of 28 waterbodies, of which Little Cobbossee Lake is one. This regional watershed group educates watershed citizens about water quality by way of a newsletter and a web site, and by supporting an education vessel and a seasonal conservation corps and by hosting educational workshops for kids. The CWD also works closely with the Natural Resources Conservation Service to collaboratively address agricultural based nutrient loading. The Kennebec County Soil and Water Conservation District regularly joins forces with the CWD to identify NPS sites and develop effective mitigation strategies.

Based on the teamwork approach to lake improvement demonstrated over the past 30 years, there is a very high probability that the CWD will continue to garner support from the local community, regional agencies, and the Maine DEP to advance the Little Cobbossee Lake water quality restoration efforts.

APPENDICES

LITTLE COBBOSSEE LAKE

Total Maximum Daily (Annual Phosphorus) Load

Maine Lake TMDLs and Phosphorus Control Action Plans (PCAPs)

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

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

Nutrient enrichment of lakes through excess total phosphorus originating from watershed soil erosion has been generally recognized as the primary source of NPS pollution. Major land use activities contributing to the external phosphorus load in lakes include residential-commercial developments, roadways, agriculture, and commercial forestry. Statewide, there are 28 lakes in Maine which do not meet water quality standards due to excessive amounts of in-lake total phosphorus - the great majority of which are located in south-central Maine (Kennebec County).

The first Maine lake TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. TMDLs have been approved by US-EPA for Madawaska Lake (Aroostook County), Sebasticook Lake, East Pond (Belgrade Lakes), China Lake, Webber, Threemile and Threecornered ponds (Kennebec County), Mousam Lake, Highland Lake (Falmouth), Annabessacook Lake, Pleasant and Upper Narrows ponds (under contract with CWD), Sabattus, Highland Lake (Bridgton - with assistance from Lakes Environmental Association - LEA), Unity, and Toothaker ponds. 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 Long Lake (Bridgton - with assistance from LEA), Togus, Lovejoy, and Duckpuddle ponds. PCAP-TMDL studies have also been initiated for Lilly, Hermon-Hammond, and Sewall ponds, as well as two of the remaining seven 303(d) listed PCAP-TMDL waterbodies in Aroostook County (Trafton Lake and Lake Christina-Reservoir).

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

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

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

Water Quality Monitoring: (Source: CWD, Maine DEP and VLMP 2003) Water quality monitoring data for Little Cobbossee Lake (station 1, deep hole) has been collected since 1973 (VLMP 1976 to 2003, with 1977, 1984 and 1989 omitted). Hence, this present water quality assessment is based on 25 years of Secchi disk transparency (SDT) measures, combined with 11 years of epilimnion core total phosphorus data, and16 years of water chemistry-including chlorophyll-a monitoring data.

Water Quality Measures: (Source: CWD, Maine DEP and VLMP 2003) Historically, Little Cobbossee Lake has a range of SDT measures from 0.8 to 5.0 meters, with an average of 3.2 m; an epilimnion core TP range of 20 to 51 (outlier 140 ppb in 2003) with an average of 34 parts per billion (ppb), and chlorophyll-a measures ranging from 1.1 to 59.7, with an average of 13.6 ppb. Recent dissolved oxygen (DO) profiles indicate low levels of DO in deep areas of the lake. Late summer dissolved oxygen levels from 2001 thru 2003 remained fairly low (less than 2 ppm) within 50% of the water column (lower 5 meters). The potential for total phosphorus to leave the bottom sediments and become available to algae in the water column (internal loading) is high (Maine DEP-VLMP 2003).

Priority Ranking, Pollutant of Concern and Algae Bloom History: Little Cobbossee Lake is listed on the State's 2000 303(d) list of waters in non-attainment of Maine State water quality standards and was moved up in the priority development order due to the need to complete an accelerated approach to lakes TMDL development. The Little Cobbossee Lake TMDL has been developed for total phosphorus, the major limiting nutrient to algae growth in Maine lakes.

Water transparencies appear to have improved from 1988 to 1996, however have declined in more recent years (1999 - 2003, with the exception of the summer of 2001 - 2.7 meter minimum). On the basis of measured water transparencies at or below 2 meters in the summertime, nuisance algae blooms were found to be prevalent during 13 of the 25 years of record, mostly 1976 to 1987 (8 out of 10 years).

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

WATER QUALITY STANDARDS & TARGET GOALS

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

Maine DEP’s functional definition of nuisance algae blooms include episodic occurrence of Secchi disk transparencies (SDTs) < 2 meters for lakes with low levels of apparent color (<26 SPU) and for higher color lakes where low SDT readings are accompanied by elevated chlorophyll a levels. Little Cobbossee Lake is a lightly colored lake (average color 28 SPUs), with relatively low late summer minimal SDT readings, in association with moderate to high chlorophyll a levels.

