Lake Champlain Phosphorus TMDL

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BACKGROUND INFORMATION

Section 303(d) of the Federal Clean Water Act requires each state to identify waters for which wastewater effluent limitations normally required are not stringent enough to attain water quality standards, and to establish total maximum daily loads (TMDLs) for such waters for the pollutant of concern. The TMDL establishes the allowable pollutant loading from all contributing sources at a level necessary to attain the applicable water quality standards. TMDLs must account for seasonal variability and include a margin of safety that accounts for uncertainty of how pollutant loadings may impact the receiving water's quality. Once the public has had an opportunity to review and comment on the TMDL, it is submitted to the U.S. Environmental Protection Agency (USEPA) for approval. Upon approval, the TMDL is incorporated into the state's water quality management plan.

The following statements and referenced documents have been developed by the Vermont Department of Environmental Conservation (DEC) and the New York State DEC for submission to the USEPA as a TMDL for phosphorus in Lake Champlain. This TMDL has been developed in accordance with Section 303(d) of the Clean Water Act, 40 CFR 130.7, and other relevant USEPA guidance documents including USEPA New England Regional Guidance on Submittal Requirements for Lake and Reservoir Nutrient TMDLs (USEPA 1991, 1999a, 1999b).

Description of Lake Champlain

Lake Champlain is one of the largest lakes in North America, and is shared by the States of Vermont and New York and the Province of Quebec. The lake is 120 miles long, with a surface area of 435 square miles and a maximum depth of 400 feet. The 8,234 square mile watershed drains nearly half the land area of Vermont, as well as portions of northeastern New York and southern Quebec. Additional descriptive information about Lake Champlain and its watershed can be found in Lake Champlain Basin Program (1996, 1999a).

Phosphorus Concerns

Lake Champlain is divided into 13 segments for phosphorus management purposes, as shown in Figure 1. Total phosphorus concentrations vary greatly among the lake segments. Lake segments such as Malletts Bay and the Main Lake have phosphorus levels in the low-mesotrophic range of 0.009-0.012 milligrams per liter (mg/l). Eutrophic conditions exist in the South Lake, St. Albans Bay, and Missisquoi Bay segments where mean phosphorus concentrations are in the range of 0.024-0.058 mg/l (Vermont DEC and New York State DEC 1997).

A Comprehensive Pollution Prevention, Control, and Restoration Plan for Lake Champlain was prepared by the Lake Champlain Management Conference (1996a) under the Lake Champlain Special Designation Act of 1990. This plan described the phosphorus problem in Lake Champlain and identified the need to reduce phosphorus in targeted watersheds of the lake as one of the top three priorities for action. The plan established a goal to "*reduce phosphorus inputs to Lake Champlain to*

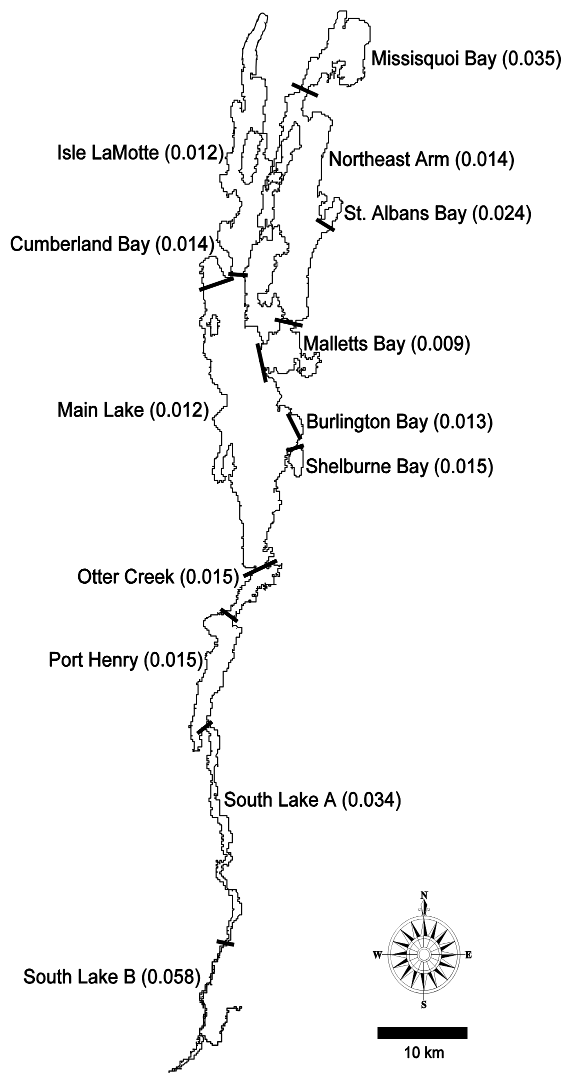

Figure 1. Map of Lake Champlain phosphorus management segments. Values in parentheses are 1990-1991 mean total phosphorus concentrations (mg/l) in each lake segment (Vermont DEC and New York State DEC, 1997).

promote a healthy and diverse ecosystem for sustainable human use and enjoyment of the lake." The plan endorsed a phosphorus management process involving the establishment of numeric, in-lake total phosphorus concentration criteria, and the assignment of watershed-based phosphorus loading targets designed to achieve the in-lake criteria over a time period of 20 years (i.e., by 2016).

The 1996 Lake Champlain Management Conference plan was approved by the Governors of Vermont and New York and the USEPA Regional Administrators from Regions 1 and 2. The Government of Quebec also agreed, through a 1996 renewal of a Memorandum of Understanding on Environmental Cooperation on the Management of Lake Champlain, to participate in cooperative actions guided by the recommendations in the Management Conference plan. The Management Conference plan provides the initial framework for the Lake Champlain Phosphorus TMDL.

Priority Ranking

Vermont Priority Ranking

The Vermont DEC submitted a Year 2000 List of Waters to the USEPA under Section 303(d) of the Clean Water Act. The New England Regional Office of the U.S. Environmental Protection Agency approved Vermont's Year 2000 List of Waters on May 22, 2001. The following nine phosphorus management segments of Lake Champlain (Figure 1) were listed in the "impaired waters" category because these segments do not meet Vermont Water Quality Standards due to phosphorus pollution.

South Lake A	Otter Creek	Northeast Arm
South Lake B	Main Lake	St. Albans Bay
Port Henry	Shelburne Bay	Missisquoi Bay

The Vermont Year 2000 List of Waters includes the planned TMDL completion date for each listed waterbody. The TMDL dates reflect the relative priority assigned to each impaired water. The Lake Champlain segments impaired by phosphorus received a high priority ranking, as indicated by the early (2001) date assigned for completion of the Lake Champlain Phosphorus TMDL.

New York Priority Ranking

In 1998, the New York State DEC submitted a list of waters that are targeted for TMDL development as required under Section 303(d) of the Clean Water Act. Lake Champlain was included as one of the *Priority* water bodies on the list. Phosphorus was identified as the pollutant of concern.

Phosphorus Sources

Phosphorus enters Lake Champlain from multiple point and nonpoint sources in Vermont, New York, and Quebec. A total phosphorus budget, annual mass balance model, and load allocation strategy was developed by the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State

DEC 1997, Smeltzer and Quinn 1996, Smeltzer 1999). The study was funded by the USEPA Clean Lakes Program and the States of Vermont and New York, with cooperative assistance provided by the U.S. Geological Survey.

Phosphorus sources to Lake Champlain were measured by an extensive field sampling program conducted during 1990-1992 (Vermont DEC and New York State DEC 1997). The study assessed all significant phosphorus sources to the lake, including loading from 31 major tributaries, 88 wastewater treatment plant discharges, ungaged areas, and direct precipitation. The loading data were used to identify and rank the major sources, and to support the development of a phosphorus mass balance model for Lake Champlain.

The total phosphorus load to Lake Champlain from all sources was estimated to be 647 metric tons per year (mt/yr) during the 1991 hydrologic base year (Vermont DEC and New York State DEC 1997). As shown in Figure 2, point sources in Vermont, New York, and Quebec accounted for 29% of the total load in 1991, with the remainder coming from cultural and natural nonpoint sources.

Nonpoint source loads to Lake Champlain include natural background levels of phosphorus. The natural background components of the nonpoint source load were estimated by comparing the nonpoint source total phosphorus concentration and the percentage of non-forested land area in the 17 tributary watersheds of the Lake Champlain basin (Vermont DEC and New York State DEC 1997). A relationship was found between the percentage of agricultural and developed land and the phosphorus concentration in the streams. The results suggest that the mean phosphorus concentration in Lake Champlain tributaries in their original forested state was about 0.015 mg/l. The natural phosphorus loading rate to the lake was estimated by applying the 0.015 mg/l stream concentration to all tributaries and ungaged areas where current levels are higher than 0.015 mg/l, eliminating the point source loadings, and assuming that atmospheric loadings have remained unchanged. Using this procedure, the natural background component of the phosphorus loading to Lake Champlain from Vermont, New York, and Quebec was estimated to be 151 mt/yr, or about 33 % of the total nonpoint source load, and 23 % of the total phosphorus loading to the lake during the 1991 base year.

Hegman et al. (1999) estimated that 56% of the nonpoint source load to Lake Champlain was derived from agricultural land, with 37% coming from urban or developed land, and 7% from forest land. Detailed information on phosphorus loads contributed by individual tributaries, wastewater discharges, and other sources can be found in Vermont DEC and New York State DEC (1997). A summary of the 1991 base year loads is given in Table 1.

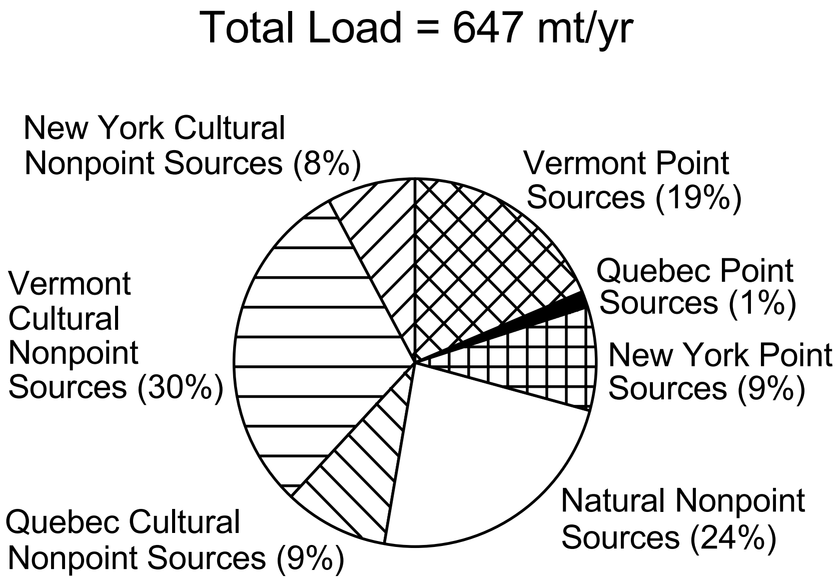

Figure 2. Total phosphorus sources to Lake Champlain during the 1991 base year (from Smeltzer and Quinn, 1996).

Table 1. Phosphorus loads to each lake segment measured during the 1991 base year (Vermont DEC and New York State DEC 1997, Lake Champlain Basin Program 1996a).

Lake Segment	1991 Load (mt/yr) Point	Nonpoint	Total
Vermont/Quebec[1]			
South Lake B	3.2	24.8	28.0
South Lake A	0.1	2.4	2.5
Port Henry	0.0	0.4	0.4
Otter Creek	62.8	58.9	121.7
Main Lake	27.7	60.3	88.0
Shelburne Bay	5.3	11.1	16.4
Burlington Bay	11.2	0.3	11.5
Malletts Bay	3.1	29.8	32.9
Northeast Arm	0.0	3.2	3.2
St. Albans Bay	0.8	7.2	8.0
Missisquoi Bay	15.4	151.9	167.3
Isle LaMotte	0.0	0.6	0.6
Vermont/Quebec Total	**129.6**	**350.8**	**480.4**
New York			
South Lake B	3.9	24.3	28.2
South Lake A	9.6	3.5	13.1
Port Henry	1.8	2.6	4.4
Otter Creek	0.0	0.1	0.1
Main Lake	7.1	31.8	38.9
Cumberland Bay	29.2	8.8	38.0
Isle LaMotte	7.4	20.9	28.3
New York Total	**59.0**	**91.9**	**150.9**
TOTAL	**188.6**	**442.7**	**631.3**[2]

[1] Quebec sources are included in the loads for Missisquoi Bay.
[2] Total does not include direct precipitation to the lake surface.

NUMERIC WATER QUALITY CRITERIA

Numeric, in-lake total phosphorus concentration criteria for each segment of Lake Champlain were incorporated into the Vermont Water Quality Standards in 1991 following a public rule-making process. The criteria were derived, in part, from a lake user survey analysis of the relationship between aesthetic values and uses and total phosphorus concentrations (North American Lake Management Society 1992, Smeltzer 1999). Based on the report of the Lake Champlain Phosphorus Management Task Force (1993), these criteria were endorsed, with the addition of the Cumberland Bay segment in New York and a modification for the South Lake B segment, as a set of consistent phosphorus management goals for the lake in a New York, Quebec, and Vermont Water Quality Agreement. The 1993 Water Quality Agreement established in-lake total phosphorus concentration goals ranging from 0.010-0.025 mg/l for 13 segments of Lake Champlain, as listed in Table 2. The derivation of these criteria is explained in Vermont DEC (1990) and Lake Champlain Basin Program (1996), and summarized below.

The lowest phosphorus concentrations in Lake Champlain exist in the Main Lake and Malletts Bay segments. Here, the 0.010 mg/l phosphorus criterion was considered to be realistically attainable and desirable. The 0.010 mg/l value represents the upper end of the phosphorus range for the conventional definition of an oligotrophic (low nutrient) lake. An oligotrophic standard was considered appropriate for the large, central, broad area of the lake.

In the remainder of the lake, the existing phosphorus concentrations are substantially higher than 0.010 mg/l, and the attainability of this oligotrophic criterion is doubtful. For the rest of the lake (except for St. Albans Bay, Missisquoi Bay, and the South Lake), an alternative phosphorus criterion of 0.014 mg/l was selected because it protects values and uses associated with oligotrophy (such as good aesthetics and absence of high algae levels), and is more realistically attainable. A mean value of 0.014 mg/l represents a phosphorus level at which an algal nuisance condition would be present only 1% of the time during the summer.

For the highly eutrophic segments of St. Albans Bay, Missisquoi Bay, and the South Lake, the 0.014 mg/l criterion would not be realistically attainable. St. Albans Bay has a long history of phosphorus management efforts, including treatment plant upgrades and nonpoint source controls. The Vermont DEC goal for restoring water quality in St. Albans Bay has been phosphorus reduction in the center bay area to a concentration of about 0.003 mg/l above the level outside the bay in the Northeast Arm. Consequently, a phosphorus criterion of 0.017 ug/l was selected for St. Albans Bay.

Missisquoi Bay and the South Lake segments are, to some extent, naturally eutrophic (high nutrient) areas as a result of their shallow depth and wetland-like characteristics. Many beneficial values and uses of these waters, such as productive warm-water fisheries and wildlife habitat, in fact, depend on a moderate degree of eutrophication. Therefore, a phosphorus criterion of 0.025 mg/l reflecting a moderate level of eutrophication was selected for these segments.

Table 2. Lake Champlain total phosphorus criteria (Lake Champlain Phosphorus Management Task Force 1993, Vermont Water Resources Board 1999) compared with measured 1990-1991 mean concentrations in each lake segment (Vermont DEC and New York State DEC 1997).

Lake Segment	**Criterion (mg/l)**	**Measured Value (mg/l)**
South Lake B	0.054[1] (0.025[2])	0.058
South Lake A	0.025	0.034
Port Henry	0.014	0.015
Otter Creek	0.014	0.015
Main Lake	0.010	0.012
Shelburne Bay	0.014	0.015
Burlington Bay	0.014	0.013
Cumberland Bay	0.014	0.014
Malletts Bay	0.010	0.009
Northeast Arm	0.014	0.014
St. Albans Bay	0.017	0.024
Missisquoi Bay	0.025	0.035
Isle LaMotte	0.014	0.012

[1] Criterion listed in Vermont Water Quality Standards.
[2] Goal specified in the 1993 New York, Quebec, and Vermont Water Quality Agreement

For the South Lake B segment, the criterion in the 1993 New York, Quebec, and Vermont Water Quality Agreement (0.025 mg/l) differs from the criterion in the Vermont Water Quality Standards (0.054 mg/l). For purposes of the Lake Champlain Phosphorus TMDL, the criterion in the Vermont Water Quality Standards (Vermont Water Resources Board 1999) will apply. The reasons for this change are discussed below.

The Vermont DEC, New York State DEC, and the USEPA agreed that attainment of the 0.025 mg/l phosphorus goal for the South Lake B segment would not be required in the modeling analysis used to establish loading targets because the nonpoint source reductions necessary to attain the goal would exceed the maximum potential reductions considered possible with best management practices (Vermont DEC and New York State DEC 1997). The modeling analysis indicated that the target loads established by the Lake Champlain Management Conference (1996a) will attain the Vermont 0.054 mg/l criterion for the South Lake B segment, but not the 0.025 mg/l goal. Vermont DEC and New York State DEC (1997) recommended that the 0.025 mg/l goal for the South Lake B segment be re-examined based on further research on phosphorus sources and impacts in the South Lake region of Lake Champlain.

As previously described, total phosphorus criteria were set for various Lake Champlain segments to protect against nuisance algal conditions during the summer months. A study by Effler et al. (2000) of the spatial patterns of water quality indicators in the South Lake concluded that management strategies that focus on reductions in phosphorus loading will not result in substantive increases in Secchi disc transparency, because phytoplankton biomass is unimportant in regulating the prevailing water clarity conditions. Study results indicated that terrigenous inputs, particularly clay particles, cause light penetration to be lower, turbidity and phosphorus concentrations to be higher, and particle composition to differ greatly in the South Lake, relative to deeper portions of Lake Champlain. Generally progressive gradients were documented within the South Lake for Secchi depth, the light attenuation coefficient, turbidity, particulate organic carbon, total phosphorus, and particulate phosphorus, that demonstrate diminishing impacts of the terrigenous inputs with the approach to the deeper portions of the lake. The high levels of inanimate particles (tripton) that prevail in the South Lake compromise total phosphorus concentration and Secchi depth as measures of trophic state.

Unlike other Lake Champlain segments, water clarity in the South Lake is not primarily controlled by phosphorus-mediated algal production. Therefore, adoption of the 0.054 mg/l criterion will not compromise the water clarity-related beneficial uses for the South Lake B segment.

The Lake Champlain Phosphorus Management Task Force (1993) report indicated that the total phosphorus concentration criteria listed in Table 2 should be applied as "*summer or annual mean values in central, open-water regions of each lake segment*." Similarly, the current Vermont Water Quality Standards state that the criteria shall be achieved as the "*annual mean total phosphorus concentration in the photosynthetic depth (euphotic) zone in central, open water areas of each lake segment*." Lake samples obtained during the open-water season (April-November) were used to estimate annual mean phosphorus concentrations, and to support a modeling analysis that established phosphorus loading targets consistent with attaining the in-lake criteria as annual mean values (Vermont DEC and New York State DEC 1997).

Mean total phosphorus concentrations in Lake Champlain measured during 1990-1991 (Vermont DEC and New York State DEC 1997) exceeded the water quality criteria values in most of the 13 lake segments (Table 2). These were the data used to list nine segments of Lake Champlain as "impaired waters" in the Vermont DEC Year 2000 List of Waters.

Monitoring of phosphorus concentrations in Lake Champlain has continued annually since 1990, as documented in Vermont DEC and New York State DEC (2002). Annual mean total phosphorus concentrations in each segment of Lake Champlain during 1990-2001 are shown in Figure 3, in comparison with the in-lake criteria values.

Phosphorus concentrations remained consistently above the criteria values during recent years in several lake segments, including Missisquoi Bay, St. Albans Bay, Northeast Arm, Main Lake, Port Henry, and South Lake A. No phosphorus monitoring under this program was conducted from 1992-2000 in the Shelburne Bay and Otter Creek segments, so additional years of monitoring will be needed before the current phosphorus status of these two lake segments can be reliably assessed.

The recent monitoring data shown in Figure 3 indicate that many segments of Lake Champlain remain out of compliance with the criteria listed in Table 2. Development and implementation of a phosphorus TMDL for Lake Champlain is necessary in order to attain water quality standards in the lake. A comprehensive monitoring program will be needed to assess progress in reducing phosphorus loads and in-lake concentrations, as described in the Monitoring Plan section of this document.