Currently, Little Cobbossee Lake does not meet water quality standards due to a significant decline in water transparency trends over time, reflecting prevalence of summertime nuisance blue-green algal blooms, combined with hypolimnetic dissolved oxygen deficiencies. This water quality assessment uses historic documented conditions as the primary basis for comparison.

Designated Uses and Antidegradation Policy: Little Cobbossee 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 Little Cobbossee Lake is set at 15 ppb total phosphorus (115 kg TP per year). This numeric water quality goal for Little Cobbossee Lake was not simply based on observed springtime in-lake phosphorus concentrations, as this standard has not been historically attained. 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.

In summary, the numeric water quality target of 15 ppb for total phosphorus in Little Cobbossee Lake was chosen primarily as a goal to reflect late spring - early summer (unstratified) water quality, corresponding to non-bloom conditions, as reflected in suitable (water quality attainment) measures of both Secchi disk transparency (> 2.0 meters) and chlorophyll-a (< 8.0 ppb).

ESTIMATED PHOSPHORUS EXPORT BY LAND USE CLASS

Table 3 details the numerical data used to determine external phosphorus loading for the Little Cobbossee Lake watershed. The key below explains the columns and the narrative that follows the table (pages 27-29) relative to each of the representative land use classes.

Key for Columns in Table 3

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

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

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

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

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

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

TP Export Load kg P: Total hectares x applicable total phosphorus coefficient

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

Table 3. LITTLE COBBOSSEE Lake Direct Watershed Estimated 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 Land							
Hayland (manured)	17.0	1.0%	0.65 - 1.81	1.24	6.9	8.5	5.9%
Hayland (non-manured)	116.0	6.7%	0.35 - 1.81	0.64	46.9	30.0	20.7%
Pasture	80.0	4.6%	0.14 - 4.90	0.81	32.4	26.2	18.0%
Orchard	161.0	9.3%	0.15 - 0.75	0.20	65.2	13.0	9.0%
Sub-Totals	**374**	**22%**	**Little**	**Cobbossee**	**151**	**78**	**54%**
Shoreline Development							
Low Impact residential	0.2	0.0%	0.25 - 1.75	1.21	0.1	0.1	0.1%
Medium Impact residential	0.9	0.1%	0.40 - 2.20	1.50	0.4	0.6	0.4%
Shoreline Septic Systems	**Little Cobbossee Lake Septic Model**					3.6	2.5%
Private/Camp Roads	0.7	0.0%	0.60 - 10.0	2.00	0.3	0.5	0.4%
Sub-Totals	**2**	**0.1%**	**Little**	**Cobbossee**	**1**	**5**	**3%**
Non-Shoreline Development							
Low Density Residential	41.8	2.4%	0.25 - 1.75	0.5	16.9	8.4	5.8%
State Roads	9.0	0.5%	0.60 - 10.0	1.5	3.6	5.5	3.8%
Town Roads	4.3	0.2%	0.60 - 10.0	1.5	1.7	2.6	1.8%
Unimproved Roads	4.0	0.2%	0.60 - 10.0	2	1.6	3.3	2.2%
Cemeteries	1.2	0.1%	0.25 - 0.98	0.8	0.5	0.4	0.3%
Golf Course	11.6	0.7%	1.55 - 4.50	1.6	4.7	7.5	5.2%
Commercial	3.0	0.2%	0.80 - 4.20	1.4	1.2	1.7	1.2%
Sub-Totals	**75**	**4%**	**Little**	**Cobbossee**	**30**	**29**	**20%**
Total: DEVELOPED LAND	**451**	**26%**	**Little**	**Cobbossee**	**182**	**112**	**77%**
Undisturbed/Unmanaged Forest	929.2	53.9%	0.01 - 0.20	0.04	376.0	15.0	10.3%
Scrub-Shrub	115.0	6.7%	0.01 - 0.20	0.10	46.5	4.7	3.2%
Grassland/Reverting Fields	101.0	5.9%	0.01 - 0.20	0.20	40.9	8.2	5.6%
Wetlands	49.1	2.8%	0.02 - 0.83	0.02	19.9	0.4	0.3%
Total: NON-DEVELOPED LAND	**1,194**	**69%**	**Little**	**Cobbossee**	**483**	**28**	**19%**
Total: Surface Water (Atmospheric)	**79**	**5%**		**0.16**	**32**	**5**	**4%**
TOTAL: DIRECT WATERSHED	**1,724**	**100%**	**Little**	**Cobbossee**	**698**	**145**	**100%**

Total Phosphorus Land Use Loads

Estimates of total phosphorus exported from different land uses found in the Little Cobbossee Lake watershed are presented in Table 3 and represent the current extent of external phosphorus loading to the lake basin. The TP load from the associated waterbody (Shed Pond) is accounted for on the basis of *estimated flushing rate x volume x TP concentration*. TP-loading measures are expressed as a range of values to reflect the degree of uncertainty generally associated with such relative estimates (Walker 2001). The watershed total phosphorus loadings were primarily determined using literature-derived export coefficients as found in Schroeder (1979), Reckhow et al. (1980), Maine DEP (1981 and 1989), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for low density residential properties, roadways, and other types of developments (commercial and agricultural and timber harvesting).

In some cases (primarily roads and shoreline residential) selected phosphorus loading coefficients were reduced to account for the estimated bioavailability of the soil 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 accounted 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 effectively alter the overall conclusions and final recommendations of the Little Cobbossee PCAP-TMDL report regarding identified needs and NPS/BMP implementation plans for the Little Cobbossee watershed.*

Agricultural Lands: Phosphorus loading coefficients as applied to agricultural land uses were adopted, in part, from Reckhow et. al. 1980: manured hayland 1.24 kg TP/ha, pasture 0.81 kg TP/ ha; and Dennis and Sage 1981: low-intensity hayland 0.64 kg TP/ha. The lower-end phosphorus loading coefficient chosen for orchards (0.20) is based on current effective management measures in the watershed.

Shoreline Residential Lots (House and Camp): To determine phosphorus loading estimates, each developed shoreline lot was mapped using GIS software, and verified by ground-truthing and aerial photography analysis. The range of phosphorus loading coefficients used (0.25 – 2.20 kg ha/yr) were developed using information on residential lot stormwater export of algal available phosphorus as derived from Dennis et al (1992).

Private Camp Roads: The total phosphorus loading coefficient for private camp roads (2.00 kg/ha) was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997), as well as best professional judgment (Jeff Dennis, Maine DEP).

Non-Shoreline Development

Residential: Non-shoreline residential areas in the watershed are best characterized as low density residential - reflected in the 0.50 TP loading coefficient.

Golf Courses: The total phosphorus loading coefficient (1.60 kg TP/ha) applied to the golf course area takes into account the limited use of fertilizer containing phosphorus as well as the area of the course included within the watershed - tree-lined fairways as opposed to greens and tees.

Public Roadways: Town and state roadways (5.3 ha) were assigned a total phosphorus loading rate of 1.50 kg per hectare per year. This coefficient was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997).

Total Developed Lands Phosphorus Loading: A total of 77% (112 kg) of the total phosphorus loading to Little Cobbossee Lake is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture (65 kg) and orchards (13 kg); non-shoreline

development (29 kg) and shoreline development (5 kg), including septic systems (3.6 kg) and camp/private roads (0.5 kg) – as depicted in Table 3.

Non-Developed Lands Phosphorus Loading: The phosphorus export coefficient for forested land (0.04) is based on a New England regional study (Likens et al 1977). The lower total phosphorus loading coefficient chosen for atmospheric deposition (0.16 kg TP/ha) is similar to that used for the China Lake TMDL (Kennebec County), while the upper range (0.21 kg TP/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: Forested areas, combined wetlands, reverting fields, old field scrub shrub and open land account for 19% (28 kg) of the total phosphorus load entering Little Cobbossee Lake.

Atmospheric Deposition (Open Water): Little Cobbossee Lake surface waters (32 ha) comprise 5% of the total watershed area (698 ha) and account for an estimated 5 kg of total phosphorus, representing 3% of the total phosphorus load entering Little Cobbossee Lake.

Phosphorus Load Summary

It is our professional opinion that the selected export coefficients are appropriate for the Little Cobbossee Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external (watershed generated) nonpoint source pollution approximates 145 kg TP/yr. This annual external watershed generated loading to Little Cobbossee Lake equates to a total phosphorus loading modeled at 20 ppb (153 kg TP) - approximately 38 kg above the TMDL target goal of 15 ppb (115 kg TP/year). Notably, both indirect (Shed Pond=18 kg) and internal (pond bottom sediments = 30 kg) sources of phosphorus are also significant additional contributors to the existing nonpoint pollution related water quality problem in Little Cobbossee Lake.