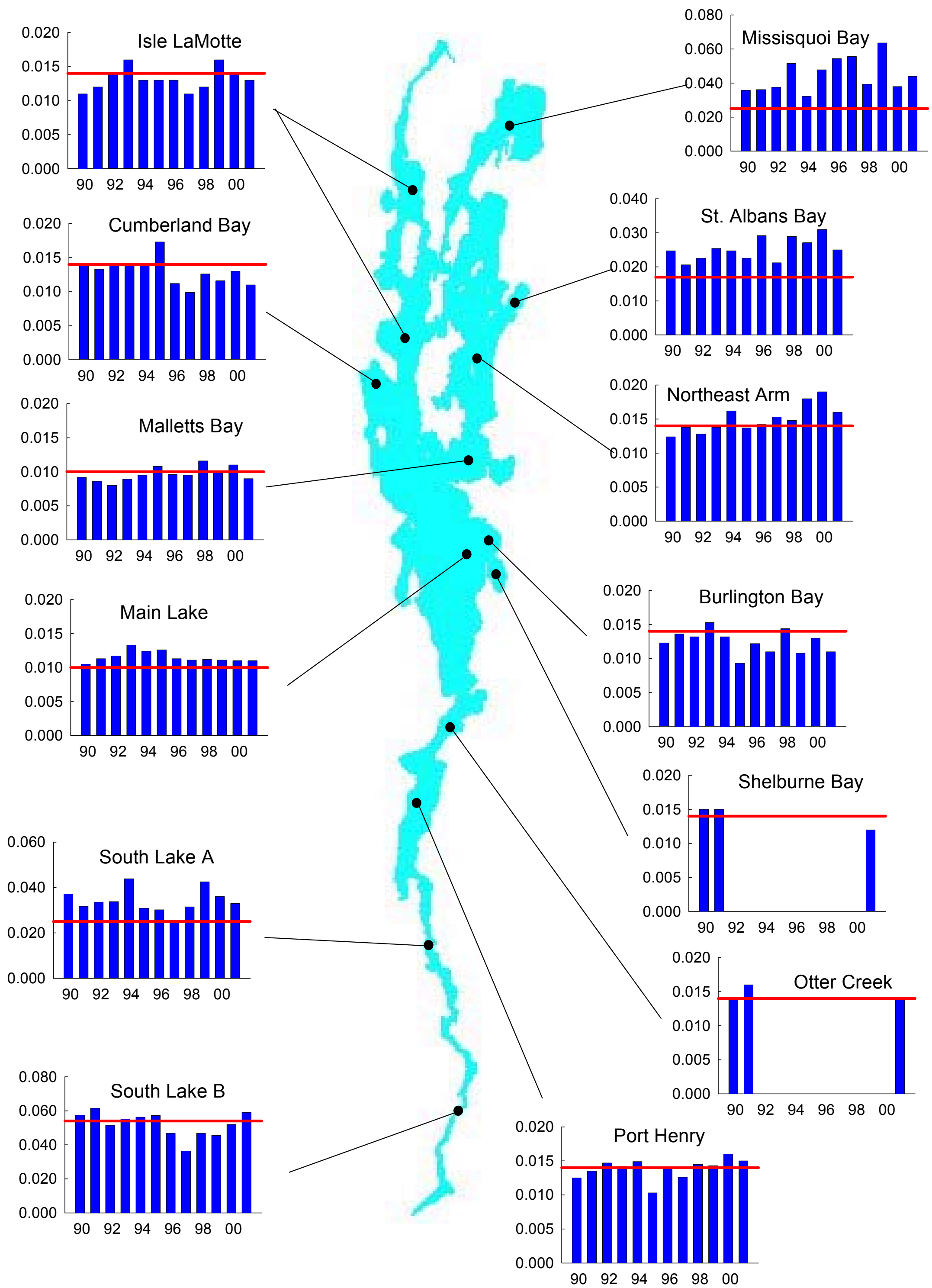

Figure 3. Annual mean total phosphorus concentrations (mg/l) in Lake Champlain segments during 1990-2001, in comparison with the in-lake criteria (horizontal lines). Data are from Vermont DEC and New York State DEC (2002).

TOTAL LOADING CAPACITY

Modeling Methods

A phosphorus mass balance model for Lake Champlain was developed by the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997). This model considered the circulation patterns within the lake, and established a predictive link between the in-lake total phosphorus concentrations and the phosphorus loading from each lake segment watershed.

The Lake Champlain phosphorus model was based on a modified version of the U.S. Army Corps of Engineers BATHTUB program (Walker 1987). The model used an annual steady-state approach with spatial segmentation that accounted for diffusive exchange mixing and advective transport of water and phosphorus between 13 lake segments (Vermont DEC and New York State DEC 1997, Smeltzer and Quinn 1996, Smeltzer 1999). The model was used to analyze alternative combinations of load reductions from each lake segment watershed in Vermont, Quebec, and New York, and to predict the load reductions required to attain the in-lake phosphorus criteria in each lake segment.

Some of the assumptions used in the phosphorus budget and modeling analysis are listed below, and are described in more detail in Vermont DEC and New York State DEC (1997).

- Vertical profile sampling confirmed that vertical phosphorus concentration gradients within the water column were generally much less pronounced than the spatial differences among lake segments. Therefore, it was appropriate to model each lake segment as a mixed reactor with vertically-averaged water column phosphorus concentrations.

- The tributary nonpoint source component was estimated by subtracting the point source loads from the total loads in each tributary. This procedure assumed that all phosphorus entering a stream is eventually conveyed to the river mouth. If significant quantities of phosphorus are permanently attenuated along the stream course (e.g., in sediments within impoundments), then this procedure will underestimate the relative proportion of nonpoint source loading in the total load observed at the river mouth.

- The model was calibrated using chloride and total phosphorus concentrations from a two-year data set (1990-1992). The model was not verified using data from an independent time period because the lake's phosphorus residence time indicated that the two-year survey period was too short to provide independent loading and lake response relationships between the two years. However, a good calibration fit between observed and modeled phosphorus concentrations in each lake segment was achieved using independently estimated sedimentation coefficients from Walker (1987) for all but three lake segments. The successful calibration of the model provides some level of confidence in its predicted results.

The model application to Lake Champlain included an error analysis of model prediction uncertainty. Statistical error estimates for model predictions were produced by the BATHTUB program and used to evaluate the probability of achieving the in-lake criteria with phosphorus loadings at their target values. Target loads were established for each lake segment watershed (with exceptions noted below) such that the mean values of the model-predicted phosphorus concentration probability distributions were equal to or less than the criteria for each lake segment (Vermont DEC and New York State DEC 1997).

Lake Champlain Management Conference Preliminary Allocations

The model was used to support an allocation of phosphorus reductions in Lake Champlain negotiated between the States of Vermont and New York and the USEPA. The resulting phosphorus reduction agreement was accepted by the Lake Champlain Management Conference and incorporated into the comprehensive plan document (Lake Champlain Management Conference 1996a). The watershed-based phosphorus loading targets presented in the Lake Champlain Management Conference plan were derived as follows.

Before applying the model, preliminary point source loading targets were first derived for each lake segment watershed in each state according to the procedure described in Lake Champlain Management Conference (1996a). Wastewater loads were calculated using the full permitted flows at each facility, or 1.5 times the 1995 average flow, whichever was less. An advanced treatment effluent phosphorus concentration of 0.8 mg/l was assumed for most facilities with design flows larger than 0.2 million gallons per day (mgd) in both the Vermont and New York portions of the basin.

Preliminary nonpoint source loading targets were derived using the lake phosphorus mass balance model (with point source loads at their preliminary target levels) to identify the remaining loading reductions necessary to achieve the in-lake phosphorus criteria in each lake segment. The mass balance model was used with a spreadsheet-based optimization procedure that found the minimum-cost combination of watershed nonpoint source loading targets that would achieve the in-lake criteria, as described in Vermont DEC and New York State DEC (1997). Information on the cost-effectiveness (dollars per kilogram P reduced annually) and maximum potential nonpoint source phosphorus reductions in each lake segment watershed was used to direct the optimization procedure.

The modeling analysis was conducted such that the predicted mean lake total phosphorus concentrations would be equal to or less than the in-lake criteria values, once the target loading rates were attained. The goal for the Missisquoi Bay segment (Table 2) was slightly relaxed in the preliminary modeling analysis from 0.025 to 0.027 mg/l because attainment of the 0.025 mg/l value would require nonpoint source load reductions in excess of the maximum potential reductions assumed in the procedure (Vermont DEC and New York State DEC 1997). However, the TMDL total loading capacity for Missisquoi Bay was based on full attainment of the actual criterion of 0.025 mg/l (see below).

The preliminary phosphorus loading targets established by the Lake Champlain Management Conference are listed in Table 3. The total allowable phosphorus load to Lake Champlain was found to be 439 mt/yr, including 319 mt/yr from Vermont (with Quebec) and 120 mt/yr from New York. This total allowable loading target represents a 30% reduction from the total watershed load of 631 mt/yr measured during the 1991 reference year (Table 3).

Under the Lake Champlain phosphorus reduction agreement (Lake Champlain Management Conference 1996a), the States of Vermont and New York retained the opportunity to adjust their point and nonpoint source loading targets for each watershed. If changes are made to the target loads, the lake phosphorus model must be used to verify that the adjusted loads will attain the in-lake criteria without affecting the loading targets for the other state.

Once the Lake Champlain Phosphorus TMDL is approved by the USEPA, any changes to the sum of the point source load allocations in a watershed, with corresponding changes to the sum of the nonpoint source load allocations, will require that a revised TMDL be submitted to the USEPA for approval. Such changes may be necessary, for example, if monitoring shows that water quality criteria or target loads are not likely to be attained within the 20-year time frame established by the Lake Champlain Management Conference (1996a). Changes to individual point source wasteload allocations made without affecting the sum of wasteload allocations in a lake segment watershed (or changes to individual nonpoint source load allocations without affecting the sum of load allocations) do not require USEPA approval.

TMDL Total Loading Capacity

Vermont

The preliminary loading targets established in the Lake Champlain Management Conference (1996a) plan served to establish an overall division of responsibility between Vermont and New York for phosphorus loading reduction. The Lake Champlain Management Conference plan was the result of a five-year process with extensive public involvement, and was approved by the Governors of Vermont and New York and the USEPA Regional Administrators. For this reason, the TMDL retains the <u>total</u> allowable loads for each lake segment watershed from the Lake Champlain Management Conference plan with only minimal modifications, as discussed below. However, the proposed balance of point vs. nonpoint source loading targets within the total allowable loads for the each watershed in Vermont was determined after further consideration by the Vermont DEC, following a public participation process during 2001-2002.

The Vermont DEC determined that one of the wasteload allocation alternatives considered in the initial draft of the TMDL should include the full, currently permitted loads at each Vermont wastewater treatment facility. The manner in which “currently permitted loads” were defined for the Vermont facilities for this purpose is explained in the section on Point Source Allocation Alternatives (below). Since the preliminary loading targets developed by the Lake Champlain Management Conference (1966a) were based on less than the full permitted wastewater loads in some cases, modification of the

Table 3. Lake Champlain Phosphorus TMDL total loading capacity, compared with 1991 measured loads and preliminary allocations (mt/yr) presented in the Lake Champlain Management Conference plan.

Lake Segment Watershed	1991 Measured Loads[1]			Preliminary Target Allocation[2]			TMDL Total Loading Capacity
	Point	Nonpoint	Total	Point	Nonpoint	Total	
Vermont							
South Lake B	3.2	24.8	28.0	1.5	19.3	20.8	20.8
South Lake A	0.1	2.4	2.4	0.1	0.6	0.6	0.6
Port Henry	0.0	0.4	0.4	0.0	0.1	0.1	0.1
Otter Creek	62.8	58.9	121.7	7.1	49.0	56.1	56.1
Main Lake	27.7	60.3	88.0	18.3	58.2	76.6	76.6
Shelburne Bay	5.3	11.1	16.4	0.9	11.0	12.0	12.0
Burlington Bay	11.2	0.3	11.5	2.8	0.3	3.1	5.8
Malletts Bay	3.1	29.8	32.9	2.6	26.1	28.6	28.6
Northeast Arm	0.0	3.2	3.2	0.0	1.2	1.2	1.2
St. Albans Bay	0.8	7.2	8.0	2.4	7.0	9.5	8.0
Missisquoi Bay	6.9[3]	94.2[3]	101.1[3]	5.3	104.4	109.7	58.3[4]
Isle LaMotte	0.0	0.6	0.6	0.0	0.3	0.3	0.3
	121.1	293.1	414.2	41.1	277.5	318.6	268.4
Quebec							
Missisquoi Bay	8.5[3]	57.7[3]	66.2[3]	(Included in Vermont Loads)			38.9[5]
Vermont/Quebec Total	129.6	350.8	480.4	41.1	277.5	318.6	307.3
New York							
South Lake B	3.9	24.3	28.2	1.9	24.3	26.2	23.9
South Lake A	9.6	3.5	13.1	7.4	2.0	9.4	11.2
Port Henry	1.8	2.6	4.3	0.7	1.8	2.5	3.4
Otter Creek	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Main Lake	7.1	31.8	38.9	4.3	30.8	35.0	33.7
Cumberland Bay	29.2	8.8	38.0	17.2	8.3	25.5	25.2
Isle LaMotte	7.4	20.9	28.3	2.0	19.5	21.5	22.3
	59.0	91.9	150.9	33.5	86.8	120.2	119.8
TOTAL	**188.5**	**442.7**	**631.3**[6]	**74.6**	**364.5**	**439.1**	**427.1**

[1] Vermont DEC and New York State DEC (1997)
[2] Lake Champlain Management Conference (1996a)
[3] Missisquoi Bay Phosphorus Reduction Task Force (2000)
[4] 60% of 97.2 mt/yr total loading capacity for Missisquoi Bay
[5] 40% of 97.2 mt/yr total loading capacity for Missisquoi Bay
[6] Value excludes precipitation direct to the lake surface.

total allowable load for one Vermont lake segment (Burlington Bay) was found to be necessary in order to accommodate the currently permitted load alternative.

The total loading capacity in the TMDL for Burlington Bay was increased from the value of 3.1 mt/yr given in the Lake Champlain Management Conference (1996a) plan to a total of 5.8 mt/yr (Table 3). The Vermont DEC determined that the TMDL wasteload allocation should include the option of allowing the full, currently permitted loads at each Vermont wastewater treatment facility. The revised value of 5.8 mt/yr includes the currently permitted point source load of 5.5 mt/yr from the Burlington Main facility, and the 0.3 mt/yr nonpoint source load specified in the Lake Champlain Management Conference plan. The lake phosphorus mass balance model (Vermont DEC and New York State DEC 1997) was used to verify that increasing the allowable load to the Burlington Bay segment to 5.8 mt/yr was consistent with attaining the in-lake criteria for that segment without affecting the allocations for any other lake segment watershed in Vermont or New York.

Preliminary technical review by the USEPA Region 1 of an earlier draft of the Vermont Lake Champlain Phosphorus TMDL document indicated that the total loading capacity for Missisquoi Bay also needed to be modified from the value of 109.7 mt/yr given in the Lake Champlain Management Conference (1966a) plan. The USEPA determined that the TMDL must specify loading capacities consistent with attaining the actual water quality criterion of 0.025 mg/l for Missisquoi Bay (Table 2), rather than the modified endpoint of 0.027 mg/l on which the loading targets in the Lake Champlain Management Conference Plan were based. The lake phosphorus mass balance model (Vermont DEC and New York State DEC 1997) was used to derive a revised total loading capacity of 97.2 mt/yr for Missisquoi Bay (Table 3), consistent with attaining the 0.025 mg/l criterion. Loading targets for the other lake segments were not affected by this change for Missisquoi Bay.

The Lake Champlain Management Conference (1996a) plan established a preliminary total target allocation of 9.5 mt/yr for St. Albans Bay, representing an increase over the measured 1991 loading rate of 8.0 mt/yr (Table 3). However, phosphorus levels in St. Albans Bay have not declined as expected after reductions in point source loadings were achieved in 1987. As discussed in a later section of this document, internal phosphorus loading from the bay's sediments appears to be the major reason for the continued elevated phosphorus concentrations in St. Albans Bay. Achieving water quality standards in St. Albans Bay will depend on reductions in internal phosphorus loading. However, it seems prudent to cap the allowable phosphorus loads to St. Albans Bay at their 1991 levels, rather than allow further increases in external loading, in order to accelerate and maintain the recovery of the bay. For this reason, the TMDL total loading capacity for St. Albans Bay was set at the 1991 rate of 8.0 mt/yr (Table 3).

The total loading capacities that will be used in the TMDL are listed for each Vermont lake segment watershed in Table 3. The phosphorus concentrations predicted for each lake segment after attainment of the TMDL total loading capacity values listed in Table 3 are compared with the in-lake criteria in Figure 4. Figure 4 shows that reducing phosphorus loads down to the TMDL target values should result in attainment of the in-lake criteria values in each lake segment. However, the error bars in

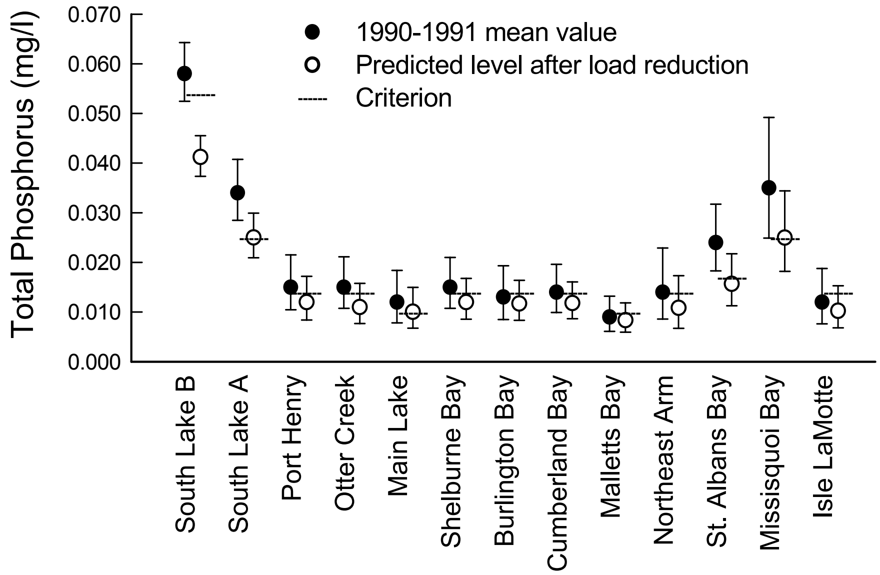

Figure 4. Predicted phosphorus concentrations in Lake Champlain segments following targeted load reductions, compared with 1991 measured mean levels and in-lake criteria values (from Table 2). Error bars show 95% confidence intervals for the existing mean and predicted phosphorus concentrations. The predicted concentrations and criteria values are listed below. (Figure modified from Vermont DEC and New York State DEC 1997.)

Lake Segment	Predicted Phosphorus Conc. (mg/l)	Criterion (mg/l)
South Lake B	0.040	0.054
South Lake A	0.025	0.025
Port Henry	0.012	0.014
Otter Creek	0.011	0.014
Main Lake	0.010	0.010
Shelburne Bay	0.012	0.014
Burlington Bay	0.012	0.014
Cumberland Bay	0.012	0.014
Malletts Bay	0.008	0.010
Northeast Arm	0.011	0.014
St. Albans Bay	0.015	0.017
Missisquoi Bay	0.025	0.025
Isle LaMotte	0.010	0.014

Figure 4 illustrate the degree of prediction uncertainty associated with the phosphorus mass balance model developed for Lake Champlain.

New York

A review of the preliminary target loads contained in the Lake Champlain Management Conference (1996a) plan revealed that the allocation between point and nonpoint sources did not always reflect loads which could be reasonably or economically achieved. Point source allocations were based on 1995 flow and loading data that did not necessarily represent actual long term conditions at the wastewater treatment facilities. This resulted in some plants being given allocations greater than required, while others were asked to achieve removals that would be difficult and expensive to attain. Further, New York felt that additional nonpoint source load reductions, over and above those contained in the plan, could be achieved. New York chose to recalculate the total loading targets for the New York watersheds. Loading targets for Vermont were not affected by the process.

The TMDL total loading capacity resulting from this procedure is shown for each New York lake segment in Table 3. The process resulted in a redistribution of the loading targets among some New York watersheds. Achievement of these loads will result in the attainment of the in-lake criteria in each of the lake segments. The balance between point and nonpoint sources is addressed in a later section.

Vermont and Quebec Agreement on Missisquoi Bay

Missisquoi Bay and its 1,200 square mile watershed are shared by Vermont and Quebec. The Lake Champlain Management Conference phosphorus reduction plan committed Vermont to seek a subsequent agreement with the Province of Quebec on a sharing of responsibility for achieving the loading target for Missisquoi Bay.

Vermont and Quebec formed a Missisquoi Bay Phosphorus Reduction Task Force in 1997. The purpose of the Task Force was to determine the amount of phosphorus loading that is derived from sources in Vermont and Quebec, and to recommend a fair division of responsibility for phosphorus reduction.

The report of the Missisquoi Bay Phosphorus Reduction Task Force (2000) recommended that the division of responsibility between Vermont and Quebec be based on their respective phosphorus loading contributions during the 1991 reference year. The Task Force relied on land use data and phosphorus export modeling by Hegman et al. (1999) to determine that Vermont contributed 60% of the 167.3 mt/yr phosphorus load to Missisquoi Bay during 1991, and Quebec contributed the remaining 40%. The Task Force recommended that the preliminary 109.7 mt/yr target load for Missisquoi Bay (Table 3) be divided by the same proportion, allocating 60% to Vermont and 40% to Quebec.

The Vermont DEC and the Quebec Ministry of the Environment have agreed to adopt the revised total loading capacity of 97.2 mt/yr for Missisquoi Bay in order to fully achieve the in-lake phosphorus concentration criterion of 0.025 mg/l. The revised loading target of 97.2 mt/yr will be divided between Vermont and Quebec using the same 60/40% basis proposed by the Missisquoi Bay Phosphorus Reduction Task Force (2000). The total loading capacities for Missisquoi Bay are 58.3 mt/yr (60%) for Vermont and 38.9 mt/yr (40%) for Quebec (Table 3). These allocations were formally adopted in an Agreement Concerning Phosphorus Reduction in Missisquoi Bay, signed by Vermont and Quebec in August, 2002 .

POINT SOURCE WASTELOAD ALLOCATION

Vermont Wasteload Allocation

Considerations and Requirements

The phosphorus wasteload allocations presented in the TMDL for Vermont point sources were based on several considerations and requirements. The first consideration was the need to refine the preliminary approach used by the Lake Champlain Management Conference (1996a) so that individual wasteload allocations are specified for each direct wastewater discharge to Lake Champlain or to a lake tributary. The Vermont DEC found that individual facility phosphorus allocations are necessary to guide the issuance of discharge permits, especially when facility expansions are being considered. Individual facility wasteload allocations are also supported by USEPA (1999a, 1999b) TMDL guidance.

The USEPA interprets 40 CFR 130.2(h) to mean that allocations for point source discharges subject to the requirement for a National Pollutant Discharge Elimination System (NPDES) permit must be included in the wasteload allocation portion of the TMDL. In addition to direct wastewater treatment facility discharges, the NPDES program includes the following other permit types in Vermont.

- Phase 2 municipal separate storm sewer system (MS4) permits
- Certain individual stormwater permits
- Discharge permits for combined sewer overflows (CSOs)
- General construction site stormwater permits
- General multi-sector stormwater permits
- Concentrated Animal Feeding Operation (CAFO) permits

Since sources such as CSOs and stormwater outfalls discharge to receiving waters via discreet conveyances, they are by definition point sources for regulatory purposes under the Clean Water Act. However, unlike domestic sewage or industrial wastewater, the stormwater-related sources listed above originate as nonpoint source runoff. Nonpoint source runoff is driven by brief and intermittent rainstorms or snowmelt events, and is highly variable in quantity and phosphorus content from one event to the next. Monitoring and accounting for phosphorus loads in stormwater runoff is technically difficult and expensive because of the variable nature of these events, making it difficult to assign and enforce facility-specific effluent limits. Data are not available from CSOs and stormwater outfalls to characterize their individual phosphorus loads for the purpose of the TMDL. Because of these monitoring difficulties and the geographic scale of the Lake Champlain Phosphorus TMDL, it was not technically feasible to separate the allocations for phosphorus sources requiring NPDES permits from more general nonpoint source load allocation categories based on land use.