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LINKING WATER QUALITY and POLLUTANT SOURCES

Assimilative Loading Capacity: The Little Cobbossee TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity, or other appropriate measures. It is thought appropriate and justifiable to express the Little Cobbossee TMDL as an annual load since the lake basin has a an annual flushing rate of 4.6 flushes per year, which is well within the 7 flush times per year rule of thumb used by Maine DEP to differentiate between lentic and lotic system nutrient functioning.

The Little Cobbossee Lake basin lake assimilative capacity is capped at 115 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 15 ppb. This value reflects the modeled annual phosphorus loading responsible for historical trophic state conditions, based on a long term goal of maintaining average phosphorus concentrations at or below 15 ppb.

Future Development: The Maine DEP water quality goal of maintaining a stable trophic state includes a reduction of current P-loading which accounts for both recent P-loading as well as potential future development in the watershed. The methods used by Maine DEP to estimate future growth (Dennis et al. 1992) are inherently conservative, as they provide for relatively high-end regional growth estimates and largely non-mitigated P-export from new development. This provides an additional non-quantified margin of safety to ensure the attainment of state water quality goals. Previously unaccounted P-loading from anticipated future development on Little Cobbossee Lake watershed approximates 4 kg annually (0.5 x 8 or 1 ppb change in trophic state).

Undoubtedly, human growth will continue to occur in the Little Cobbossee Lake watershed, contributing new sources of phosphorus to the lake. Hence, existing phosphorus source loads must be reduced by at least 4 kg to allow for anticipated new sources of phosphorus to Little Cobbossee Lake.

Overall, the presence of nuisance algae blooms in Little Cobbossee Lake may be reduced, along with halting the trend of increasing trophic state, if the existing combined phosphorus loading is reduced by approximately 103 kg TP/yr. Reductions already underway in nonpoint source total phosphorus loadings are expected from the continued implementation of best management practices - primarily from continued improvements to agricultural lands and roadways (see NPS/ BMP Implementation Plan and PCAP Summary).

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Little Cobbossee Lake - in terms of sediment TP recycling - were analyzed (using lake volume-weighted mass differences between early and late summer) and estimated on the basis of water column TP data from in-depth studies by CWD in 2002. Results indicate that internal loading during thermal stratification contributed approximately 30 kg of total phosphorus to the annual phosphorus budget of Little Cobbossee Lake during the summer of 2002.

Linking Pollutant Loading to a Numeric Target: The basin loading assimilative capacity for Little Cobbossee Lake was set at 115 kg/yr of total phosphorus to meet the numeric water quality target of 15 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to numeric target.

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

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

L = P (A z p) / (1-R) where, **(1 ppb change = 8 kg)**

115 = **L** = external total phosphorus load capacity (kg TP/year)
15.0 = **P** = spring overturn total phosphorus concentration (ppb) - target goal
0.32 = **A** = lake basin surface area (km^2)
3.5 = **z** = mean depth of lake basin (m) **A z p = 5.2**
4.6 = **p** = annual flushing rate (flushes/year)
0.68 = **1- R** = phosphorus retention coefficient, where:
0.32 = **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, China, Mousam, Highland, Webber, Threemile, Threecornered, Annabessacook, Pleasant, Sabattus, Highland (Bridgton), Unity, and Toothaker TMDLs (Maine DEP 2000-2004) have all 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 Little Cobbossee Lake TMDL was developed using existing lake water quality monitoring data, derived watershed export coefficients (Reckhow et al. 1980, Maine DEP 1981 and 1989, Dennis 1986, Dennis et al. 1992, Bouchard et al. 1995, Soranno et al. 1996, and Mattson and Isaac 1999) and a phosphorus retention model which incorporates both empirically derived and observed retention coefficients (Vollenwieder 1969, Dillon 1974, Dillon and Rigler 1974 a and b, and 1975, Kirchner and Dillon 1975). Use of the Larsen and Mercier (1976) total phosphorus retention term, based on localized data (northeast and north-central U.S.) from 20 lakes in the US-EPA National Eutrophication Survey (US-EPA-New England) provides a more accurate model for northeastern regional lakes.

Strengths:

- Approach is commonly accepted practice in lake management
- Makes best use of available water quality monitoring data

Weaknesses:

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

Critical Conditions exist in Little Cobbossee Lake in the summer, when conditions most favor the growth of algae and aquatic macrophytes. Anoxia in hypolimnetic water occurs during late summer and early autumn when the potential (frequency and occurrence) of nuisance algae blooms are greatest and may be a frequent, if not regular, phenomenon under ice cover in winter. During the 2002 monitoring season, internal loading resulted in a two-fold increase in in-lake phosphorus. It is unclear what the degree of inter-annual variability is, or to what extent internal loading during winter affects spring turnover concentrations. In any event, the lake supports excessive algal biomass annually with annual minimum water transparency readings regularly around 2 meters or less. The total phosphorus in-lake target of 15 ppb was established based on state-wide data to achieve desired water quality protection during the open water season, and also to provide protection throughout the year (see Seasonal Variation section).