The NPDES stormwater-related phosphorus sources listed above are included (except for CAFOs) in the general category of developed land sources, which also includes runoff from nonpoint sources such as residential areas, small construction sites, back roads, and erosion of streambanks and stream channels caused directly or indirectly by development of the landscape. Phosphorus loading from developed land can be estimated using land use and phosphorus export modeling methods. The base-year phosphorus loading to Lake Champlain from developed land sources was estimated using these modeling methods, and allocations for developed land, agricultural land, and forest land sources were derived for each lake segment watershed as described in the Vermont Load Allocation section of this document. The wasteload allocation portion of this TMDL includes a category for developed land sources, while recognizing that this category incorporates both point sources that require NPDES permits, and nonpoint sources that do not require such permits.

Stormwater and process water discharges from CAFOs are subject to NPDES permits and, therefore, require wasteload allocations. However, Vermont DEC, in conjunction with the Vermont Department of Agriculture, Food, and Markets, does not believe there are any farms in Vermont that currently require and NPDES permit, given that the state's Large Farm Operation Rules and Program are administered to ensure that large farms do not create a discharge below the 25-year/24-hour storm event. Any NPDES permits issued by the Vermont DEC for CAFOs in Vermont will eliminate and prohibit discharges to waters. Therefore, any CAFOs that may be identified in the future are given a wasteload allocation of zero in the Lake Champlain Phosphorus TMDL, with respect to discharges below the 25-year/24-hour storm event. Discharges from large farm operations during larger, more infrequent storm events are currently accounted for in the load allocation portion of the TMDL. If such facilities are identified in the future that require an NPDES permit, allocations for discharges above the 25-year/24-hour storm event will be considered to be wasteload allocations.

There are certain types of permitted discharges that are not included in the point source wasteload allocation portion of the Lake Champlain Phosphorus TMDL. Direct discharges that contain no significant amounts of phosphorus (e.g., well overflows, non-contact cooling water) are not included in the wasteload allocation. Large indirect discharge systems and certain septic systems require permits from the Vermont DEC. However, these sub-surface wastewater disposal systems all receive a very high degree of phosphorus removal treatment through soil contact, and are therefore not included as significant phosphorus sources in the wasteload allocation.

Wasteload allocations in Vermont must be conducted in a manner consistent with the Vermont Agency of Natural Resources Wasteload Allocation Process (Administrative Rule 87-46), adopted in 1987. This rule assumes that the total point source allocation is a fixed assimilative capacity determined by water quality modeling. The allocation process has previously been applied only for specific river reaches with no more than a few individual competing discharges. The rule was not designed for the situation that exists for the Lake Champlain Phosphorus TMDL where the balance between allowable point and nonpoint source loads is part of the allocation decision, and where the basin includes 48% of the area of Vermont and as many as 60 wastewater treatment facilities. However, the Wasteload Allocation Process was applied as closely as possible in developing wasteload allocation alternatives for the Lake Champlain Phosphorus TMDL.

Five wasteload allocation alternatives for wastewater treatment facilities were presented for public discussion in the June 22, 2001 Draft Vermont Lake Champlain Phosphorus TMDL, consistent with the Wasteload Allocation Process and the Vermont Water Quality Standards. The Vermont DEC considered the relative cost-effectiveness of these alternatives and public comments in developing the wasteload allocation portion of this TMDL.

Wastewater Treatment Facility Wasteload Allocations

The TMDL individual phosphorus wasteload allocations are listed for all 60 currently permitted Vermont facilities in Table 4. The total allocated load from Vermont facilities is 55.8 mt/yr, representing a 22.3 mt/yr reduction from the currently permitted load of 78.1 mt/yr (Table 4). The basis for calculating the currently permitted annual loads and for deriving the individual facility wasteload allocations is described below.

All phosphorus wasteload allocation values in this document are expressed in units of metric tons per year (as elemental P), consistent with previous reports and plans (Vermont DEC and New York State DEC 1997, Lake Champlain Management Conference 1996a). However, phosphorus load limits in discharge permits are generally given in units of pounds per day. To facilitate comparison, the following conversions may be used.

1.0 mt/yr = 1,000 kg/yr = 6.04 lbs/day

Currently Permitted Loads

A Vermont statute regulating discharges of phosphorus (10 V.S.A. §1266a) established a monthly average effluent phosphorus limit of 0.8 mg/l for wastewater treatment facilities in the Lake Champlain Basin. Facilities permitted prior to 1991 that discharge less than 0.2 mgd, and municipal aerated lagoon type wastewater treatment plants permitted prior to 1991, are exempt from the 0.8 mg/l limit. The 0.8 mg/l effluent limit currently applies to 29 Vermont municipal and industrial treatment facilities in the basin (Table 4). A limit of 1.0 mg/l has been established for five other facilities according to an earlier version of the same statute. Stricter effluent phosphorus limits are specified in the discharge permits for certain other facilities, based on site-specific considerations.

Currently permitted annual phosphorus loads were calculated as follows. For facilities with mass load limits (e.g., lbs/day) directly specified in their discharge permits, the specified load limits were used. For facilities with concentration limits (e.g., 0.8 mg/l) but no mass load limits, the currently permitted load was calculated from the permitted flow and the permitted concentration. For facilities with no phosphorus load or concentration limits in their permits, there was no established basis for calculating the currently permitted load. In these cases, the currently permitted load was calculated from the permitted flow and a default effluent phosphorus concentration. In most cases, a default phosphorus concentration of 5.0 mg/l was used, which is a value often assumed by Vermont DEC for planning purposes for secondary treatment facilities. A default value of 0.1 mg/l was used for the subsurface disposal system at Newport Center and for the Pittsford and Salisbury fish hatcheries. The permitted

Table 4. Vermont individual facility phosphorus wasteload allocations, compared with the currently permitted annual load.

Vermont Facility	Lake Segment	Current Permit Flow Limit (mgd)	Current Permit Conc. Limit (mg/l)	Current Permit Load Limit (lbs/day)	Default Conc. Limit (mg/l)	Currently Permitted Annual Load (mt/yr)	TMDL Wasteload Allocation (mt/yr)	Reduction in Permitted Load (mt/yr)
Alburg	Isle LaMotte	0.130	1.0			0.180	0.108	0.072
Barre City	Main Lake	4.000	0.8	22.7		3.759	3.314	0.445
Benson	South Lake B	0.018			5.0	0.122	0.122	
Brandon	Otter Creek	0.700	0.8	4.7		0.778	0.580	0.198
Brown Ledge Camp	Malletts Bay	0.004	1.0			0.005	0.005	
Burlington East	Main Lake	1.200	0.8	8.0		1.325	0.994	0.330
Burlington Electric	Main Lake	0.125	0.1	0.1		0.017	0.017	
Burlington Main	Burlington Bay	5.300	0.8	33.4		5.531	4.392	1.139
Burlington North	Main Lake	2.000	0.8	13.3		2.202	1.657	0.545
Cabot	Main Lake	0.050	0.8	0.3		0.055	0.041	0.013
Castleton	South Lake B	0.480	0.8	2.4		0.397	0.397	
Enosburg Falls	Missisquoi Bay	0.450	0.8	3.0		0.497	0.373	0.124
Essex Junction	Main Lake	3.100	0.8	18.4		3.047	2.569	0.478
Fair Haven	South Lake B	0.500	0.8	3.3		0.546	0.414	0.132
Fairfax	Malletts Bay	0.078			5.0	0.539	0.539	
Hardwick	Malletts Bay	0.371			5.0	2.562	0.410	2.152
Hinesburg	Shelburne Bay	0.250	1.0	2.1		0.348	0.276	0.072
IBM	Main Lake	8.000	0.8	33.4		5.531	5.531	
Jeffersonville	Malletts Bay	0.077			5.0	0.532	0.532	
Johnson	Malletts Bay	0.270	0.8	1.8		0.298	0.224	0.074
Marshfield	Main Lake	0.045			5.0	0.311	0.311	
Middlebury	Otter Creek	2.200	0.8	14.7		2.434	1.823	0.611
Milton	Malletts Bay	1.000	0.8	6.7		1.110	0.829	0.281
Montpelier	Main Lake	3.970	0.8	26.5		4.388	3.290	1.099
Morrisville	Malletts Bay	0.425	0.8	2.8		0.464	0.352	0.112
Newport Center	Missisquoi Bay	0.042			0.1	0.006	0.006	
North Troy	Missisquoi Bay	0.110			5.0	0.760	0.760	
Northfield	Main Lake	1.000	0.8	6.78		1.123	0.829	0.294
Northwest State Correctional	St. Albans Bay	0.040	0.5			0.028	0.028	
Orwell	South Lake A	0.033			5.0	0.228	0.228	
Otter Valley Union High School	Otter Creek	0.025			5.0	0.173	0.173	
Pittsford	Otter Creek	0.070			5.0	0.483	0.483	
Pittsford Fish Culture Station	Otter Creek	5.000			0.1	0.691	0.691	
Plainfield	Main Lake	0.100			5.0	0.691	0.691	
Poultney	South Lake B	0.500	0.8	2.64		0.437	0.414	0.023
Proctor	Otter Creek	0.325			5.0	2.244	0.359	1.885
Richford	Missisquoi Bay	0.380			5.0	2.624	0.420	2.204
Richmond	Main Lake	0.222	0.8	1.48		0.245	0.184	0.061
Rock Tenn	Missisquoi Bay	3.500	0.8	21.0		3.478	1.260	2.218
Rutland City	Otter Creek	6.800	0.8	45.4		7.518	5.634	1.884
Salisbury Fish Culture Station	Otter Creek	1.310			0.1	0.181	0.181	
Shelburne #1	Shelburne Bay	0.440	0.8	2.1		0.348	0.348	
Shelburne #2	Shelburne Bay	0.660	0.8	3.0		0.497	0.497	
Sheldon Springs	Missisquoi Bay	0.054			5.0	0.373	0.373	
Shoreham	Otter Creek	0.035			5.0	0.242	0.242	
South Burlington Airport Park.	Main Lake	2.300	0.8	15.3		2.534	1.906	0.628
South Burlington Bart. Bay	Shelburne Bay	1.250	0.8	5.3		0.878	0.878	
St. Albans City	St. Albans Bay	4.000	0.5			2.762	2.762	
Stowe	Main Lake	1.000	0.8	1.7		0.282	0.282	
Swanton	Missisquoi Bay	0.900	1.0	7.5		1.242	0.746	0.496
Troy/Jay	Missisquoi Bay	0.200			5.0	1.381	0.221	1.160
Vergennes	Otter Creek	0.750	1.0	5.5		0.911	0.621	0.289
Wallingford	Otter Creek	0.120			5.0	0.829	0.829	
Waterbury	Main Lake	0.510			5.0	3.522	0.563	2.958
Weed Fish Culture Station	Main Lake	11.500		5.52		0.914	0.914	
West Pawlet	South Lake B	0.040			5.0	0.276	0.276	
West Rutland	Otter Creek	0.450	0.8	2.2		0.364	0.364	
Williamstown	Main Lake	0.150			5.0	1.036	1.036	
Winooski	Main Lake	1.400	0.8	8.0		1.325	1.160	0.165
Wyeth	Malletts Bay	0.425	0.78	3.0		0.497	0.352	0.145
TOTAL						**78.1**	**55.8**	**22.3**

flows, concentration limits, mass loading limits, and default concentration values applied to each facility are given in Table 4.

Individual Facility Wasteload Allocations

This TMDL proposes two changes to the current phosphorus removal policy for Vermont wastewater treatment facilities. The first change is that the statutory exemption for aerated lagoon plants should be removed in 10 V.S.A. §1266a. The following eight municipal aerated lagoon facilities with greater than 0.2 mgd permitted flow that are now exempt from the 0.8 mg/l treatment requirement will be required to remove phosphorus to 0.8 mg/l on a monthly average basis.

Hardwick	Richford	Vergennes*
Hinesburg*	Swanton*	Waterbury
Proctor	Troy/Jay	

* These facilities are already required to remove phosphorus to 1.0 mg/l.

The second change will apply an annual average load limit, calculated at an effluent phosphorus concentration of 0.6 mg/l at the currently permitted flow, to all facilities that are currently required to achieve a 0.8 mg/l limit. The 0.6 mg/l concentration value would not be specified directly in the discharge permits, but would be used as a basis for calculating the annual load limits. The annual load limit based on a 0.6 mg/l effluent concentration value will also apply to three facilities (Alburg, Swanton, and Vergennes) that are currently exempt from the 0.8 mg/l requirement, but have permit limits of 1.0 mg/l as a monthly average. These three facilities have equipment in place or planned that will allow them to achieve the annual load limit based on 0.6 mg/l at minimal additional cost. This second change will affect the following 25 facilities.

Alburg	Essex Junction	Poultney
Barre City	Fair Haven	Richmond
Brandon	Johnson	Rock Tenn*
Burlington East	Middlebury	Rutland City
Burlington Main	Milton	South Burlington Airport Park.
Burlington North	Montpelier	Swanton
Cabot	Morrisville	Vergennes
Enosburg Falls	Northfield	Winooski
		Wyeth

* The annual load limit for Rock Tenn was calculated using a reduced flow rate because the permitted flow of 3.5 mgd greatly exceeds the current and anticipated future water use needs at this facility.

The following nine facilities have phosphorus limits in their current discharge permits that restrict them to loads less than the annual load at 0.6 mg/l. These facilities will retain their currently permitted loads in the wasteload allocation.

Castleton	Stowe	Shelburne #2
West Rutland	Weed Fish Culture Station	South Burlington Bartletts Bay
IBM	Shelburne #1	St. Albans City

Growth in Wastewater Loads

USEPA regulations indicate that TMDLs should consider future, as well as existing point and nonpoint sources. The Vermont Wasteload Allocation Process requires that future population growth be considered in establishing wasteload allocations. Capacity for future growth in wastewater flows is built into the design and permitting of wastewater treatment facilities, and future growth capacity is therefore included in the individual facility wasteload allocations listed in Table 4.

The allowance made within the TMDL wasteload allocation for future increases in wastewater flows and phosphorus loads can be assessed by comparing the permitted flows and the phosphorus wasteload allocations for each facility (Table 4) with their current discharge rates. Table 5 shows the actual flows and phosphorus loads discharged by each Vermont facility during 2001 in comparison with levels that are permitted under the TMDL. The 2001 data for each facility were obtained from monthly effluent monitoring reports submitted to the Vermont DEC. Phosphorus monitoring was not conducted at six of the facilities during 2001, and loads for these six plants were estimated using the default phosphorus concentrations given in Table 4.

The total wastewater flow rate from all 60 Vermont facilities during 2001 was 42.1 mgd (Table 5), in comparison with the total permitted flow of 80.4 mgd. This means that the existing discharge permits on which the TMDL is based allow for an overall increase in wastewater flows of 91% beyond current levels. Nearly all facilities have enough unused flow capacity to grow more than 50% above their 2001 discharge rates.

The actual 2001 phosphorus load discharged from all Vermont facilities was 33.5 mt/yr (Table 5), in comparison with the total TMDL wasteload allocation of 55.8 mt/yr. The difference between the allocated loads and the actually discharged phosphorus loads will be greater than the 22.3 mt/yr indicated in Table 5 when phosphorus removal upgrades are completed at some facilities as required to achieve the TMDL wasteload allocation.

In contrast with the substantial allowances for future wastewater flow increases, population growth within the basin is likely to occur at much lower rates. For example, the percentage changes between 1990 and 2000 in the population of the six Vermont counties containing nearly all of the wastewater discharges to Lake Champlain are shown below (U.S. Census data). Growth in population ranged from 2-18% over this past decade.

Table 5. Comparison of actual flows and phosphorus loading rates for Vermont wastewater treatment facilities during 2001 with permitted flows and TMDL wasteload allocations.

Vermont Facility	Permitted Flow (mgd)	Actual 2001 Flow (mgd)	TMDL Wasteload Allocation (mt/yr)	Actual 2001 Load (mt//yr)
Alburg	0.130	0.020	0.108	0.003
Barre City	4.000	2.134	3.314	0.354
Benson	0.018	0.010	0.122	0.070
Brandon	0.700	0.299	0.580	0.123
Brown Ledge Camp	0.004	0.002	0.005	0.003
Burlington East	1.200	0.746	0.994	0.493
Burlington Electric	0.125	0.025	0.017	0.004
Burlington Main	5.300	4.020	4.392	2.993
Burlington North	2.000	0.959	1.657	0.570
Cabot	0.050	0.004	0.041	0.003
Castleton	0.480	0.277	0.397	0.063
Enosburg Falls	0.450	0.181	0.373	0.102
Essex Junction	3.100	1.589	2.569	1.190
Fair Haven	0.500	0.283	0.414	0.365
Fairfax	0.078	0.039	0.539	0.333
Hardwick	0.371	0.166	0.410	0.792
Hinesburg	0.250	0.144	0.276	0.091
IBM	8.000	3.878	5.531	2.819
Jeffersonville	0.077	0.046	0.532	0.362
Johnson	0.270	0.130	0.224	0.061
Marshfield	0.045	0.018	0.311	0.126
Middlebury	2.200	0.923	1.823	1.285
Milton	1.000	0.157	0.829	0.669
Montpelier	3.970	1.724	3.290	4.900
Morrisville	0.425	0.306	0.352	0.206
Newport Center	0.042	0.004	0.006	0.001
North Troy	0.110	0.084	0.760	0.163
Northfield	1.000	0.487	0.829	2.066
Northwest State Correctional	0.040	0.026	0.028	0.004
Orwell	0.033	0.008	0.228	0.071
Otter Valley Union High School	0.025	0.006	0.173	0.040
Pittsford	0.070	0.050	0.483	0.117
Pittsford Fish Culture Station	5.000	1.475	0.691	0.204
Plainfield	0.100	0.062	0.691	0.127
Poultney	0.500	0.330	0.414	1.096
Proctor	0.325	0.187	0.359	1.291
Richford	0.380	0.199	0.420	0.808
Richmond	0.222	0.116	0.184	0.227
Rock Tenn	3.500	0.282	1.260	0.252
Rutland City	6.800	4.905	5.634	2.145
Salisbury Fish Culture Station	1.310	0.864	0.181	0.026
Shelburne #1	0.440	0.294	0.348	0.328
Shelburne #2	0.660	0.256	0.497	0.178
Sheldon Springs	0.054	0.019	0.373	0.053
Shoreham	0.035	0.004	0.242	0.028
South Burlington Airport Park.	2.300	1.341	1.906	1.170
South Burlington Bart. Bay	1.250	0.544	0.878	0.246
St. Albans City	4.000	2.399	2.762	0.480
Stowe	1.000	0.182	0.282	0.060
Swanton	0.900	0.329	0.746	0.240
Troy/Jay	0.200	0.029	0.221	0.110
Vergennes	0.750	0.340	0.621	0.231
Wallingford	0.120	0.099	0.829	0.301
Waterbury	0.510	0.299	0.563	2.041
Weed Fish Culture Station	11.500	7.688	0.914	0.433
West Pawlet	0.040	0.014	0.276	0.097
West Rutland	0.450	0.194	0.364	0.051
Williamstown	0.150	0.083	1.036	0.517
Winooski	1.400	0.681	1.160	0.342
Wyeth	0.425	0.123	0.352	0.009
TOTAL	**80.4**	**42.1**	**55.8**	**33.5**

Vermont County	Percent Population Increase 1990-2000
Addison	9.2
Chittenden	11.2
Franklin	13.6
Lamoille	17.7
Rutland	2.0
Washington	6.3

Population growth is not the only factor that drives increases in wastewater flows, but it is an important indicator of wastewater flow needs. Allowances in the TMDL for increases in wastewater flows and phosphorus loads are much greater than the population growth rates that might be anticipated between now and the 2016 phosphorus reduction target date established by the Lake Champlain Management Conference (1996a).

This comparison indicates that there is no essential need to add a growth allowance to the TMDL wasteload allocation to accommodate future increases in wastewater flows. If a local economic development created the need to expand the size of a treatment facility or to build a new facility, there appears to be room within the total wasteload allowances for a reallocation of the permitted phosphorus loads among the various discharges within the same lake segment watershed. Such a reallocation or trade to accommodate a new or increased discharge is allowed under the Vermont Wasteload Allocation Process, with oversight by the Vermont Agency of Natural Resources.

There are other options available to accommodate flow expansions at wastewater treatment facilities without altering the wasteload allocation. It is often possible through operational adjustments to reduce the effluent phosphorus concentration in proportion to the permitted flow increase so that the permitted load remains the same. Several Vermont municipalities seeking wastewater flow expansions (e.g., Shelburne, South Burlington, Stowe, and others) have already adopted this option through permit modifications in order to comply with the "*no significant increase over currently permitted phosphorus loadings*" provision of the Vermont Water Quality Standards (Section 3-01 B.2.c.2).

Developed Land Wasteload Allocations

The wasteload allocations for developed land sources in each lake segment watershed are given in Table 6. The allocations for developed land sources were derived from a land use and phosphorus export modeling analysis, as described in the Vermont Load Allocation section of this TMDL document. The developed land wasteload allocation category includes all stormwater discharges requiring NPDES permits, other state-permitted stormwater discharges, and nonpoint source loads from residential and other developed areas, backroads, small construction sites, and erosion of stream banks and stream channels caused directly or indirectly by land development in the watershed.

Table 6. Vermont wasteload allocation summary.

Lake Segment	Wasteload Allocation for Wastewater Treatment Facilities[1]	Wasteload Allocation for Developed Land Sources[2]	Total Wasteload Allocation
South Lake B	1.62	8.8	10.4
South Lake A	0.23	0.1	0.3
Port Henry	0.00	0.0	0.0
Otter Creek	11.98	16.6	28.6
Main Lake	25.29	36.8	62.1
Shelburne Bay	2.00	8.9	10.9
Burlington Bay	4.39	1.4	5.8
Malletts Bay	3.24	12.0	15.3
Northeast Arm	0.00	0.2	0.2
St. Albans Bay	2.79	1.0	3.8
Missisquoi Bay	4.16	8.2	12.4
Isle LaMotte	0.11	0.1	0.2
Total	**55.8**	**94.0**	**149.8**

[1] From Table 4.

[2] Includes all stormwater discharges requiring NPDES permits, other state-permitted stormwater discharges, and nonpoint source loads from residential and other developed areas, backroads, small construction sites, and erosion of stream banks and stream channels caused directly or indirectly by land development in the watershed. (See Vermont Load Allocation section for derivation of allocation values for developed land sources.)

New York Wasteload Allocation

Considerations and Requirements

In the currently effective regulations, wasteload allocations (WLAs) are allocated to point sources and load allocations (LAs) are attributed to nonpoint sources and background. In some cases, storm water may be regulated through the National Pollutant Discharge Elimination System (NPDES) point source permitting program. In addition, combined sewer overflows (CSOs) are regulated through NPDES point source permits. NYSDEC understands that USEPA's position is that NPDES-regulated discharges of storm water are to be included within the WLA component of the TMDL. However, no direct sampling of storm water outfalls or CSOs was conducted as part of the monitoring study used to support the TMDL. Therefore, the TMDL establishes a general LA for runoff from "urban land." The urban land LA can be best characterized as predominantly unregulated runoff and a relatively small portion of runoff from CSOs, and construction and industrial activities subject to the NPDES storm water permitting program.

The New York portion of the Lake Champlain watershed does not contain any Phase I or Phase II municipal separate storm water sewer systems (MS4s) that would be subject to NPDES permits and, therefore, included in a WLA. Although the CSOs and the discharges of storm water from construction and industrial activities were not included in the WLA, New York State DEC acknowledges that allocations for these regulated discharges of storm water appropriately should be considered to be WLAs. The New York State DEC intends to treat these allocations as WLAs during implementation of the TMDL. The New York State DEC has issued permits which include conditions, that through implementation, will reduce phosphorus loads to the lake. CSO permits have been, and will be issued with implementation schedules that require the development of Long Term Control Plans (LTCPs), including monitoring, the development of inflow/infiltration (I/I) reduction studies, and implementation of the CSO best management practices (BMPs). We anticipate that the implementation of the CSO conditions will reduce the frequency and duration of the discharges from the CSOs, thereby reducing the phosphorus loads from the CSOs. The New York State DEC has issued storm water general permits which require development and implementation of storm water pollution prevention plans for discharges from construction and industrial activities. These plans must include BMPs to prevent the discharge of pollutants in storm water runoff.

Storm water and process water discharges from Concentrated Animal Feeding Operations (CAFOs) are subject to NPDES permits and, therefore, require WLAs. New York's portion of the Lake Champlain watershed does contain CAFOs which would be included in a WLA. New York's permits do not allow any discharge from CAFOs below the 25-year/24-hour storm event. Therefore, the WLA for discharges from CAFOs below that storm event is zero. Discharges from CAFOs during larger, more infrequent storm events are accounted for in the LA portion of the TMDL. New York State DEC acknowledges that the allocations for these regulated discharges appropriately should be considered to be WLAs. The New York State DEC intends to treat these allocations as WLAs during implementation of the TMDL.

Wastewater Treatment Facility Wasteload Allocations

The basis for the initial TMDL limits are the point source target loads contained in Appendix C of the Lake Champlain Management Conference (1996a) plan. These target loads were defined as follows.

1. For all facilities, the point source wasteload allocation (WLA) was calculated using either the permitted flow or 1.5 times the 1995 flow, whichever was less.

2. For facilities with a design flow less than 0.2 mgd or for facilities greater than 0.2 mgd but with lagoon treatment units, the WLA load was calculated using the 1995 average effluent phosphorus concentration.

3. For facilities with design flows exceeding 0.2 mgd, the WLA was calculated using the 1995 phosphorus concentration or 0.8 mg/l, whichever was less.

Several factors combined to induce New York to change the preliminary WLA.

1. The 1995 flows and effluent phosphorus concentrations were not indicative of the longer term conditions at all plants.

2. New York was of the opinion that the overall nonpoint source load allocation contained in the Lake Champlain Management Conference (1996a) plan could be reduced slightly. This freed up some additional load for point sources in the New York portion of the basin (see nonpoint source discussion below).

These factors resulted in the following changes to the New York wasteload allocations. The 1995 flow used to calculate the allocation for the Willsboro facility was estimated at twice the actual value. The WLA was recalculated using the correct flow. The preliminary allocation for the Adirondack Fish Culture Station was determined prior to the new permit. The current allocation reflects the permit limit. Year 2000 Discharge Monitoring Report (DMR) data indicate that both facilities can easily meet the reduced WLAs. WLAs for Ticonderoga, Westport, Peru, Peru/Valcour, Champlain, Rouses Point and Wyeth-Ayerst (Chazy) were revised based on 1999-2000 DMR and regional sampling data. Two new plants at Cadyville and Chazy were added to the WLA. The individual WLA for Cadyville reflects their current DMR results, while Chazy's WLA is set equal to its existing permit limit. The WLAs for the remaining point sources were left unchanged from those contained in the management plan.

Table 7 contains the individual wasteload allocations for each of the New York point sources. A comparison between the WLA and the current phosphorus load for each plant in the New York portion of the basin is shown in Table 8.

Table 7. New York point source wasteload allocation (WLA).

Point Source Discharge	Wasteload Allocation Load (mt/yr)	Wasteload Allocation Concentration (mg/l @ design flow)
South Lake B		
Fort Ann	0.22	1.45
Granville	0.72	0.80
Great Meadows Correctional	0.28	0.50
Washington Correctional	0.12	0.35
Whitehall	0.60	0.72
Segment Total	**1.94**	
South Lake A		
Crown Point	0.09	1.05
International Paper Co.	6.34	0.27
Ticonderoga	1.47	0.71
Segment Total	**7.90**	
Port Henry/Otter Creek		
Port Henry	0.49	0.80
Westport	0.40	2.40
Segment Total	**0.89**	
Main Lake		
Ausable Forks	0.74	3.60
Keeseville	0.33	0.80
Lake Placid	2.16	0.62
Peru	0.61	0.89
Peru/Valcour	0.01	0.13
Wadhams	0.04	1.90
Willsboro	0.33	1.90
Segment Total	**4.22**	
Cumberland Bay		
Adirondak Fish Cultural Sta.	0.08	0.02
Cadyville	0.04	5.00
Dannemora	3.36	1.60
Plattsburgh	10.85	0.49
Champlain Park	0.29	1.30
Saranac Lake	2.24	0.58
St. Armand	0.28	3.40
Segment Total	**17.12**	
Isle LaMotte		
Altona Correctional	0.08	0.71
Champlain	0.57	1.03
Chazy	0.10	0.80
Rouses Point	2.61	0.95
Wyeth-Ayerst, Chazy	0.08	0.60
Segment Total	**3.43**	
TOTAL	**35.50**	

Table 8. New York point source wasteload allocation (WLA) vs. current load.

Point Source Discharge	**Wasteload Allocation (mt/yr)**	**Wasteload Allocation (lbs/day)**	**Current Load (lbs/day)**	**Bond Act Grant**
South Lake B				
Fort Ann	0.22	1.33	0.81	
Granville	0.72	4.30	14.20	Yes
Great Meadows Correctional	0.28	1.67	0.60	
Washington Correctional	0.12	0.72	0.22	
Whitehall	0.60	3.60	5.60	Yes
Segment Total	**1.94**	**11.62**	**21.43**	
South Lake A				
Crown Point	0.09	0.53	0.29	
International Paper Co.	6.34	38.30	37.50	
Ticonderoga	1.47	8.90	8.90	
Segment Total	**7.90**	**47.73**	**46.70**	
Port Henry/Otter Creek				
Port Henry	0.49	2.94	16.00	Yes
Westport	0.40	2.40	2.40	
Segment Total	**0.89**	**5.34**	**18.40**	
Main Lake				
Ausable Forks	0.74	4.47	2.17	
Keeseville	0.33	2.00	8.65	Yes
Lake Placid	2.16	13.00	24.50	
Peru	0.61	3.70	3.70	
Peru/Valcour	0.01	0.05	0.03	
Wadhams	0.04	0.24	0.18	
Willsboro	0.33	2.00	0.98	Yes
Segment Total	**4.22**	**25.44**	**40.20**	
Cumberland Bay				
Adirondak Fish Cultural Sta.	0.08	0.45	0.11	
Cadyville	0.04	0.25	0.13	
Dannemora	3.36	20.30	19.05	
Plattsburgh	10.85	65.50	50.10	
Champlain Park	0.29	1.75	1.70	
Saranac Lake	2.24	13.50	9.50	
St. Armand	0.28	1.70	1.00	
Segment Total	**17.12**	**103.45**	**81.60**	
Isle LaMotte				
Altona Correctional	0.08	0.50	0.57	
Champlain	0.57	3.45	3.45	
Chazy	0.10	0.60		
Rouses Point	2.61	15.78	15.78	
Wyeth-Ayerst, Chazy	0.07	0.40	0.40	
Segment Total	**3.43**	**20.73**	**20.20**	

[1] Current Load - Data from plant DMR's and/or regional sampling. When data from both sources were available the average value was used.

NONPOINT SOURCE LOAD ALLOCATION

Vermont Load Allocation

Total nonpoint source load allocations for each Vermont lake segment watershed were calculated by subtracting the wasteload allocations for wastewater discharges in each watershed (Table 6) from the TMDL total loading capacities (Table 3). Developed land phosphorus sources are treated as nonpoint sources in this section for the purpose of deriving load allocations for the other land use categories (forest and agriculture). However, developed land sources (which include a mixture of point and nonpoint sources) were ultimately placed on the wasteload allocation side of the TMDL, based on the considerations and requirements discussed in the Vermont Wasteload Allocation section of this document.

The developed land category includes all stormwater discharges requiring NPDES permits, other state-permitted stormwater discharges, and nonpoint source loads from residential and other developed areas, backroads, small construction sites, and erosion of stream banks and stream channels caused directly or indirectly by land development in the watershed. The forest category includes naturally occurring background loadings, as well as nonpoint source runoff from forests where harvesting and associated road-building is occurring.

The basis for subdividing the load allocation into individual land use categories was as follows. Phosphorus loads allocated to forest land (including natural background) were held at their 1991 baseline levels. Loads allocated to agricultural and developed lands were reduced by equal proportions from their 1991 baseline levels to meet the total load allocation for each lake segment watershed.

The proportions of the 1991 baseline nonpoint source loads attributed to each land use category were estimated using the Lake Champlain Basin land use and land cover data set (ca. 1993) documented by Millette (1997), and the phosphorus export modeling analysis of Hegman et al. (1999). The loading function model (with animal unit corrections) developed by Hegman et al. (1999) was used to estimate the proportions of the total 1991 nonpoint source loads derived from each land use category in each lake segment watershed. These proportions were applied to the 1991 nonpoint source loads measured by Vermont DEC and New York State DEC (1997) as shown in Table 9.

The allocations assigned in the TMDL to each land use category are shown in Table 10. Table 10 also provides an overall summary of the wasteload allocations and the load allocations developed for the Vermont portion of the Lake Champlain Phosphorus TMDL. The 1991 agricultural and developed land loads estimated for each lake segment watershed (Table 9) were reduced by equal proportions until the total allowable loads were attained. The allocations presented in Table 10 do not require any net reductions in forest loads below the 1991 baseline levels.

Table 9. Proportions of the 1991 nonpoint source phosphorus loads derived from each land use category in the Vermont portion of each lake segment watershed.

Vermont Lake Segment Watershed	1991 Total Nonpoint Load (mt/yr)[1]	Forest Load Percent[3]	Agric. Load Percent[3]	Developed Load Percent[3]	1991 Forest Load (mt/yr)	1991 Agric. Load (mt/yr)	1991 Developed Load (mt/yr)
South Lake B	24.8	11.2%	41.4%	47.5%	2.8	10.3	11.8
South Lake A	2.4	2.4%	79.0%	18.6%	0.06	1.9	0.44
Port Henry	0.38	1.2%	75.4%	23.4%	0.00	0.29	0.09
Otter Creek	58.9	6.9%	54.5%	38.6%	4.1	32.1	22.7
Main Lake	60.3	9.6%	17.4%	73.0%	5.8	10.5	44.0
Shelburne Bay	11.1	2.0%	8.7%	89.3%	0.22	1.0	9.9
Burlington Bay	0.27	0.1%	0.3%	99.7%	0.00	0.00	0.27
Malletts Bay	29.8	8.1%	43.7%	48.2%	2.4	13.1	14.4
Northeast Arm	3.2	1.6%	82.0%	16.4%	0.05	2.6	0.52
St. Albans Bay	7.2	0.8%	80.0%	19.3%	0.06	5.8	1.4
Missisquoi Bay	94.2[2]	3.4%	81.1%	15.5%	3.2	76.4	14.6
Isle LaMotte	0.56	2.3%	68.2%	29.6%	0.01	0.38	0.17
TOTAL	**293.1**				**18.7**	**154.1**	**120.3**

[1] Vermont DEC and New York State DEC (1997)
[2] Missisquoi Bay Phosphorus Reduction Task Force (2000)
[3] Hegman et al. (1999) and Hegman, pers. comm. 12/18/00.

Table 10. Summary of Vermont wasteload allocations and load allocations (mt/yr).

Lake Segment	Total Loading Capacity[1]	Wastewater Wasteload Allocation[2]	Developed Land Wasteload Allocation	Total Wasteload Allocation	Agric. Load Allocation	Forest Load Allocation	Other Load Allocation	Total Load Allocation
South Lake B	20.8	1.6	8.8	10.4	7.6	2.8		10.4
South Lake A	0.6	0.2	0.1	0.3	0.3	0.1		0.3
Port Henry	0.1	0.0	0.0	0.0	0.1	0.0		0.1
Otter Creek	56.1	12.0	16.6	28.6	23.4	4.1		27.5
Main Lake	76.6	25.3	36.8	62.1	8.7	5.8		14.5
Shelburne Bay	12.0	2.0	8.9	10.9	0.9	0.2		1.1
Burlington Bay	5.8	4.4	1.4	5.8	0.0	0.0		0.0
Malletts Bay	28.6	3.2	12.0	15.3	10.9	2.4		13.3
Northeast Arm	1.2	0.0	0.2	0.2	1.0	0.1		1.0
St. Albans Bay	8.0	2.8	1.0	3.8	4.2	0.1		4.2
Missisquoi Bay	58.3	4.2	8.2	12.4	31.2	3.2	11.5	45.9
Isle LaMotte	0.3	0.1	0.1	0.2	0.1	0.0		0.1
Total	**268.4**	**55.8**	**94.0**	**149.8**	**88.4**	**18.7**	**11.5**	**118.6**

[1] From Table 3.
[2] From Table 6.

The load allocations for each land use category were expressed in Table 11 as load reductions required, relative to the 1991 loads. The load reduction responsibilities given in Table 11 were calculated by subtracting the load allocations (Table 10) from the 1991 loads (Table 9) for each land use category. Table 11 shows that total nonpoint source loads (including the developed land category) from Vermont must be reduced overall by 80.5 mt/yr (27%) from their 1991 levels A fourth ("other") category of nonpoint sources was created in Tables 10 and 11 for the allocation for the Missisquoi Bay watershed, for reasons discussed below.

A large portion of the total Vermont nonpoint source load reduction requirement for the Lake Champlain Basin occurs in the Missisquoi Bay watershed where loads associated with agriculture are the dominant nonpoint source (Table 9). The load reduction responsibility that would be assigned to agricultural sources in the Missisquoi Bay watershed using these calculation methods would be 33.6 mt/yr. However, the Vermont Department of Agriculture, Food, and Markets has estimated that the maximum load reduction attainable in the Vermont portion of the Missisquoi Bay watershed from practices funded by the Vermont Best Management Practice Cost Share Program is only 24.3 mt/yr, relative to the 1991 agricultural loads (Table 12). While there is considerable uncertainty about the quantity of phosphorus reduction attainable from various agricultural BMPs, the Lake Champlain Basin Program (2000a) also concluded that the agricultural nonpoint source load reduction requirement for the Missisquoi Bay watershed exceeds the reduction believed to be possible using the existing Vermont BMP Cost Share Program.

The land use and phosphorus export modeling analysis of Hegman et al. (1999) found that the measured phosphorus loads from the three major tributaries to Missisquoi Bay were significantly under-predicted by a model which considered the areas of forest, agriculture, developed land in the watershed. While the model under-prediction could be corrected by including consideration of the excess animal unit density in the Missisquoi Bay tributary watersheds, relative to other watersheds in the Lake Champlain Basin, the reason for the unusually high phosphorus loading from the Missisquoi Bay watershed is not fully understood. Problems of stream stability and streambank erosion are especially acute in the Missisquoi Bay watershed, and phosphorus loading from these processes is likely an important factor here (Vermont Agency of Natural Resources 2001).

For these reasons, an additional ("other") category of nonpoint sources was created for the allocations for the Missisquoi Bay watershed. The maximum agricultural load reduction attainable from the existing cost share program was 24.3 mt/yr (Table 12). The load reduction responsibility assigned to agricultural sources treatable by the existing cost share program was therefore capped at 24.3 mt/yr in Table 11. The balance of the reduction needed (9.3 mt/yr) was assigned to an "other" category. The maximum agricultural reduction estimate of 24.3 mt/yr represents about 73% of the reduction that would have been assigned to agriculture in the Missisquoi Bay watershed in Table 11 using the method applied to the other watersheds. Accordingly, 73% of the allocation that would have been assigned entirely to agriculture in Table 10 was placed into the agriculture category, and the remaining 27% was placed into the "other" category.

Table 11. Load reduction responsibilities (mt/yr, relative to 1991 loads) for Vermont lake segment watersheds.

Lake Segment	Forest Load Reduction	Agriculture Load Reduction	Developed Land Load Reduction	Other Load Reduction	Total Load Reduction
South Lake B	0.00	2.62	3.01		5.63
South Lake A	0.00	1.62	0.38		1.99
Port Henry	0.00	0.22	0.07		0.28
Otter Creek	0.00	8.64	6.12		14.76
Main Lake	0.00	1.72	7.23		8.95
Shelburne Bay	0.00	0.10	1.03		1.13
Burlington Bay	0.00	0.00	-1.14		-1.14
Malletts Bay	0.00	2.14	2.35		4.49
Northeast Arm	0.00	1.64	0.33		1.97
St. Albans Bay	0.00	1.64	0.40		2.04
Missisquoi Bay	0.00	24.29	6.44	9.33	40.06
Isle LaMotte	0.00	0.26	0.11		0.37
Total	**0.00**	**44.9**	**26.3**	**9.3**	**80.5**

Table 12. Maximum attainable agricultural phosphorus load reductions in the Missisquoi Bay watershed from the Vermont Best Management Practice Cost Share Program (Vermont Department of Agriculture, Food, and Markets estimates, 6/15/01).

Activity	**Animal Units Treated**	**Phosphorus Reduction per Animal Unit (lbs P/unit/yr)**	**Phosphorus Reduction (mt/yr)**
Accepted Agricultural Practices and Best Management Practices Implemented Prior to 2001			13.62
Future barnyard treatments for untreated animals	16,210	0.5	3.62
Future manure storage treatments for untreated animals	8,319	0.3	1.11
Future manure storage expansions and retrofits to existing structures	18,190	0.3	2.44
Annual practices (nutrient management, grazing management, erosion control)			3.50
TOTAL			**24.3**

Addressing the “other” category of nonpoint source reductions needed in the Missisquoi Bay watershed will require major attention to stream stability problems. Streambank erosion is a large source of phosphorus loading in the Missisquoi Bay watershed and elsewhere in the Lake Champlain Basin (Vermont Agency of Natural Resources 2001). While some of the treatments to improve stream stability will need to involve agricultural land and practices such as riparian buffers on pasture and cropland, there are other watershed level processes causing fundamental hydrologic changes that cannot be addressed solely by on-farm measures. The “other” category of nonpoint source reduction requirements was established for Missisquoi Bay to recognize the limitations of the existing agricultural cost-share program, and to promote the special attention needed for stream restoration and protection in the Missisquoi Bay watershed.

New York Load Allocation

The nonpoint source load allocations for each New York watershed are identified in Table 13. The nonpoint source load allocation of 84.3 mt/yr represents an overall reduction of 7.7 mt/yr, or 8.4% from the measured 1991 total nonpoint source load from New York.

The total nonpoint source load allocations for each lake segment were subdivided for the TMDL according to the three major land use categories of forest, agriculture and urban. The forest category includes runoff from forests in silvicultural management. Agriculture includes livestock and crop growing operations. Urban refers to a variety of land uses including homes, lawns, driveways, and back roads found in lightly developed rural areas of New York, as well as large parking lots, commercial buildings, and streets found in town centers and other densely developed areas.

The basis for subdividing the New York nonpoint source load allocation into individual land use categories was as follows. Phosphorus loads allocated to forest land (including natural background) were held at their 1991 baseline levels. Loads allocated to agricultural and urban lands were reduced by 10% from their 1991 baseline levels. The 10% reduction will be realized from past, current, and future implementation of BMPs in the watershed. New York considers the figure of 10% to be a conservative estimate. An aggressive application of BMPs should attain higher removal percentages.

The percentages of the 1991 baseline nonpoint source loads attributed to each land use category were estimated using the Lake Champlain Basin land use and land cover data set (ca.1993) documented by Millette (1997), and the phosphorus export modeling analysis of Hegman et al. (1999). The loading function model (with animal unit corrections) developed by Hegman et al. (1999) was used to estimate the proportions of the total 1991 nonpoint source loads derived from each land use category in each lake segment watershed. These proportions were applied to the 1991 nonpoint source loads measured by Vermont DEC and New York State DEC (1997) as shown in Table 14.

The 1991 agricultural and urban loads estimated for each lake segment watershed (Table13) were reduced by 10% to calculate the load allocations. The nonpoint source load allocations assigned to each land use category are shown in Table 15. It is intended that these land use based allocations will guide the implementation of a variety of management programs to reduce phosphorus loads from agricultural and urban nonpoint sources, and to support programs aimed at preventing increases in phosphorus loads caused by forest logging activities.

Table 13. Nonpoint source load allocations and load reductions for each New York lake segment watershed.