LOAD ALLOCATIONS (LA's) - The load allocation for Little Cobbossee Lake equals 115 kg TP on an annual basis and represents, in part, that portion of the lake's assimilative capacity allocated to non-point (overland) sources of phosphorus (from Table 3). Direct external TP sources (averaging 145 kg annually) have been identified and accounted for in the land-use breakdown portrayed in Table 3. Further reductions in non-point source phosphorus loadings are expected from the continued implementation of NPS best management practices (see summary, pages 19-21). As previously mentioned, it was not possible to separate natural background from non-point pollution sources in this watershed because of the limited and general nature of the available information. As in other Maine TMDL lakes, in-lake nutrient loadings in Little Cobbossee Lake originate from a combination of direct and indirect external (watershed + Shed Pond) and internal (lake sediment) sources of total phosphorus.

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

MARGIN OF SAFETY (MOS): An implicit margin of safety was incorporated into the Little Cobbossee Lake TMDL through the conservative selection of the numeric water quality target, as well as the selection of relatively conservative phosphorus export loading coefficients for cultural pollution sources (Table 3). Based on both the Little Cobbossee Lake historical records and a summary of statewide Maine lakes water quality data for lightly-colored (26-30 SPU) lakes - the target of 15 ppb (115 kg TP/yr in Little Cobbossee Lake) represents a highly conservative goal to assure attainment of Maine DEP water quality goals of non-sustained and non-repeated blue-green summer-time algae blooms due to NPS pollution or cultural eutrophication and stable or decreasing trophic state. The statewide data base for non-to lightly colored Maine lakes indicate that summer nuisance algae blooms (growth of algae which causes Secchi disk transparency to be less than 2 meters) are more likely to occur at 17 ppb or above.

SEASONAL VARIATION: The Little Cobbossee Lake TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year – during the summer, when conditions most favor the growth of algae and aquatic macrophytes. With an average flushing rate of 4.6 flushes/year, the average annual phosphorus loading is most critical to the water quality in Little Cobbossee Lake. Maine DEP lake biologists, as a general rule, use more than six flushes annually (bi-monthly) as the cutoff for considering seasonal variation as a major factor (to distinguish lakes vs. rivers) in the evaluation of total phosphorus loadings in aquatic environments in Maine. Nonpoint source best management practices (BMPs) proposed for the

Little Cobbossee Lake watershed have been designed to address total phosphorus loading during all seasons.

PUBLIC PARTICIPATION: Adequate public participation in the Little Cobbosee Lake TMDL development process was ensured - during which land use and phosphorus load reductions were discussed - through the following avenues:

1. CWD Director, Bill Monagle**,** explained the Little Cobbossee Lake TMDL to the CWD Board of Trustees on several occasions beginning with the commencement of the project. The CWD Board of Trustees has two municipally appointed members from the Town of Winthrop and one each from the Towns of Manchester and Readfield. The meetings of the CWD were held monthly and were publicly noticed. Dates for which the CWD specifically noticed Little Cobbossee Lake TMDL on the monthly agenda which is mailed to all member towns and the local newspaper included; October 15, 2002, September 16, 2003, October 21, 2003, September 21, 2004, and October 19, 2004.

2. On May 3, 2004, Bill Monagle addressed the Winthrop Town Council to explain CWD's programs and current efforts regarding the Town's lake resources, including the Little Cobbossee Lake TMDL.

3. Currently, there is not an organized Little Cobbossee Lake stakeholder group (i.e. formal lake association); however, the Friends of the Cobbossee Watershed (*Friends*) is a very active regional stakeholder group with the ability to implement most of the NPS-BMPs recommended in this report.

Stakeholder and Public Review Process

Further meaningful public participation in developing the Little Cobbossee Lake TMDL was met through a routine 2-week stakeholder review period (January 12-26, 2005). The following Little Cobbossee Lake - watershed stakeholders provided comments that were directly addressed in the current version of this PCAP-TMDL report: Kennebec County SWCD (provided updated agricultural information on current management practices and minor edits regarding agricultural operations in the watershed) and David Rocque, Maine Department of Agriculture (requested further research on agricultural operations in the watershed).

This stakeholder review was followed by a 1-month public review process through March 4, 2005, as advertised in the Kennebec Journal (Augusta) and the Winthrop Community Advertiser.

No substantial public comments were received during the month-long public review period.

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