Lake Segment	1991 Measured Loads[1] (mt/yr) Point	Nonpoint	Total	TMDL Loading Capacity (mt/yr) Total[2]	Point[3]	Nonpoint	Nonpoint Reduction (mt/yr)
South Lake B	3.9	24.3	28.2	23.9	1.9	22.0	2.3
South Lake A	9.6	3.5	13.1	11.2	7.9	3.3	0.2
Port Henry / Otter Creek	1.8	2.7	4.5	3.4	0.9	2.5	0.2
Main Lake	7.1	31.8	38.9	33.7	4.2	29.5	2.3
Cumberland	29.2	8.8	38.0	25.2	17.1	8.1	0.7
Isle LaMotte	7.4	20.9	28.3	22.3	3.4	18.9	2.0
TOTAL	**59.0**	**92.0**	**151.0**	**119.8**	**35.5**	**84.3**	**7.7**

[1] Vermont DEC and New York State DEC (1997)
[2] from Table 3
[3] from Table 7

Table 14. New York lake segment 1991 nonpoint source loads by land use category.

Lake Segment	1991 Total Nonpoint Load (mt/yr)[1]	Forest Load Percent[2]	Agric. Load Percent[2]	Urban Load Percent[2]	1991 Forest Load (mt/yr)	1991 Agric. Load (mt/yr)	1991 Urban Load (mt/yr)
South Lake B	24.3	4.6%	63.7%	31.7%	1.1	15.5	7.7
South Lake A	3.5	19.5%	12.4%	68.1%	0.7	0.4	2.4
Port Henry/Otter Creek	2.7	13.2%	39.4%	47.4%	0.3	1.1	1.3
Main Lake	31.8	28.2%	3.9%	67.9%	9.0	1.2	21.6
Cumberland Bay	8.8	22.0%	13.6%	64.5%	1.9	1.2	5.7
Isle LaMotte	20.9	4.1%	79.6%	16.3%	0.9	16.6	3.4
Total	**92.0**				**13.9**	**36.0**	**42.1**

[1] Vermont DEC and New York State DEC (1997)
[2] Hegman et al. (1999)

Table 15. New York nonpoint source load allocations by land use category.

Lake Segment	1991 Total Nonpoint Load (mt/yr)	Nonpoint Load Reduction Required (mt/yr)	Nonpoint Load Allocation: Forest Load (mt/yr)	Nonpoint Load Allocation: Agric. Load (mt/yr)	Nonpoint Load Allocation: Urban Load (mt/yr)	Nonpoint Load Allocation: Total Nonpoint Load Allocation (mt/yr)
South Lake B	24.3	2.3	1.1	14.0	6.9	22.0
South Lake A	3.5	0.2	0.7	0.4	2.2	3.3
Port Henry/Otter Creek	2.7	0.2	0.3	1.0	1.2	2.5
Main Lake	31.8	2.3	9.0	1.1	19.4	29.5
Cumberland Bay	8.8	0.7	1.9	1.1	5.1	8.1
Isle LaMotte	20.9	2.0	0.9	14.9	3.1	18.9
Total	**92.0**	**7.7**	**13.9**	**32.5**	**37.9**	**84.3**

MARGIN OF SAFETY

EPA regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. The lake phosphorus model (Vermont DEC and New York State DEC, 1997) used loading values and other terms that were best estimates with known precision, derived from an extensive field data collection program. This provided a very close correlation between the model and monitoring data. Given this close correlation, the implicit MOS provided by the assumptions described below is sufficient for this TMDL.

The TMDL includes an implicit margin of safety provided by two conservative assumptions in the phosphorus model used to determine the loading capacity of the lake. The first conservative assumption is that changes in the ratio of particulate to dissolved phosphorus entering the lake after the TMDL is achieved will not affect the internal phosphorus sedimentation balance in the lake. The ratio of particulate to dissolved phosphorus is important because dissolved phosphorus remains in the water column over time and contributes to total phosphorus levels in the lake more than does particulate phosphorus, the fraction of phosphorus bound up in sediment (Chapra 1997). Some of the settled particulate phosphorus is recycled back into the water column and some is buried in the sediment, becoming unavailable. In the Lake Champlain model, the net flux of phosphorus into the sediments is reflected in the internal net sedimentation terms for each lake segment.

Wastewater treatment plant discharges contain primarily dissolved phosphorus (typically more than 90%), whereas nonpoint source and stormwater loads contain primarily the particulate form of phosphorus derived from sediments in stormwater and other sources such as eroding streambanks. The internal sedimentation terms in the Lake Champlain phosphorus model reflects the sedimentation rate present in 1991, when 180.1 mt/yr of phosphorus came from wastewater treatment plants and 385.0 mt/y came from nonpoint sources in Vermont and New York (see Table 3), representing a particulate/dissolved ratio of approximately 2:1. Under the load and wasteload allocations specified in the TMDL for Vermont and New York, wastewater treatment plant discharges will be reduced disproportionately, creating a new particulate/dissolved ratio of approximately 3:1 (296.9 mt/y from nonpoint and stormwater, and 91.3 mt/y from treatment plants). While the actual particulate/dissolved ratios are likely to be a little different from these because treatment plant and nonpoint source categories are not comprised of 100% dissolved and particulate phosphorus respectively, the ratios presented are a reasonable approximation of the expected change. The new 3:1 ratio is likely to produce a higher rate of internal sedimentation than the ratio that existed when the model was calibrated, resulting in more total phosphorus being removed from the system than what was calculated by the model and used to establish the loading capacities. The model's assumption of constant net sedimentation rates in each lake segment is therefore a conservative assumption.

Other factors in addition to the particulate/dissolved phosphorus ratio may affect the net sedimentation balance after load reduction. For example, it is common for internal loading from phosphorus stored in lake sediments after years of excessive external loading to delay recovery, especially in shallow bays or lakes. Such internal loading could result in lower net phosphorus sedimentation after load reductions are achieved. However, this situation would be expected to resolve over time (sometimes decades) as the historical phosphorus accumulation in the sediments gradually becomes depleted.

A second implicit margin of safety is provided by the fact that the model's mean predicted phosphorus concentrations are below the applicable phosphorus criteria for most lake segments. The goal of the modeling effort was for the mean predicted levels to meet the phosphorus criterion for each lake segment following implementation of the load and wasteload allocations. In actuality, the mean predicted levels are below criteria for most (10 of 13) lake segments (see Figure 4). The difference between the criteria and the mean predicted levels averages 0.0028 mg/l, and represents an additional margin of safety for these lake segments. For the three remaining segments, the mean predicted phosphorus concentration is equal to the criterion.

In addition to the implicit margin of safety described above, the following factors, while not being relied upon as providing a margin of safety, combine to produce a high level of confidence that the overall goals of the TMDL will be met.

Vermont treatment plant wasteload allocations allow for full permitted (i.e. design capacity) wastewater flows at all facilities. It is unlikely that all facilities in the basin will experience flow increases up to their full permitted capacities. Even with growth and point source trading, loadings are likely to remain below the total wasteload allocation for wastewater treatment facilities.

In addition, Vermont facilities with phosphorus concentration limits specified in their permits are operated to achieve discharges below the required concentrations. This is because, in order to achieve consistent monthly compliance with permit requirements, plant operators must be conservative and apply treatment chemical doses that are targeted to achieve an effluent phosphorus level somewhat below the permit level.

In New York, the treatment plant wasteload allocations were based in part on either permitted (design) flow or 1.5 times the 1995 flow, whichever was less. From a loading perspective, a comparison of the wasteload allocation of 214.4 lbs/day (Table 8) to the current load of 185.5 lbs/day (the sum of the individual discharge wasteload allocations or existing discharge loads, whichever is less) shows that there is an excess load of 28.9 lbs/day available. This represents a buffer of 16% over the current load. Based on recent basin population trends in the New York portion of the basin (<1% increase per year) it is unlikely, within the time frame of this plan, that basin facilities will collectively experience flow or load increases that would result in the wasteload allocation being reached.

Finally, as discussed in the reasonable assurances section of the TMDL document, there is ample reason to believe that the nonpoint source reductions will be met or exceeded. Relative to the 1991 baseline loads, New York has determined that an overall nonpoint source reduction of 8.4% is necessary to achieve its portion of the watershed phosphorus allocation. Based on BMPs implemented since 1991 as well as on-going and planned actions, the state believes this goal is reasonable and achievable. The continued aggressive implementation of the state's Nonpoint Source Management Program is, in fact, expected to result in removals in excess of those required.

As discussed in the Vermont Implementation Plan section of this document, Vermont's approach for controlling nonpoint sources does not limit the load reductions to those necessary to attain the load allocations. The plan instead calls for a full implementation effort in each program area to address all controllable phosphorus sources. Directing this fullest possible implementation effort at all major nonpoint sources of phosphorus in the Vermont portion of the basin may achieve greater load reductions than are called for in the TMDL.

ANNUAL LOADS AND SEASONAL VARIATION

As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(i), TMDLs may be expressed in other terms when appropriate. For Lake Champlain, the TMDL is expressed in terms of allowable annual loadings of phosphorus. Although critical conditions occur during the summer season in some lake segments when algae growth is more likely to interfere with uses, water quality in Lake Champlain is generally not sensitive to daily or short term loading. With a water residence time of about two years (Vermont DEC and New York State DEC), the lake generally responds to loadings that occur over longer periods of time (e.g., annual loads).

A steady-state modeling approach was used to develop annual load allocations for phosphorus in Lake Champlain because the in-lake numeric phosphorus criteria were expressed as annual mean values (Lake Champlain Phosphorus Management Task Force 1993). The use of mean values for lake eutrophication criteria is usually preferred over expressing criteria as daily "not to exceed" values (North American Lake Management Society 1992).

Federal regulations require that TMDLs describe the manner in which seasonal variation in loading was considered. The effects of seasonal variability were accounted for in the modeling analysis for Lake Champlain by using tributary annual mean load estimates that were based on phosphorus concentration vs. flow relationships for each tributary measured across the entire spectrum of seasonal flow conditions (Vermont DEC and New York State DEC 1997).

All tributary phosphorus loading estimates were developed using the FLUX program (Walker 1987, 1990; Vermont DEC and New York State DEC 1997). This program was designed for situations where a continuous daily flow record is available, combined with discrete water quality samples obtained throughout the range of flow conditions. The program provides a choice of several alternative loading estimation methods, from which the optimum method for the study or individual site can be selected. Stratification with respect to flow interval or season can be used in the FLUX procedures in order to reduce the variance of the loading estimates.

Flow and sample data from the period of March 1990 to April 1992 were used to calibrate the concentration vs. flow relationships employed by the FLUX program. Estimates of the annual mean flows and loadings were based on complete annual hydrologic cycles.

Examination of concentration vs. flow plots indicated that most of the Lake Champlain tributaries had significant relationships with total phosphorus concentration and daily flow. Therefore, a regression-based load estimation procedure was developed between concentration and flow within each flow stratum, and applied with a correction for bias to each daily flow value to produce an estimate of the mean phosphorus loading rate for the time period. The same regression method was applied to all tributaries. This approach sacrifices optimum (lowest error) estimates for each stream, in favor of consistency of method across all streams. In practice, however, it was found that mean loading values and their standard errors were generally similar across all alternative load estimation methods provided by the FLUX program, i.e., annual vs. seasonal phosphorus load estimates.

REASONABLE ASSURANCES

USEPA guidance calls for reasonable assurances when TMDLs are developed for waters impaired by both point and nonpoint sources. In a water impaired by both point and nonpoint sources, where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur, reasonable assurance that the nonpoint source reductions will happen must be explained.

Overall responsibility for the planning and coordination of phosphorus reduction efforts in the Lake Champlain Basin rests with the states and the Lake Champlain Basin Program Steering Committee, which is the executive body charged with overseeing the implementation of the Lake Champlain Management Conference plan. The Lake Champlain Management Conference plan *Opportunities for Action* listed a number of specific action items relating to phosphorus reduction from both point and nonpoint sources. Many of the action items in *Opportunities for Action* have been pursued by the states and other management agencies, but substantial further efforts are necessary (Lake Champlain Basin Program 1999b, 2000b).

The Lake Champlain Basin Program (2000a) evaluated progress toward the phosphorus reduction goals and presented a number of potential next steps to be taken to achieve the target loads. The Lake Champlain Basin Program (2000a) report found that implementation efforts by state and federal agencies since 1996 have generally met or exceeded the first five-year phosphorus reduction targets established by the Lake Champlain Management Conference (1996a). However, relying solely on existing point and nonpoint source phosphorus reduction programs will not be sufficient to achieve the ultimate 20-year phosphorus loading targets, at least for some lake segment watersheds. Current programs will need to be sustained and enhanced, and new approaches will need to be developed and implemented.

Many of these new programs or approaches for Vermont are described in detail in the Vermont implementation plan. For example, Vermont's new stormwater program controls discharges from new development more rigorously than ever before, by requiring compliance with state of the art technical standards contained in the new state stormwater management manual. In addition, the recently adopted Watershed Improvement Program requires retrofitting of selected existing stormwater discharges in certain Lake Champlain watersheds, which is something that has never been required before.

Vermont has also adopted a new approach to managing rivers and streams which seeks to restore whole stream systems to a stable condition, addressing erosion issues in both the stream and the watershed. The rivers program is building on a strong foundation of geomorphic-based assessments, and is addressing erosion and sedimentation issues in a way that they have not been addressed before, with excellent results thus far.

Vermont's agricultural nonpoint source program has recently received a major boost from the new Farm Bill (the Farm Security and Investment Act of 2002), which is expected to provide at least triple the annual funding for conservation cost-share programs in Vermont through the year 2007. This funding will allow water quality issues on farms to be addressed more quickly and completely than was previously possible. These new efforts to control sources previously unaddressed, combined with the strong track record of the ongoing agricultural programs, provide reasonable assurance that the nonpoint source and stormwater reductions will occur. Furthermore, Vermont's 1999 "Upgrade for Enhanced Nonpoint Source Management Program" places a new emphasis on water quality results, including five and fifteen-year phosphorus load reduction targets for Lake Champlain consistent with the TMDL.

Relative to the 1991 baseline loads, New York has determined that an overall nonpoint source reduction of 8.4% is necessary to achieve its portion of the watershed phosphorus allocation. Based on BMPs implemented since 1991 as well as on-going and planned actions, the state feels this goal is reasonable and achievable. The continued aggressive implementation of the state's Nonpoint Source Management Program is expected to result in removals in excess of those required.

The progress to date in reducing phosphorus loads to Lake Champlain has been possible because of a sustained commitment of state and federal funding for point and nonpoint source programs (Lake Champlain Basin Program 1999b, 2000a). This track record of successful implementation efforts, and the continued commitment of the states and the relevant federal agencies to the Lake Champlain Basin Program, provide further reasonable assurances that progress will continue to be made in meeting the phosphorus load allocations established by the TMDL.

The Lake Champlain Basin Program Steering Committee will oversee periodic reviews and revisions to the comprehensive basin plan, including a focus on specific measures needed to accomplish the phosphorus loading targets. Implementation of the Lake Champlain Phosphorus TMDL will be guided by this ongoing Lake Champlain Basin Program planning process.

IMPLEMENTATION PLAN

USEPA (1999a) guidance indicates that TMDLs should be submitted in association with an implementation plan. In the case of the Lake Champlain Phosphorus TMDL, some initial implementation plans and related discussions are contained in the Lake Champlain Management Conference (1996a) basin plan *Opportunities for Action* and in the Lake Champlain Basin Program (2000a) report on the feasibility of meeting the phosphorus reduction targets. Some specific considerations for implementing the Lake Champlain Phosphorus TMDL in Vermont and New York are discussed below.

Vermont Implementation Plan

River Basin Planning Process

The Vermont DEC river basin planning process will play an important role in the implementation of the Lake Champlain Phosphorus TMDL. Basin planning includes assessing beneficial water-related resources and water impairments, ranking these issues, and carrying out on-the-ground collaborative efforts to restore and protect the resources. Basin assessment, public participation in public forums and watershed councils or teams, and the basin plan itself represent an umbrella process that includes the identification of water quality priorities and the implementation of water quality improvement projects for nonpoint sources derived from developed land, agriculture, forestry, and unstable streams. As described in the Vermont Water Quality Standards, "*Basin plans establish a strategy to improve or restore waters and to ensure full support of uses. Basin plans serve as the guide, consistent with applicable state and federal law for how various sources of pollution within each basin will be managed in order to achieve compliance with the Vermont Water Quality Standards and the Vermont water quality policy*."

Basin assessments are conducted every five years on a rotating basis for all river basins in Vermont. The assessments are based on the results of water quality monitoring programs, professional and public evaluations of the existing water quality in the particular basin, and known threats to water quality. A basin plan is developed following each basin assessment report. The basin plans summarize assessment, planning, and implementation activities at the state and local level and identify topics or areas of special importance in the basin. The basin plans also identify available management programs and tools to address the planned water quality improvement priorities.

It is required by 10 V.S.A. §1253(d) that basin plans be completed for each of the 17 major watersheds in Vermont by January, 2006. The river basin planning process is underway in several Vermont watersheds within the Lake Champlain Basin including the Lamoille and Poultney/Mettowee watersheds, with an anticipated schedule as shown in Table 16. With the adoption of the Lake Champlain Phosphorus TMDL, point and nonpoint source management to reduce phosphorus loading will become an important element of basin plans, especially where substantial phosphorus reductions are required by the TMDL.

Table 16. River basin assessment and planning schedule for Vermont watersheds in the Lake Champlain Basin.

River Basin Name	Assessment Report	Basin Planning
Poultney/Mettawee	1999	2001- 2002
Otter Creek	1998	2003 - 2004
Lower Lake Champlain Direct	1998[1]	2003 - 2004
Upper Lake Champlain Direct	2002	2003 -2004
Missisquoi	2003	2002 - 2003
Lamoille	2001	2001 - 2002
Winooski	2003	2004 - 2005

[1] Water quality information was compiled for this basin and the assessment process was completed in 1998, but no report was issued.

The Vermont Watershed Planning Process will be guided by a document (presently in draft form) titled "*Vermont Watershed Initiative - Guidelines for Watershed Planning*." This document will contain reminders that certain overriding themes exist that are applicable to all basins. These themes include issues such as problematic sedimentation, elevated nutrient runoff, river instability, thermal modification, indicators of pathogens, fish habitat requirements, and a need for adequate access to waters for recreational enjoyment. Related appropriate land use practices are listed. The Watershed Coordinators, Watershed Council members, and others involved in the watershed planning process or in the preparation of remediation plans and strategies can draw on these practices in formulating the plan.

In order to achieve the goal of restoring and protecting the river or lake ecology, the basin planning process recognizes the importance of public involvement. The Vermont Water Quality Standards state that "...public participation shall be sought to identify and inventory problems, solutions, high quality waters, existing uses and significant resources of high public interest." Citizens who make their living from the land have a special opportunity to contribute to water quality and advocate for an approach that balances environmental considerations in protecting and restoring water resources with economic interests. Without balance, there will be limited progress in achieving the goals of protecting the land from the forces of the rivers and the rivers from the runoff of the land.

Further discussions by local watershed councils and teams can work out appropriate strategies to control phosphorus. For example, strategically situated buffers of natural vegetation where rivers spill into fields at flood stage, maintenance of grassed flood chutes, and prompt incorporation of manure are some of the strategies that are beneficial to both phosphorus reduction and the land owner. Many effective techniques for TMDL implementation are discussed below, such as the implementation of the Vermont Better Back Roads program and control of erosion on construction sites. These and many other practices must be tailored for each major and minor watershed draining to Lake Champlain. Each watershed has unique characteristics, a unique set of human goals, and unique water quality and economic conditions that must be balanced in order to move forward effectively to meet common goals.

The Vermont Department of Agriculture, Foods and Markets will work cooperatively with the Vermont DEC in preparing the portion of the basin plans which relate to the implementation of controls and programs affecting agricultural nonpoint source waste and runoff. The cooperative roles of these Departments are defined in the 1993 Memorandum of Understanding between the Vermont DEC and the Department of Agriculture, Foods and Markets.

In order for the complex combination of practices to be identified and implemented in each watershed there must be a watershed coordinator who is responsible for working with the public through forums, councils, and other groups to gain support for a combination of practices and approaches that will "preserve the best and restore the rest." Although point source control is an important element of this TMDL, nonpoint sources make up a larger portion of the phosphorus entering Lake Champlain. Therefore there is a great need to identify the most effective nonpoint source phosphorus controls in each of the seven planning watersheds draining to Lake Champlain, and to adopt and implement an appropriate plan.

The model of the Agency of Natural Resources for watershed planning now includes a Watershed Coordinator serving the role of planner and implementor. These roles are described in a document that lays out a framework for watershed planning titled "*Vermont Watershed Initiative - Guidelines for Watershed Planning*." This document, in addition to describing the basic roles of the Watershed Coordinator, the Watershed Councils, the Statewide Steering Committee, and other functions, also describes an enduring role of the Watershed Coordinator in assuring that the resources are brought to the recommendations of the plan and to the ongoing implementation role of the Watershed Council. In order to achieve the goal of the TMDL in nonpoint phosphorus control, a Watershed Coordinator/Implementor (1.0 FTE at $75,000/year) will be required for each of the seven major planning watersheds draining to Lake Champlain from Vermont.

Wastewater Treatment Facilities

Compliance with the currently permitted loads for wastewater treatment facilities is being accomplished through implementation of existing state statute (10 V.S.A. §1266a) establishing a 0.8 mg/l effluent phosphorus limit for certain facilities. Table 4 lists the Vermont facilities that have phosphorus concentration or loading limits specified in their current discharge permits, in accordance with this statute or other requirements. All but four of the facilities subject to phosphorus limits in their permits have either already been upgraded or are currently undergoing construction to attain the permit limits indicated in Table 4. Phosphorus removal upgrades at the remaining four facilities (Cabot, Milton, Northfield, and Richmond) are expected to commence in the near future.

Implementation of the additional phosphorus removal treatment required in the TMDL beyond the currently permitted loads will be accomplished through appropriate modification of the individual facility discharge permits as the permits come up for renewal during their five-year permit cycles. Annual loading limits calculated using a 0.6 mg/l effluent phosphorus concentration at the permitted flow will be added to the permits for the 25 facilities where this provision applies. In addition, eight aerated lagoon facilities with greater than 0.2 mgd permitted flow will be required by their discharge permits to meet a 0.8 mg/l monthly average phosphorus concentration limit.

When a Vermont municipality in the Lake Champlain Basin is required to remove phosphorus under current statute, the capital cost for necessary structures and equipment is funded by 100% State grants, as authorized by 10 V.S.A. §1625e. The annual operation and maintenance costs are borne by the municipalities and sewer users. All phosphorus removal costs at private industrial and other non-municipal facilities are borne by the owners of the facility.

Certain statutory changes will be necessary to implement the wasteload allocation. Since aerated lagoon facilities are currently exempt from the 0.8 mg/l treatment requirement under 10 V.S.A. §1266a, a change to this statute will be necessary to implement this aspect of the TMDL. Eligibility of municipalities for 100% state grant funding for the capital cost of phosphorus removal facilities should be extended in 10 V.S.A. §1625e to include all cost-effective modifications necessary to meet wasteload allocation requirements under the Lake Champlain Phosphorus TMDL. This would allow the use of state grant funds to construct anaerobic selector zones for biological phosphorus removal at facilities where selector zones would result in operating cost savings to municipalities subject to phosphorus removal requirements under the TMDL (see below).

The Vermont DEC developed cost estimates for various wasteload allocation alternatives to support the public process of choosing the appropriate point source policy for the Lake Champlain Phosphorus TMDL. Both capital costs and annual operation and maintenance costs were estimated. The cost of implementing the wasteload allocation at each Vermont municipal facility for which a change from current permit limits will be required is indicated in Table 17. Costs were not estimated for the two private industrial facilities that will be affected.

The cost estimates in Table 17 represent the additional capital and operating costs necessary to comply with the wasteload allocation, above the cost of compliance with currently permitted loads. The annual operating costs were calculated based on the full permitted flow rates at all facilities. Therefore, the annual operating costs are over-estimates of the actual costs likely to be incurred by these facilities, since most will operate well below their full permitted flows during the 20-year period of the analysis.

The cost analysis considered the option of constructing and operating anaerobic selector zones at facilities where their use would be justified from an engineering and economic standpoint. Anaerobic selectors are unaerated mixing zones that have been shown to promote the growth of microorganisms that take up phosphorus biologically rather than chemically, thereby allowing reduced chemical consumption and reduced sludge generation. Selector zones increase the capital cost for phosphorus removal, but can substantially reduce the operating cost. For some facilities, selector zones would result in net operating cost savings relative to current operating costs, even if more stringent phosphorus limits are required. The cost information presented in Table 17 assumes use of selector zones at all facilities where the addition of selector zones would be applicable.

Table 17 shows that the total additional capital cost of implementing the wasteload allocation at all affected Vermont municipal treatment facilities will be up $5,444,000, depending on the extent to which municipalities choose to construct selector zones. Capital construction costs for phosphorus removal projects necessary to attain the TMDL wasteload allocation requirements should continue to be funded through 100% state grants. The annual operational cost impact of the wasteload allocation varies from facility to facility, but net operational cost savings (relative to the cost of meeting currently permitted loads) are possible at ten of the facilities if selector zones are constructed.

Agricultural Nonpoint Sources

Reduction of phosphorus loading from agricultural sources in Vermont is being accomplished by a variety of existing state and federal programs. The Vermont Accepted Agricultural Practice (AAP) Regulations, adopted in 1995 by the Vermont Department of Agriculture, Food, and Markets, establish certain mandatory requirements for farming practices to prevent and reduce water pollution from

Table 17. Costs to implement the TMDL point source wasteload allocation at Vermont municipal facilities for which the TMDL will result in a change from the currently permitted loads. The estimates are additional costs, above the cost of attaining the currently permitted loads at each facility, calculated at the full permitted flow. Costs assume construction and operation of optional selector zones wherever they would be appropriate additions to the existing facility. Negative values for annual operating costs indicate that use of selector zones will result in net operational cost savings.

Facility	Added Capital Cost ($)	Change in Annual Operating Cost ($/yr)
Alburg[2]	0	0
Barre[2]	650,000[4]	-65,536
Brandon[2]	300,000[4]	-24,111
Burlington East[2]	400,000[4]	-17,525
Burlington Main[2]	0	12,163
Burlington North[2]	500,000[4]	-29,208
Cabot[2]	0	148
Enosburg Falls[2]	0	1,335
Essex Jct.[2]	600,000[4]	-49,426
Fair Haven[2]	0	1,483
Hardwick[1]	58,000	35,300
Hinesburg[1]	0	0
Johnson[2]	0	801
Middlebury[2]	0	6,526
Milton[2]	0	2,967
Montpelier[2]	650,000[4]	-57,978
Morrisville[2]	250,000[4]	-14,639
Northfield[2]	0	2,967
Poultney[2]	0	223
Proctor[1]	79,000	32,300
Richford[1]	83,000	35,500
Richmond[2,3]	0	659
Rutland[2]	800,000[4]	-99,308
S. Burlington Air. Park.[2]	525,000[4]	-33,589
Swanton[1,2]	0	5,340
Troy/Jay[1]	62,000	20,000
Vergennes[1,2]	0	3,115
Waterbury[1]	62,000	62,000
Winooski[2]	425,000[4]	-36,707
TOTAL	**5,444,000**	**-205,200**

[1] Aerated lagoon facility that will be required to meet a 0.8 mg/l monthly average phosphorus concentration limit.

[2] Facility that will be required to meet a 0.8 mg/l monthly average phosphorus concentration limit, and an annual average load limit calculated using a 0.6 mg/l concentration.

[3] Selector zones are planned at the Richmond facility to meet currently permitted loads, and are therefore not shown as an added capital cost to implement the TMDL.

[4] Cost of optional selector zones.

phosphorus and other pollutants. These rules, which affect all farming operations throughout Vermont regardless of size or type, include requirements for the discharge, storage, and proper application of manure and fertilizer, and establish minimum requirements for vegetated buffer zones between certain crop lands where runoff or erosion is occurring and surface waters. Farm operators throughout the Vermont portion of the Lake Champlain Basin have been successful in their efforts to avoid land spreading of agricultural wastes during the prohibited December 15 to April 1 period.

State and federal cost-share funding is made available to farmers to assist them in complying with the Accepted Agricultural Practice Rules, and to encourage implementation of other voluntary agricultural measures known as best management practices (BMPs). Administration of state funds for this purpose is governed by the Best Management Practice Regulations adopted in 1996 by the Vermont Department of Agriculture, Food, and Markets. Federal cost-share funds are provided to farmers in the Lake Champlain Basin for conservation practices and other BMPs through the U.S. Department of Agriculture Environmental Quality Incentive Program (EQIP) and other cost sharing programs such as PL83-566 Watershed Protection and Agricultural Management Assistance. In many cases, farmers within the Basin can take advantage of and combine cost share funds under the state BMP program and the federal programs in order to reduce the amount of their out-of-pocket expense.

The Lake Champlain Basin Program (2000a) reported that $9.6 million was spent in Vermont on agricultural nonpoint source pollution control programs between 1996-2001. Of this total, which includes both capital costs and annual operating costs, 58% came from federal assistance (EQIP and PL-566), 22% was provided by state funds, and 20% was provided as cost-share funds by the farmers. The Lake Champlain Basin Program (2000a) report estimated that an additional $62.7 million will be needed to implement agricultural BMPs on all Vermont farms in the basin where BMPs are needed for water quality reasons. The needed practices include both structures (e.g., manure storage, barnyard improvements) and annual (non-structural) practices. An optimal division of these funds would involve a 65% federal share from U.S. Department of Agriculture programs, a 20% state share, and a 15% farmer share. The $62.7 million cost is probably an over-estimate of the amount needed to attain the agricultural phosphorus load allocations in the TMDL because not every farm in every lake segment watershed would need to be treated.

A trend affecting the future of agriculture within Vermont, especially dairy agriculture, involves a growing number of larger farms. The Vermont Large Farm Operation (LFO) rules, which became effective in 1999 and are administered by the Vermont Department of Agriculture, Food and Markets, establish a permit program for existing and new large farms. LFO permits address such issues as odor, noise, and traffic, and limit the number of on-farm livestock. LFO permits also address management of on-farm wastes and the land application of nutrients. There are, at present, ten farm operations within the Lake Champlain Basin that have been issued an LFO permit. Another eight farms within the Basin have either applied for or inquired about a permit. Of these, five are currently under the 950 animal unit threshold. Farms will continue to grow in size and will be permitted under this program.

In addition to the State's LFO permit program, Vermont has authority to regulate Concentrated Animal Feeding Operations (CAFOs) under the National Pollutant Discharge Elimination System (NPDES). A memorandum of understanding concerning CAFO and LFO regulation was enacted in October 1999 between the Vermont Department of Agriculture, Food, and Markets and the Vermont DEC. At present, there have been no CAFO permits issued by the Vermont DEC.

The Vermont Department of Agriculture is required by the LFO law to regulate the construction, operation and/or expansion of farms designed to house greater than 950 animal units or domestic fowl in numbers exceeding the limits in the law. This number of animal units and domestic fowl is established at a level lower than that used for CAFO permitting. The Vermont Department of Agriculture administers the regulatory aspects of the LFO program in accordance with state and federal technical criteria which, when complied with by LFO permit holders, will result in farms not causing direct discharges to waters of the state. The goal is that large farms permitted and regulated under the LFO program are managed in such a manner to not cause a direct discharge.

The Federal Clean Water Act defines CAFOs as point sources that are subject to the NPDES permit program. However, farm operations are not required to obtain an NPDES permit unless there is a discharge. Vermont DEC is charged with NPDES permitting authority. Any NPDES permits issued for CAFOs in Vermont will eliminate and prohibit discharges to waters at or below the 24-hour, 25-year storm event.

Permitting of CAFOs by Vermont DEC will be undertaken on a case-by-case basis where evidence of a discharge or potential discharge exists. A memorandum of understanding between the Vermont Agency of Natural Resources, the Vermont DEC and the Vermont Department of Agriculture, Food and Markets has been adopted (10/22/99) concerning CAFO and LFO regulation. The memorandum covers matters including sharing of farm information, issuance of permits, permit compliance and inspection, investigation of complaints, enforcement, and periodic reporting.

Monitoring of compliance with the no discharge requirement arises from the state's previously established complaint-driven system of agricultural related investigations, from the LFO Rules, and from the 1999 Memorandum of Understanding. The rules require record keeping, annual reporting, and self-reporting of non-compliance by each permittee. The rules also enable the Department of Agriculture to inspect any facilities, equipment, practices, or operations required under the permit and to sample or monitor any substances or parameters at any location. The Memorandum specifies quarterly meetings between the two departments to discuss a number of topics including permit compliance.

The protection and preservation of agricultural land is being accomplished within the Vermont portion of the basin through the cooperative efforts of federal and state programs and willing land owners. This work, while notably different from the application of BMPs or other soil and water conservation practices, is critical in keeping the agricultural land base found in the basin in perpetual agricultural use. Conversion of agricultural land to some other non-agricultural use or purpose (e.g., residential or commercial) has been shown to result in the potential for significant increases in phosphorus and other pollutant loadings.

As part of the agricultural implementation effort, Vermont will seek to accelerate the establishment and protection of riparian buffers on agricultural land with incentive funds available through the U.S. Department of Agriculture Conservation Reserve Program (CRP) and through the newly available Conservation Reserve Enhancement Program (CREP). CREP, which uses state appropriations and matching federal funds, is a joint, state and federal land retirement conservation program designed to address state and nationally significant agriculture-related environmental effects. This voluntary program uses financial incentives to encourage farmers to enroll in contracts of 10 to 15 and up to 30 years in duration to remove riparian land from agricultural production. CREP will target specific priority watershed with the highest estimated nonpoint source pollution levels, including South Lake B, Otter Creek, and Missisquoi Bay, and those areas considered natural resource priorities by the Vermont Agency of Natural Resources and the Lake Champlain Basin Program.

The Vermont Legislature approved the Governor's FY 2002 budget request of $600,000 in state monies for the Lake Champlain CREP. This has the potential to raise $3 million in U.S. Department of Agriculture matching funds. A project enrollment goal of 1,000 acres has been established with targets of 750 acres of pasture land and 250 acres of crop land. The total state and federal funds available should fully fund CREP on all 1,000 acres. Farmers are also eligible for cost share of up to 90% for installation of practices directly through the U.S. Department of Agriculture. CREP practice installation will consist primarily of filter strips and riparian buffers, and may also include grassed waterways and wetland restoration. In the first five months of the program 257 acres were enrolled. Additional state and federal funds will be needed to continue this successful program.

The Lake Champlain Basin Program (2000a) estimated that there are approximately 79 miles of stream bordered by agricultural land in the Vermont portion of the Lake Champlain Basin that are in need of riparian buffer installation and/or streambank repair. The total cost of needed buffer installation and streambank repair on agricultural land in Vermont, including technical assistance costs, was estimated to be $15.3 million. The additional cost of lost agricultural production over a ten-year period on land used as buffers would be approximately $4.6 million. The total funding need is therefore about $20 million, of which 80% would be provided as the federal share under the CREP program and 20% would be the state share.

Vermont will also seek to accelerate the establishment of nutrient, crop and pesticide management services available to farm operators in the basin. Cost share funding available both through the federal EQIP program and the Vermont Department of Agriculture, Food, and Markets helps farmers address these issues. Development and implementation of nutrient management plans is consistent with the Unified National Strategy for Animal Feeding Operations jointly developed by the USEPA and the U.S. Department of Agriculture. The U.S. Department of Agriculture and the University of Vermont have developed a "phosphorus index" that will serve as a basis for nutrient management standards and specifications in the future. The Lake Champlain Basin Program has funded efforts to develop "whole farm" mass balance approaches that minimize importation of phosphorus onto the farm by using low-phosphorus feed and by reducing the purchase of supplemental feed, or increase the export of phosphorus by the sale of composted manure.

The Lake Champlain Basin Program (2000a) report found that even if the BMPs currently funded by these existing programs were implemented on all the farms remaining in need of these BMPs, the effort might still fall short of meeting the nonpoint source load allocation for some lake segment watersheds. Additional BMPs, especially non-structural measures, and other techniques should be promoted and adopted by farm operators to ensure that the nonpoint source phosphorus loading targets from agricultural sources in the basin are achieved. Expanded programs are needed in the following areas.

1. *Implementation of AAPs.* Significant progress has occurred since the AAPs became effective, most notably in reducing winter manure applications. Increased awareness and outreach efforts to farm operators regarding the AAP requirements will continue to increase compliance. Enforcement of AAP requirements by the Department of Agriculture, Food and Markets is through a complaint-driven system. Specific AAPs that have phosphorus loading reduction potential include discharges, nutrient and pesticide application, soil cultivation, and vegetative buffer zones.

   Additional resources are needed by the Vermont Department of Agriculture, Food and Markets or the Natural Resources Conservation Districts to conduct and target agricultural non-point source pollution outreach to farm operators within the Lake Champlain Basin. More effective outreach over this large area could be provided with the addition of 1.0 FTE estimated at $75,000/year.

2. *LFO permitting.* The Vermont Department of Agriculture, Food, and Markets is continuing to permit LFO's, including those in the Lake Champlain Basin. Such action will further the full implementation of the AAPs and ensure that proper management of phosphorus found in agricultural waste and fertilizers is being achieved. Farms under an LFO permit are considered to have an adequate on-farm management system and a sufficient land base to minimize the pollution potential from the operation. The LFO permit and permit process also provides some assurance that a Concentrated Animal Feeding Operation (CAFO) permit issued by the Vermont DEC is unnecessary.

   In the future, Vermont should create a permitting program for farms of between 300 and 950 animal units. The Vermont agricultural nonpoint source pollution program needs to seek legislative approval to issue general permits which would assure AAP compliance and adequate waste storage capacity. Following a sign-up period, farmers would be given adequate time to achieve compliance. Implementation of an expanded farm permitting program will require 2.0 FTE's to carry out permit and compliance duties at a cost of $75,000/year each.

3. *Implementation of non-structural BMP measures within the basin.* The foundation of decades-long efforts to control nonpoint source pollution loadings from agriculture rests upon the voluntary adoption by farm operators of particular soil and water conservation measures. Measures widely installed throughout much of the basin over the last three decades have predominantly been structural, and include manure waste containment, milkhouse waste treatment, and barnyard paving. A considerable amount of work remains to be done using a variety of non-structural measures such as nutrient management, conservation tillage, fencing, riparian area

management, and development of alternate livestock watering supplies. Composting of animal manure, along with the potential for the export of phosphorus out of the basin, has not been widely adopted or promoted.

Currently, 80% of the annual amount of cost-share funds under the EQIP program are used for structural measures, and twenty percent is used for non-structural measures. Increased funding is needed to support both structural and non-structural BMP practices in the basin.

4. R*eview of the Vermont AAPs.* The Vermont AAPs are recognized as important statewide and industry-wide restrictions intended to reduce nonpoint source pollutant discharges through implementation of improved farming techniques. Continued reductions in nonpoint source pollution should be accelerated by modifying or improving certain restrictions contained in the AAPs. The Vermont Department of Agriculture, Food, and Markets is ultimately responsible for developing and administering any revisions to the AAPs. The Department of Agriculture, Food and Markets will work with water quality partners to revise the AAP's on occasion, as needed. Issues currently under discussion include standards for land conversion for agricultural use, vegetative buffer zone restrictions, and possible incorporation of the phosphorus index into the nutrient management standard.

Developed Land Sources

The Lake Champlain Basin Program (2000a) report found that conversion of land from undeveloped or agricultural land uses to developed land uses may be negating some of the phosphorus loading reductions achieved by point source and agricultural nonpoint source control programs. On average, developed land in the basin yields more phosphorus runoff per unit of area than either agricultural or forest land (Hegman et al. 1999). The trend towards urbanization that is apparent in some Vermont portions of the Lake Champlain Basin is creating new phosphorus sources. In order to attain the wasteload allocation for developed land, phosphorus runoff generated by new development must be minimized through proper site design, construction techniques, and stormwater treatment, and phosphorus load reductions from existing developed areas must be achieved sufficient to offset the effects of new development.

Phosphorus and other pollutants in stormwater runoff are addressed to some extent for new developments in Vermont that require state stormwater discharge permits or state land use (Act 250) permits. Erosion control and stormwater management requirements are generally included as conditions in these permits, and these practices help limit new sources of phosphorus loading caused by land development. However, these permits are required primarily for large projects, and many small developments may have a significant cumulative effect on urbanization and phosphorus loading to Lake Champlain. Few local programs exist in Vermont that adequately limit phosphorus runoff from new development.

The Lake Champlain Basin Program (2000a) report recommended that Vermont address the growing problem of phosphorus runoff from developed land by upgrading state stormwater management guidance provided to municipalities and developers. Such guidance should be used to promote evaluation of phosphorus loads as a part of the permitting process for new developments, and to encourage both structural and non-structural stormwater controls through innovative site design, riparian buffers, retrofits for redeveloped sites, and improved road construction and maintenance.

The distribution of land use within the Vermont portion of the Lake Champlain Basin provides some insight into the relative magnitude of phosphorus loading from various types of developed land sources. The land use and land cover data set for the basin (Millette 1997, Hegman pers. comm. 12/18/00) classified "urban" land into five separate categories, as shown in Table 18. Transportation surfaces (i.e., highways and backroads) were the largest category, covering 59% of the total land area classified as urban. Residential areas were the second largest at 33%. Commercial and industrial sites added up to only 6% of the total.

Stormwater discharge permitting is applied primarily to commercial and industrial sites, and to a more limited extent to highways projects and large residential developments. The land use information in Table 18 indicates that stormwater discharge permitting programs can address only a limited amount of the total phosphorus load coming from developed land in Vermont. Implementation of all the necessary phosphorus load reductions from developed land must also include significant efforts to deal with phosphorus runoff from more rural residential areas common throughout Vermont, and from backroads. Expanded efforts in the following areas will be needed to attain the phosphorus wasteload allocation for developed land.

- Stormwater discharge permitting
- Erosion and sediment control at construction sites
- Better backroads
- Local municipal actions

Table 18. Distribution of land use within the "urban" category in the Vermont portion of the Lake Champlain Basin (Millette 1997, Hegman pers. comm. 12/1/00).

Land Use Category	Percent of Urban Area
Residential	33%
Commercial	4%
Industrial	2%
Transportation	59%
Other	3%

Stormwater Discharge Permitting

The Vermont DEC is in the process of creating a new and enhanced stormwater management program, including the development of a new Stormwater Management Rule (Vermont DEC 2001). A major component of this new program is a technical guidance manual for the analysis and control of stormwater runoff (The Center for Watershed Protection 2001). This guidance will emphasize the importance of innovative site design and non-structural means of minimizing stormwater runoff from newly developed sites.

A proposal is currently being considered which would lower the threshold for program jurisdiction to consider much smaller projects than what are now reviewed and permitted. Similarly, existing sites with impervious surfaces that are being re-developed would be subject to a post re-development standard that will reduce the on-site impervious area, or provide equivalent water quality controls.

Stormwater controls for new development will be evaluated for four separate criteria, including water quality treatment, channel protection, groundwater recharge, and overbank (10 year) flood protection. Specific onsite practices will be used to address each of these separate concerns. The recommended practices for water quality treatment will generally be capable of an 80% reduction in total suspended solids (TSS). While specific phosphorus loads will not be addressed for each permit, it is expected that a proportional reduction in phosphorus loadings will be achieved as a result of these TSS reductions.

The Federal Clean Water Act requires that the U.S. Environmental Protection Agency address urban stormwater runoff in a phased approach starting with the largest urban areas in the country, based on population census data. In 1999, the U.S. Environmental Protection Agency, and the Vermont Agency of Natural Resources as the federally delegated authority, began Phase 2 of this approach, which includes the larger Lake Champlain Basin communities. The Vermont communities must file, by March 10, 2003, a notice of intent with the Agency of Natural Resources showing how they intend to comply with the Phase 2 stormwater rule.

The following six minimum measures are required of each designated permittee under the Phase 2 rule.

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention and good housekeeping

Watershed Improvement Permits

A major new initiative of the Stormwater Management Program will involve permitting of stormwater discharges in impaired waters. There are 14 watersheds in the Vermont portion of the Lake Champlain Basin (Table 19) that are listed as “impaired” primarily due to urban stormwater runoff. These impaired

Table 19. Vermont watersheds in the Lake Champlain Basin currently listed as impaired by urban stormwater. Estimates of watershed areas, current phosphorus loads, and potential phosphorus load reductions from implementation of stormwater BMPs are from Pease (1997). Phosphorus reduction estimates are not available for all of the impaired watersheds.

Impaired Watershed	**Lake Segment**	**Watershed Area (km2)**	**Pre-BMP Load (mt/yr)**	**Potential Load Reduction (mt/yr)**
Moon Brk.	Otter Creek			
Allen Brk.	Main Lake	30	0.094	0.046
Muddy Brk.	Main Lake	54	included in Allen Brk.	
Centennial Brk.	Main Lake	3.22	0.058	0.030
Morehouse Brk.	Main Lake	1.48	0.034	0.020
Sunderland Brk.	Main Lake	14	0.060	0.034
Rice Brk.	Main Lake			
Clay Brk.	Main Lake			
Bartlett Brk.	Shelburne Bay	3.79	0.070	0.033
Potash Brk.	Shelburne Bay	21	0.238	0.129
Munroe Brk.	Shelburne Bay			
Englesby Brk.	Burlington Bay	2.43	0.065	0.030
Indian Brk.	Malletts Bay	30.63	0.026	0.012
Stevens Brk.	St. Albans Bay			
Total		**161**	**0.645**	**0.334**

waters are currently not meeting water quality standards as a result of existing development. The water quality impairments are caused primarily by stormwater discharges which are not receiving adequate treatment, such as projects that pre-date the Vermont DEC stormwater permitting program, and previously permitted stormwater discharges that are not in compliance with their original permits. The Vermont DEC believes that these waters are impaired, not water quality limited. This means that when base-level treatment requirements (i.e., BMPs) are in place and working correctly, the water quality impairments should be eliminated.

The 14 waters in the Lake Champlain Basin that are currently listed as being impaired by stormwater are not the only areas in the basin where better stormwater treatment is needed to reduce phosphorus loads to Lake Champlain. However, by focusing initially on the impaired waters, it is likely that the highest priority sites from the standpoint of reducing phosphorus loads to Lake Champlain will be addressed during the process. The phosphorus load reductions expected from implementation of urban stormwater BMPs in some of these watersheds are indicated in Table 19, based on Pease (1997).

The Vermont DEC presented a plan of action in September 2001 which is designed to immediately begin corrective measures within impaired watersheds. This will involve a phased strategy which is cost-effective and efficient to implement, and which will simultaneously eliminate water quality impairments, reduce the expired permit backlog, and address the permitting of new development.

The Vermont DEC will begin immediately to implement a three-part solution to the problem of impaired waters, implemented through the issuance of watershed-specific general permits, referred to as Watershed Improvement Permits (WIP). A WIP will be individually crafted for each impaired watershed. The following three groups of stormwater discharges will be asked to apply for coverage under the applicable Watershed Improvement Permit.

1. Stormwater discharges to the impaired water that have already been issued a stormwater discharge permit or temporary pollution permit (regardless of whether such permit is currently valid or expired).
2. Selected discharges that have been identified by the Vermont DEC as having a large impact on the receiving impaired water.
3. Proposed discharges of stormwater to the impaired water from new development.

A brief description of the Watershed Improvement Permit process for each of these three groups, along with the rationale for their inclusion in this plan, is set forth below.

Existing Permittees

All previously permitted stormwater dischargers will be included under the WIP. This includes all discharges that have previously been issued either a stormwater discharge permit or a temporary pollution permit, regardless of whether such permit is currently valid or expired. To obtain coverage under the WIP, these existing discharges will need to provide to the Vermont DEC a written certification signed by a professional engineer licensed in Vermont, that the existing stormwater management system was built and is currently operating in compliance with the previously issued permit. If such certification cannot be made, the WIP will specify a reasonable time frame for taking corrective action to construct and/or bring the previously permitted stormwater management system into compliance with the previously issued permit. Once this corrective action is taken, an engineer's certification must be provided to DEC. The WIP will also specify that an engineer will need to periodically recertify that the stormwater management system is properly operating and maintained. Finally, the Watershed Improvement Permit will clearly state that the Vermont DEC will periodically conduct scientific monitoring in the impaired water to determine if water quality is improving, and if it is not improving to the satisfaction of the Vermont DEC, additional and more stringent stormwater management measures may be required either through the modification of the WIP, the issuance of a new WIP, and/or through the issuance of individual stormwater discharge permits.

The Vermont DEC believes that this approach toward existing permittees is fair and reasonable. First, this approach merely requires that a permittee demonstrate they are doing what they originally agreed to do. Second, for those permittees whose permits expired, or for those permittees who did apply for renewed permits, this approach eliminates the time-intensive process of notifying expired permittees or reissuing individual permits. Therefore, this approach helps in eliminating the backlog of expired stormwater permits. Finally, from a technical standpoint, the Vermont DEC believes that it will only be necessary to require updated and current treatment standards for some previously permitted stormwater discharges in an impaired watershed to improve water quality and meet water quality standards. In general, once a stormwater treatment design is approved and implemented, proper ongoing maintenance should be the principal focus, not periodic re-design and re-construction. It is inevitable that treatment standards will change over time as the science of stormwater management evolves, but it is neither practicable nor cost-effective to continually retrofit large numbers of these landscape-based treatment systems (e.g., detention ponds, swales, etc.). If the Vermont DEC determines after future monitoring that certain of these systems are causing significant impacts to the receiving watershed, then the Department will address retrofitting these individual systems on a case-by-case basis either through a WIP or an individual stormwater permit.

Selected Stormwater Discharges

Within each impaired watershed there are several entities that, by virtue of their size, location and lack of adequate treatment, have an inordinate detrimental impact on the receiving water. Some of these may have previous stormwater discharge permits or temporary pollution permits, while others may pre-date the permitting program. Regardless of their previous permit status, as significant contributors to impaired waters, and as a result of being dischargers to surface waters, they legally require current permits.

The Vermont DEC will identify all "selected stormwater discharges" to an impaired water covered by a Watershed Improvement Permit using a formula devised by the Stormwater Management Program. This formula will take into account certain factors, including the areal extent of impervious surfaces, efficacy of any existing stormwater treatment, and degree of connectivity to the receiving water. The Vermont DEC believes that it is necessary to selectively require optimized stormwater treatment for these stormwater discharges in order to improve impaired waters. Requiring optimized treatment for these selected discharges is very efficient with regard to benefits versus costs, particularly when considered on a watershed basis. The top tier of these discharges within a watershed will be required to engineer treatment solutions designed to achieve the water quality, recharge, and channel protection requirements of the *Vermont Stormwater Management Manual* (The Center for Watershed Protection 2001).

New Development

At the same time that improvements to existing stormwater management systems are ongoing, the WIP will minimize phosphorus loading from new stormwater discharges by requiring stormwater treatment solutions to meet the requirements of the *Vermont Stormwater Management Manual*.

Erosion and Sediment Control at Construction Sites

Large flushes of phosphorus to surface waters can come from exposed soil at construction sites where there is little or no erosion control. Often these phosphorus sources discharge where erosion and sediment controls are ineffective or not maintained.

Erosion and stormwater control measures need to be designed early in any project planning. If exposed soil is minimized and erosion control measures are properly installed before any soil is disturbed, and maintained well during any construction activities, then soil loss to rivers, streams, and lakes will be greatly reduced. Continued maintenance of erosion and sediment control measures during construction will also greatly reduce sediment discharge. All development, including grading, clearing, and construction of driveways should provide for the retention of native top soil, stabilization of steep hillsides, and prevent erosion and sedimentation of streams and other watercourses.

The goal of construction site erosion and stormwater control is to have properly installed and functioning erosion control measures so that no soil moves offsite or into surface waters or wetlands during the construction process. Additional information on the requirements and measures listed below can be found in the *"Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites"* (Vermont Geological Survey 1982).

The Agency of Natural Resources is a statutory party in the Act 250 process. The Agency regularly comments on those projects that propose impacts on water quality of waters of the state (including Lake Champlain) or that may cause soil erosion.

General Permits are issued for construction projects over five acres in size under the Agency of Natural Resources General Permit for Stormwater Runoff from Construction Sites. The general permit requires an erosion control plan to be developed for each site to prevent erosion and sediment transport. The current General Permit contains conditions that require the submittal of an erosion and sediment control plan for all projects disturbing more than five acres of soil. The stormwater General Permit for construction sites will require developers of all sites disturbing over one acre of soil to apply for a general permit under the Phase 2 Stormwater Rule, effective in March 2003.

Municipal Permits for Developments Disturbing Less than One Acre

Simple erosion control measures are possible for one or two family dwellings and accessory uses. These can include setbacks and buffers along surface waters, wetlands, and property lines so that no soil or water move into these areas. They can also include the use of stone check dams, silt fence, stormwater diversion ditches, designated areas of infiltration, seeding, and mulching. The following erosion control policies and requirements should apply to all development activity, including single family and double family residential development with accessory uses. Site visits from local regulatory individuals should be conducted to ensure compliance with these measures during construction, and to take appropriate enforcement steps if necessary.

Adequate erosion control is required on projects that go through the Act 250 development review process. However, most development is regulated not through Act 250 but through local zoning. At the municipal level, simple erosion control measures should be required for one or two family dwellings and accessory uses through the permit application process. The applicant should provide the following information on the applicable municipal permit application.

1. The locations of any surface waters and wetlands.
2. How the structure and any disturbed soil will remain at least 50 feet from these features.
3. Where the limits of disturbance will be and how the applicant is minimizing the area of disturbance.
4. Where silt fence or stone check dams will be installed.
5. Where any roof and driveway runoff will go to infiltrate once the house or structure is complete.

Projects Requiring State Site Plan and Subdivision Review

The following additional erosion and sediment control policies and requirements apply to projects requiring site plan or subdivision review (e.g., Act 250 or General Permit for Stormwater Runoff from Construction Sites, Stormwater Discharge Permit).

1. An erosion control plan should be prepared for any project requiring site plan review or subdivision plan submission. The plan should incorporate the following principles:

    a. *Fit the development plan to the site.* The development plan shall be designed to fit the topographic, soil, and vegetative characteristics of the site. Extensive soil disturbance on steep slopes, poorly drained soils, shallow to bedrock soils, or highly erodible soils shall be avoided wherever possible. Grading within fifty feet of all water bodies shall be avoided except where necessary for the construction of bridges, stream crossings, and necessary components of stormwater management systems. Consideration shall be given to steps that can be taken to restore and conserve riparian zones, using the Agency of Natural Resources

"Shoreland and Lakeshore Vegetation Management Procedure" (June 16, 1996), or subsequent Agency procedures or rules, as guidance.

b. *Preserve existing natural drainageways and vegetation*. Existing natural drainage and vegetative cover shall be preserved. Existing streams and their riparian zones shall be maintained in their natural condition. Existing natural drainageways that carry stormwater to streams, rivers, lakes, and ponds shall be preserved.

c. *Minimize areas of disturbed soil*. Construction activities shall be sequenced so that the areal extent of disturbed soils left open to erosion at any given time is kept to a minimum. The sequencing shall be discussed in the grading plan.

d. *Minimize the duration of soil disturbance*. The sequence of construction activities shall be planned such that disturbed soil can be protected and stabilized as soon as possible. Emphasis shall be placed on prompt (generally within 48 hours) seeding and mulching of disturbed soils.

e. *Project completion date and winter erosion control*. Whenever possible, projects shall be scheduled for completion and the site stabilized no later than September 15. Perennial cover shall be established by this date. For those projects which must, by necessity, extend past September 15, all measures possible will be taken to limit exposure of soils and additional earthworks. In addition, soil disturbance between October 15 and May 1 shall necessitate the inclusion of a special winter erosion and sediment control plan addressing the specific concerns of winter construction. For those projects where winter construction would present an undue risk to water quality, suspension of construction until the next construction season shall be required.

f. *Erosion control by managing stormwater runoff from upslope and managing water on-site*. Off-site stormwater shall be prevented from entering areas of disturbed soil on-site. On the site, water must be controlled and kept to low velocities, so that erosion is minimized.

g. *Sediment control on-site and at downslope site limits*. Measures should be taken to reduce the amount of sediment mobilized from areas of disturbed soils. To control the sediment that is unavoidably produced on-site, temporary and permanent erosion and sediment control measures appropriate to the site conditions and soils (reference Chapters 4 and 5, and Appendix B of the Erosion Control Handbook) should be implemented. The off-site discharge of sediment produced on the construction site, including off-site tracking of sediment onto paved public or private roadways by construction vehicles, shall be prevented.

2. Measures for controlling erosion and sediment should include the following:

a. Use of diversion dikes to divert overland flow around the construction site into stable, vegetated areas.

b. Establishment of a minimum of 50 foot vegetated riparian buffer along all surface waters and property lines.
c. Application of seed and mulch within 48 hours of grading.
d. Use of stone check dams to trap sediment in areas of lower water flow and velocity.
e. Installation of snow fence and silt fence between the construction area and undisturbed areas to provide a barrier for both machinery and sediment.
f. Implementation of a Winter Sediment and Erosion Control Plan prior to September 15.

3. During construction, tress identified on the landscaping plan should be protected by the following practices.

    a. Snow fencing five feet outside of drip line, or trunk protections and hay bale covering when construction work must be within the canopy.
    b. Trees should be saved in undisturbed groupings, and the groundcover and understory should be protected and kept intact.
    c. Native excavated soils should be stockpiled. Existing vegetation, trees, shrubs, and groundcover should be transplanted from elsewhere on-site or from nearby once construction is complete.

Implementation

In order to ensure that the measures listed above are successfully implemented to reduce phosphorus loading to Lake Champlain from construction site erosion, the following program elements and budget amounts are needed. The program needs listed below will require four FTEs of additional staff at an initial cost of $300,000 per year, plus up to $50,000 in periodically recurring costs for handbook revision.

1. *Training and Inter-Agency Coordinator.*

    a. Training of general contractors and construction personnel for proper implementation of effective sediment and erosion control measures. There is currently no training of this sort available in Vermont.
    b. Training of engineers for the proper components and strategies of erosion and sediment control measures. There is currently no training of this sort available in Vermont.
    c. Creating training interaction between the federal, state, regional, and local levels, which will raise awareness of the requirements and necessity of effective sediment and erosion control. Continued and enhanced cooperation and communication between the various state agencies

to ensure consistency and the highest level of environmental protections for all state agencies These include erosion and sediment control and riparian buffer initiatives. There is currently no staff providing this coordination.

This function would require $60,000/yr for one full-time position for the first two years, which could be reduced to about 0.33 FTE for the next three years and then re-evaluated. The position could be either at the Agency of Natural Resources, or at other organizations such as the U.S. Natural Resources Conservation Service, the Associated General Contractors of Vermont, the University of Vermont Extension Service, or an environmental group with appropriate technical expertise.

2. *Permit Review, enforcement, and compliance.* Additional staff at the Agency of Natural Resources or in the District Offices will be required to fully implement the erosion control aspects of the Lake Champlain Phosphorus TMDL. Staff will be necessary to review and enforce the erosion control plans and perform site visits prior to, during, and after construction to ensure compliance, especially with Act 250 projects. Currently one staff member performs review, compliance, and enforcement of erosion and sediment control measures for all construction sites in the entire state covered under Act 250 and for other sites not covered under any permitting regulation. The same individual performs review, compliance, and enforcement of erosion control for all of the General Permits issued. Each year, approximately 700 Act 250 applications are reviewed by the Agency for impacts on streams and soil erosion. Site visits are performed to ensure compliance. Act 250 has nine districts throughout the state, including five primarily in the Lake Champlain Basin, each with a district coordinator and supporting staff. The Agency's erosion control position assists all of the coordinators and all of the District Environmental Commissions. The trend over the last several years has been towards larger projects, according to annual statistics provided by the Vermont Environmental Board. Larger projects require more earth disturbance and have a greater potential for soil erosion.

   $150,000/yr for two full-time positions at the Agency of Natural Resources to review erosion and sediment control plans, ensure implementation at the construction site, and pursue enforcement and corrective actions in the five districts in the Lake Champlain Basin.

3. *Adoption of the federally required General Permit for Stormwater Runoff from Construction Sites to reduce unpermitted disturbances of areas greater than five acres to areas less than one acre*. The General Permit requires the development of an erosion and sediment control plan. The adoption of the revised General Permit extending jurisdiction to sites one acre in size or larger will require the review of hundreds of more construction sites for erosion and sediment control. It is estimated that approximately half of the general permits in Vermont issued for stormwater runoff at construction sites will be in the Lake Champlain Basin.

   $75,000/year for one full-time position at the Agency of Natural Resources to review permit applications and erosion and sediment control plans, perform site visits, and ensure compliance with the General Permit.

4. *Erosion Control Handbook revision*.

The current handbook was originally published in 1982 and was last revised in 1987. This handbook is considered the official document guiding erosion and sediment control for construction sites throughout the state, including municipal guidance. The handbook needs to be updated immediately, and then revised periodically.

$10,000 to $50,000 for publishing costs and handbook content development.

Better Backroads

The condition of gravel roads can be a significant nonpoint source issue depending on how the roads are maintained and upgraded. The majority of gravel road miles in Vermont are maintained by municipalities, and Vermont towns average about 46 road miles each. Although the specific phosphorus loading component of road runoff has not been quantified in the Lake Champlain Basin, informal observations over the years lead one to the conclusion that in-stream turbidity following a rain event can often be attributed to road erosion. Vermont's town roads effectively become part of the stream network during a storm or snowmelt event, with the roadside ditches often discharging directly into streams, lakes, or wetlands. A survey of Rutland County towns (Rutland County Natural Resources Conservation District 1999) estimated conservatively that 5,600 cubic yards of road gravel leaves the roads in Rutland County and enters the waterways annually.

Infrastructure needs and water quality concerns can go virtually hand-in-hand. The very mechanisms that will protect a town's investments in their roads will also prevent sediment and phosphorus pollution of surface water. The major challenges in this partnership are insufficient road maintenance funding both locally and at the state level, lack of good planning and ordinances at the local level, and the need for increased education and visibility of this important issue.

An emerging issue involves the proliferation of driveways along town roads. The past two decades have seen a trend toward development of house lots on country roads. Increasingly, these driveways are being installed on steeper land and for longer distances. Many town road managers recognize the threat that increasing number of driveways pose to the stability of town roads. As a driveway cuts across a hillside, it intercepts and channelizes natural overland flow and its ditches receive drainage from the developed house lot. Driveway erosion and increased flow to the town road ditches produce a strain on town infrastructure and an increase in flash flood susceptibility. As the flow in roadside ditches increases with each new driveway, culverts become undersized or clogged, the ditch itself may begin eroding, and surface waters receive increased amounts of sediment phosphorus and flow volume.

Town road commissioners recognize "good drainage" as the primary road maintenance need. The Vermont Local Roads Program, located at St. Michaels College and funded through state and federal transportation funds, has been providing technical training, information, and on-site assistance to town road managers for many years. While the primary focus of this program has not been on water quality protection, many of the needed maintenance activities will also prevent or reduce erosion and thus water pollution. However, lack of funding and knowledge can prevent these practices from being fully used.

The Vermont Better Backroads Program, a coalition of Vermont organizations, began in 1994. Its goal is to address the need for increased education and funding for town road maintenance and erosion control issues that can specifically reduce water pollution. The *"Vermont Better Backroads Manual"* (Windham Regional Commission 1995) describes the maintenance practices that will achieve this result. A series of workshops for road managers and crews has been offered around the state since 1995. The publication of three additional guides since then has added to the written information available. Beginning in 1997, small grants were offered to towns to correct road erosion problems. Then in 1998, a grant category to fund road inventory and capital budget planning grants was added to the grant program. This program is aimed at helping the towns fix erosion problems in a systematic manner, and to encourage them to make the funds available to fix a problem in a long-lasting way. Since 1997, a total of $105,829 has been awarded to towns in the Lake Champlain Basin for 35 erosion correction projects, and $28,852 has been awarded for 11 capital budget planning projects.

The following prevention, management, restoration, and education actions are needed throughout the Vermont portion of the Lake Champlain Basin in order to reduce phosphorus loading from backroad erosion.

Prevention

As with any problem, prevention should be a front line strategy, as it is the most effective and practical. All of these mechanisms must be instituted at the local level, but the Vermont DEC and regional and basin organizations should participate in promoting their value.

1. *Good town planning that considers the potential and adequacy of infrastructure*. Too often, roads are widened as traffic increases without concurrent improvement in the drainage and ditch infrastructure. Towns need to develop planning methods that will hold the line on road use or speeds unless the road can be completely upgraded to handle the increase traffic. A guide to evaluating roads from this point of view needs to be developed, and then made available through the Better Backroads Program.

2. *Upgrade of infrastructure to reduce flash flood susceptibility*. It has been demonstrated that up to 60% of damage sustained during flash flood events is avoidable if the infrastructure is adequate. In the case of roads, this involves such measures as adequately sized culverts, stable culvert headers, and rock lining ditches on slopes over 5%. These same basic practices would also prevent much everyday erosion. The Better Backroads Program developed some basic guidelines called *Road Drainage and Erosion Control: Two Models for Developing a Town Inventory and Capital Budget* (Vermont Better Backroads Program1999). This and other guides and computer programs are available to municipalities. Flash flood considerations should be more fully integrated into the documents and programs.

3. *Employ good driveway access standards and methods to reduce road length in developments*. As mentioned above, driveways are increasingly recognized as a threat to the stability of town ditches and culverts. A town can adopt driveway access standards to prevent the increase of sediment and flow that could exceed the capacity of the town roads and ditches. The publication *"Developing a Highway Access Policy: Guidelines and a Model Ordinance"* (Vermont Local Roads Program 1997) is available through any of the Vermont Better Backroads partners.

Management and Restoration

Decisions made every day by the road managers and crews affect the erodability of the roads. In some cases, road managers do not have adequate information to protect a road from erosion, or they are given insufficient funding and staff to do so. In other cases, they lack the extra funds to do a job right instead of resorting to quick fixes. Increased efforts should be made to get out proper maintenance information through workshops and other means. Education should be focused on other town officials and even town residents so they can request certain standards of road work. In addition, state or regional funding can help reinforce these concepts to road managers through the funding of "best fix" projects.

1. *Adhere to good road maintenance standards*. Town officials need to consider it a priority to meet certain basic maintenance standards. The Better Backroads manual is available, along with a pocket guide that can easily be taken into the field. Selectboards should budget for any extra expenses, such as renting an excavator for proper ditch shaping. Information and outreach should continue to be provided by the Better Backroads Program, the Local Roads Program, and through the Natural Resource Conservation Districts.

2. *Create a "check list" of critical considerations as a first step toward "AMPs" for gravel roads.* While the Better Backroads Manual provides much information on techniques, a concise list of standards would be helpful in calling attention to certain issues. In particular, there are a series of specific practices that need to be promoted because town officials do not always appreciate their relevance to both road stability and water quality. These practices include stabilizing back slopes and banks, installing culvert headers, and cleaning ditches before September 15 so they can be re-seeded before winter.

3. *Conduct road inventories to identify erosion problems and to support the development of capital budgets*. Towns are often caught in the routine of "band-aiding" problems instead of fixing them adequately. However, the best fix is often more expensive in the year of installation than any one year of the quick fix. With a road inventory, town road managers can help make a case for systematic fixing of on-going problems. Continued and increased funding of the "Road Inventory" portion of the Backroads Program grants should be supported. Towns participating in the Better Backroads small grant program should be required to have a road inventory and capital budget plan in order to receive funds on an on-going basis. Many towns are initiating this process as a result of incentives under certain programs by the Vermont Agency of Transportation. The

Vermont Local Roads Program and some regional planning commissions provide training and technical assistance for electronic programs. Increased technical assistance is needed to guide towns through this process. A partnership between the Better Backroads Program, regional planning commissions, the Local Roads Program, and Natural Resource Conservation Districts could achieve this goal.

4. *Increase funding to help towns cover the costs of correcting erosion problems*. Continued funding should be linked to the adherence to good maintenance procedures throughout the town. Priorities should be established for bringing in new towns to the Better Backroads and Local Roads programs.

5. *Ensure that repairs will reduce vulnerability to flash floods*. As erosion control restoration or other work is being done, sizing and design standards should be used that will withstand the forces of high runoff events. As noted previously, the publication *"Road Drainage and Erosion Control: Two Models for Developing a Town Inventory and Capital Budget*" should be updated by the Better Backroads Program to more thoroughly integrate an evaluation for flash flood susceptibility.

6. *Explore ways to share equipment between towns to reduce the cost of maintenance*. Most towns have to rent an excavator to clean roadside ditches. Availability of the equipment is one reason why some towns clean ditches in November instead of during the growing season when grass seed could be used to stabilize them. The Lamoille County Conservation District purchased a hydroseeder that can be used at a reduced cost by county towns to ensure stabilization of cleaned ditches. Conservation Districts are likely organizations to help with this kind of equipment sharing program.

Education

All of the elements of successfully reducing road erosion rely heavily on good education and outreach. Some specific ideas are listed below.

1. *Continued incorporation of erosion control into the Local Roads Programs workshop offerings*. Due to turnover of town road managers and staff, training must be continually available. Workshops could also be organized through a regional or basin organization, with the technical assistance and speakers provided by the Better Backroads Program, to focus education on a watershed basis. Additional funding would be needed to offer such workshops.

2. *Increased education to town officials regarding the potential impact of roads on surface water and the financial benefit to the town of good road maintenance*. Again, workshops could be organized through a regional or basin organization.

3. *Education of town selectboards, tree wardens, planning commissions, and conservation commissions about road maintenance needs*. Road managers who are committed to erosion

control will still need the support of town officials and voters. In particular, town residents and planning and conservation commission members need to understand the basics of maintaining roads so they don't unknowingly oppose work that will reduce the polluting impact on surface water. For instance, a well-shaped ditch is often wider and deeper than most people like to see. In addition, some maintenance measures require the cooperation of landowners, such as siting a new culvert. The conservation districts and regional planning commissions could play a critical role in this outreach.

Implementation

In order to ensure that the necessary actions occur to reduce phosphorus loading to Lake Champlain from Vermont backroads, the following program elements and budget amounts are needed.

1. *Increase the small grant funds available to towns under the Better Backroads Program in order to increase participation of Champlain basin towns.* Allow 10% of these funds to be spent on administration by the Northern Vermont Resource Conservation and Development Council (RCDC). In addition, 25% of a staff position, housed either at the Northern Vermont RCDC or the Vermont Local Roads Program, would be able to encourage town participation and aid with the application process, thus increasing towns' participation. Require towns to adopt a Capital Budget Plan that includes long-term plans to correct chronic problems in order to continue receiving grants after the second small grant.

   $60,000/year increase in grant funds to be targeted to Lake Champlain Basin towns through 2012, after which the amount could be reduced to $25,000/yr.
   $18,750/year for 25% of a staff position with travel expenses to work on participation with basin towns.

2. *Add a second "circuit-rider" to the Local Roads Program to offer on-site erosion control technical assistance to Lake Champlain Basin towns.* Assistance would be for both on-site problem solving, as well as assistance with road inventories and development of capital budgets. This 25% of a staff position would also offer workshops and presentations at a local level to showcase good projects to neighboring towns.

   $18,750/year for 25% of a staff position with travel expenses at the Vermont Local Roads Program.
   $10,000/yr for workshop expenses.

3. *Provide funding to conservation districts and regional planning commissions to conduct workshops within their region on erosion control techniques and capital budget planning for road managers, and on the basics of road maintenance needs and policies to support these techniques for selectboards and other town officials.*

$17,000/yr, for two out of every five years, for workshop expenses, oversight, and technical assistance by the Northern Vermont RCDC.

4. *Update the publication "Road Drainage and Erosion Control: Two Models for Developing a Town Inventory and Capital Budget" to incorporate the identification of infrastructure needs for reducing flash flood susceptibility.* The Vermont Better Backroads Program should oversee this effort.

   $15,000 for publication costs, with periodic updates and reprinting at $5,000 each time.

5. *Develop a concise list of basic minimum road standards that can be used as a checklist for town road managers, as public education, and as a first step toward developing Acceptable Management Practices (AMPs) for town roads.* Towns should be encouraged to meet these standards as incentives for various grants as a first step, and compliance should be evaluated.

   $8,000 for the development and publication of basic road standards by the partners of the Vermont Better Backroads program, including some local road managers.
   $10,000 every five years for outreach through workshops and on-site assistance by regional organizations.

6. *Develop a pilot equipment sharing project within the basin through a conservation district.* Work with the Lamoille County Conservation District to evaluate and improve their project. Solicit interest in another Conservation District and initiate a project. Offer affordable rental to county towns for a hydro-seeder.

   $2,000 for project initiation through the Vermont Better Backroads Program and a conservation district.
   $20,000 for equipment.

7. *Sustain the existing commitment of Agency of Natural Resources staff time to the Vermont Better Backroads Program.* Agency staff involvement is needed to ensure that the water quality focus of the program is sustained and that the additional activities listed above proceed.

   $7,500/year for 10% of a staff position.

Local Municipal Actions

There are 136 Vermont cities and towns that are either wholly or partly within the Lake Champlain Basin (Table 20). In many cases, the delivery of phosphorus to Lake Champlain from developed land results from activities that are under the jurisdiction of municipalities. Important opportunities exist to reduce phosphorus loading and protect water quality in general through actions taken at the local municipal level, as described in Vermont DEC (1999). Local actions necessary to prevent phosphorus loading from backroads and from small construction sites were described in previous sections.

Table 20. List of Vermont cities and towns either wholly or partly within the Lake Champlain Basin.

Addison	Fairfax	Montgomery	South Hero
Alburg	Fairfield	Montpelier	St. Albans
Bakersfield	Fayston	Moretown	St. Albans City
Barre City	Ferrisburg	Morristown	Stannard
Barre Town	Fletcher	Mount Holly	Starksboro
Belvidere	Franklin	Mount Tabor	Stowe
Benson	Georgia	New Haven	Sudbury
Berkshire	Goshen	Newport	Swanton
Berlin	Grand Isle	North Hero	Tinmouth
Bolton	Granville	Northfield	Troy
Brandon	Greensboro	Orange	Underhill
Bridport	Groton	Orwell	Vergennes
Bristol	Hancock	Panton	Waitsfield
Brookfield	Hardwick	Pawlet	Walden
Burlington	Highgate	Peacham	Wallingford
Cabot	Hinesburg	Peru	Waltham
Calais	Hubbardton	Pittsford	Warren
Cambridge	Huntington	Plainfield	Washington
Castleton	Hyde Park	Plymouth	Waterbury
Charlotte	Ira	Poultney	Waterville
Chittenden	Jay	Proctor	Wells
Clarendon	Jericho	Richford	West Haven
Colchester	Johnson	Richmond	West Rutland
Cornwall	Killington	Ripton	Westbridge
Craftsbury	Leicester	Roxbury	Westfield
Danby	Lincoln	Rupert	Westford
Dorset	Lowell	Rutland	Weybridge
Duxbury	Marshfield	Rutland City	Wheelock
East Montpelier	Mendon	Salisbury	Whiting
Eden	Middlebury	Shelburne	Williamstown
Elmore	Middlesex	Sheldon	Williston
Enosburg	Middletown Springs	Shoreham	Wolcott
Essex	Milton	Shrewsbury	Woodbury
Fair Haven	Monkton	South Burlington	Worcester

Additional municipal policies and actions are needed throughout the Vermont portion of the Lake Champlain Basin in order to protect riparian buffer zones and to reduce the creation of impervious surfaces by new development. These actions are necessary to minimize future increases in phosphorus loading as land is converted to developed uses.

Riparian Buffers

A riparian buffer is a band of vegetation between human land uses and surface waters that serves in many ways to protect the water quality and aquatic habitat of the adjacent river, stream, lake, pond, or wetland. A buffer needs to have certain characteristics in order to provide a phosphorus removal function. The most effective buffer is a natural, diverse, multi-layered plant community with a well-developed duff layer, uneven and uncompacted ground surface, natural obstacles (e.g., downed trees, rocks, branches), and no eroded or channelized routes for water to take through the buffer zone.

The phosphorus removal effectiveness of vegetated buffers depends on the width of the buffer zone, the hydrologic soil group within the buffer, the average slope of the buffer area, and the type of vegetation in the buffer. There is no minimum statewide setback or buffer requirement in Vermont. Vegetated buffers are required on projects adjacent to surface waters that go through the Act 250 land use permit review process, but for most development activity, buffer protection depends on local level decisions.

Towns should adopt a minimum setback and buffer requirement on all rivers, streams, lakes, and ponds. This requirement can be included as one of the general regulations in the zoning bylaws, and then would apply to all projects town-wide. Alternatively, a buffer requirement could be included as a district standard, and the setback and buffer distance could vary depending on the nature of the district.

The Agency of Natural Resources Draft Riparian Buffer Procedure (7/27/01) recommends a buffer zone width of 50-100 feet for streams and 100 feet for lakes, with greater or lesser widths possible when on-site evaluations are conducted by appropriate staff. The recommendations in the draft buffer procedure are directed at projects subject to Act 250 permitting or other Agency of Natural Resources regulatory programs. However, similar provisions would be appropriate to implement at the local level in order to reduce phosphorus loading to surface waters in the Lake Champlain Basin.

Impervious Surface Minimization and Site Design

Impervious surfaces are surfaces which cannot be effectively penetrated by water. Examples include pavement, buildings, and gravel surfaces. There is a direct link between impervious surface coverage and phosphorus export to surface waters. Replacing natural cover and soils with impervious surfaces will lead to greater phosphorus loading to surface waters, increased runoff volume and velocity, and long-term, adverse hydrologic changes through flooding and channel erosion. Pavement areas such as streets, driveways, and parking lots, produce the most serious phosphorus runoff potential. Commercial, industrial, and high-density residential land uses often contain the most impervious surfaces used by vehicles.

Careful site planning can reduce the impervious area created by pavement and roofs and the volume of runoff and phosphorus loading. Careful site planning can also preserve the natural topography, drainage, and vegetation by preserving intact as much as possible the natural features that help retain runoff. Natural depressions and channels act to slow and store water, promote sheet flow and infiltration, and filter out phosphorus-bearing sediment.

Zoning codes and development standards affect the amount of runoff generated by projects by defining street widths, housing densities, setback distances, and other factors. Development standards should encourage minimization of impervious surfaces and use of open vegetated channels for stormwater runoff. Provisions for narrower streets, shorter or shared driveways, smaller parking spaces, and reduced setback distances from roads should be part of urban or suburban zoning regulations. Alternative modes of transportation such as mass transit, bike paths, and commuter parking areas should also be encouraged in order to reduce the need for new roads and parking.

Towns can use subdivision regulation standards to minimize the creation of new impervious surfaces (Vermont DEC 1999). Planned residential and planned unit developments that concentrate development while maximizing open space should be encouraged. Open space preservation should maximize natural surface water corridors and buffers. Existing parking ratio requirements should be reviewed to see if lower minimum ratios are warranted and feasible. Maximum parking ratios should be established in order to curb excess parking construction. The initial subdivision proposal should ensure that lots with difficult access are not created.

Implementation

There is a need for technical assistance for Vermont municipalities to support the process of revising zoning regulations or other municipal ordinances to provide better water quality protection. Efforts to ensure that water quality protection considerations are built into local municipal actions would be enhanced by the creation of a dedicated position for this purpose. This position could be located at the Vermont League of Cities and Towns, the Lake Champlain Basin Program, or the Vermont Agency of Natural Resources. The cost for one full-time position would be approximately $75,000 per year.

Forest Nonpoint Sources

Performance standards titled "*Accepted Management Practices (AMPs) for Maintaining Water Quality on Logging Jobs in Vermont*" were adopted in 1987 by the Vermont Department of Forests, Parks, and Recreation. The AMPs include measures to prevent soil erosion and other forms of water pollution from truck roads, skid trails, stream crossings, and log landings. Compliance with the forestry AMPs limits the liability to some extent of logging operations from enforcement of certain state water quality regulations.

Phosphorus loads to Lake Champlain from forest lands are small relative to loads from other nonpoint sources in Vermont (Table 9). The nonpoint source phosphorus load allocations (Table 10) require only that forest sources be held to existing levels. For the purpose of the Lake Champlain Phosphorus TMDL, it will be assumed that compliance with the AMPs will prevent increases in phosphorus loading from logging activities in Vermont. Adherence to the Vermont forestry AMPs is actively encouraged by the Department of Forests, Parks, and Recreation and by professional forestry organizations through workshops and other educational efforts.

Stream Stability

Regardless of land use category, the relative stability of the fluvial systems draining the watershed may have significant impact on the level of phosphorus loading. The phosphorus contribution of streambank and channel erosion is not presently accounted for in the phosphorus export modeling analysis (Hegman et al. 1999). Stream channel instability occurs throughout Vermont watersheds in the Lake Champlain Basin.

For instance, the Missisquoi River basin has both systemic channel instability and a high phosphorus load. In a segment of the Trout River, one of the Missisquoi's largest tributaries, the Vermont Agency of Natural Resources (2001) estimated the discharge of 6.9 metric tons of total phosphorus from two channel avulsions across agricultural fields subsequent to the 1997 flood.

A streambank condition inventory and map of the Wild Branch (in the Lamoille River watershed) in Wolcott, Vermont by the Lamoille County Planning Commission in 1999 described approximately 80% of the total stream length as suffering from head cutting and/or undercutting, sloughing, or mass wasting of streambanks.

An inventory of riverbank lands owned by the Vermont Agency of Natural Resources along the Lamoille River, conducted by the Vermont Department of Fish and Wildlife in 1998, found that 37% of streambanks were "actively eroding or slumping into the river." The report also noted that "the greater alarm is that this (condition) appears to be representative of all 170 miles of riverbank, both public and private, along the Lamoille's 85 mile length."

The condition of instability (channel adjustment processes) of stream channels generally can be traced to anthropogenic sources such as developments within active flood plains (including dwellings, roads, and bridges), channel management activities such as gravel mining, bank armoring, dredging or channelization, removal or suppression of vegetation in the riparian zone, and changes in watershed hydrology such as increased stormwater runoff or water diversions. These human influences usually result in a physical stream response as the fluvial system attempts to regain a balance between its watershed inputs and its capacity to transport those inputs. This physical adjustment process may oftentimes be manifested both spatially and temporally remote from the location or time of disturbance. Cause and effect relationships are therefore often obscured by the passage of time and the magnitude of physical separation.

The fluvial geomorphic adjustments that occur in response to disturbance are part of a predictable process that often results in intractable conflicts with human investments along riparian corridors such as transportation infrastructure, agricultural lands, and residential and commercial properties. As these conflicts build, traditional channel management activities contribute to a vicious cycle of ever-increasing conflict and instability. Similarly, existing flood plain management mechanisms inadequately protect against encroachments that directly or indirectly lead to greater channel instability and increased magnitude of sediment discharges.

A successful implementation plan for reduction of fluvial sources of phosphorus should embrace a five-part strategy for the riparian corridor involving the elements of **Assessment, Protection, Management, Restoration, and Education.**

Assessment

Implementation of the four following strategies will be critically supported by the outputs of a geomorphic assessment of the physical condition, sensitivity, and adjustment process of discreet stream reaches and identification of the channel, flood plain, and watershed management history that dictates the present stream condition. Assessment, as key to supporting avoidance strategies, may be orders of magnitude more cost effective through limitation of future increases in erosion and soil loss than retrofitting of existing disturbance regimes. Implementation of a comprehensive assessment program will involve the following elements.

1. *A basin-wide or watershed stream geomorphic assessment that identifies the physical condition, sensitivity, and adjustment process of each stream reach.* Watershed associations, Natural Resource Conservation Districts, and Regional Planning Commissions around the state have expressed interest in performing assessments. A program to develop assessment protocols and reference data is being piloted by the Vermont DEC.

   Projected cost: $10,000 per 100 square miles, or approximately $460,000 over 10 years plus 0.5 FTE in Vermont DEC River Management Program for training and quality control assurance @ $37,500/year.

   Projected benefits: Public benefits will be realized through tens of millions of dollars of avoided flood and erosion losses over the life of the plan. Increased protection of fluvial stability through the avoidance of riparian corridor development, and the channel management activities and channel adjustments that inevitably occur to protect development from flooding and erosion. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

2. *Establishment of an statewide river management database system accessible to resource, land use, and infrastructure managers at all governmental levels, and to consultants, the economic development community, and to landowners.* The Vermont DEC River Management Program (RMP) will serve as a technical resource supporting the identification of stream types and fluvial processes, the avoidance of conflicts, the resolution of existing stream stability and erosion hazard problems, and the restoration of impaired or dis-functional riparian corridors. The RMP will manage the fluvial data management system.

Projected cost: $75,000 to complete development and application (personnel costs) plus 0.5 FTE in Vermont DEC River Management Program @ $37,500/year to enhance the system for the first five years of operation and 0.25 FTE to maintain the system for the remaining period of the plan. Total cost is $75,000 one time, $37,500 annually for five years and $18,750 annually thereafter.

Projected benefits: Will profoundly enhance the efficiency of channel management practices associated with property protection, habitat enhancement, phosphorus reduction, flood response and recovery, transportation infrastructure maintenance and improvement and will be critical to support the assessment initiatives noted in Protection (1) above. Benefits may exceed $10,000,000. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

3. *Building the capacity and technical capabilities of watershed groups, Regional Planning Commissions, and the consulting community to conduct watershed level stream stability assessments as part of the basin planning process.* Current stream conditions and type of instability should provide the basis for the alternatives analysis and a prioritization of restoration reaches within each basin plan.

   Projected cost: 0.25 FTE ($18,750) annually, beginning in the second year of the plan and continuing for 10 years, for the Agency of Natural Resources to provide technical assistance and guidance.

   Projected benefits: Strengthens and empowers partnerships. Provides mechanism for regional or watershed level organizations to support municipal government to deal with existing conflicts with fluvial systems and avoid exacerbating existing conditions. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

Protection

Protection of stable, functioning, fluvial systems from the anthropogenic encroachments and influences that lead to channel adjustment is orders of magnitude more cost-effective as a phosphorus control measure than restoration of unstable rivers. Implementation of an effective and comprehensive riparian corridor and watershed protection strategy will involve the following elements.

1. *An erosion hazards/stream stability map that assists in the identification of the magnitude of riparian corridor necessary to maintain a stable, functioning, fluvial system.* The Vermont Geological Survey in cooperation with the Vermont DEC and the Vermont Division of Emergency Management is currently developing the mapping methodology. Such mapping may become a critical element of local natural hazard mitigation plans as recommended by FEMA and, as such,

will provide an important incentive for municipal buy-in to the fluvial assessment and protection strategies.

Projected cost: Average of $5,000 per municipality, or approximately $500,000 over 10 years plus 0.5 FTE in Vermont Geological Survey staff to publish maps and quality control assurance @ $37,500/year.

Projected benefits: Same as Assessment (1) above.

2. *Support the adoption and implementation of community and individual land use management or protection mechanisms that minimize conflicts between the physical imperatives of fluvial systems and human investments on the landscape.* These mechanisms should be guided by the outputs developed in Assessment (1), and Protection (1) above.

   Projected cost: $500,000 annually in increased incentives to local government through state and federal grant authorities for adoption of meaningful riparian corridor protection mechanisms including easement acquisitions. This includes 0.5 FTE @ $37,500/year, possibly within the Department of Housing and Community Affairs, to assist communities and 0.5 FTE @ $37,500/year within Vermont DEC to provide technical assistance to project applicants local review boards and District Commissions.

   Projected benefits: Same as Assessment (1) above.

Management

Management of fluvial systems and addressing the everyday conflicts of fluvial geomorphology and human investments in the landscape may have profound impacts on the volume of phosphorus discharged in the Lake Champlain Basin. Unfortunately, these day-to-day conflicts often arise from a alarming cycle where instability and erosion caused by a flood are followed by channel management activities that may cause streams to unravel further and be susceptible to damage during the next flood. Implementation of an effective and comprehensive riparian corridor and watershed management strategy will involve the following elements.

1. *An expansion of agricultural BMP's to provide greater emphasis on riparian corridor management activities. This will require increased funding emphasis on riparian corridor management by government funded agricultural programs and assurance that riparian corridor treatment projects are consistent with stable fluvial geomorphic processes.* Programs include the U.S. Department of Agriculture programs such as the Conservation Reserve Enhancement Program (CREP), the Wildlife Habitat Incentives Program (WHIP), the Environmental Quality Incentive Program (EQIP), the Agricultural Management Assistance Program (AMA), and the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program. This effort should include incentives at the state level for cooperators' implementation of any of these riparian corridor management practices. Examples of enhanced practices or standards would include

identifying highly erodible flood plain soils (those located on low terraces and susceptible to channel avulsions if row-cropped), distinguishing (from a programmatic incentives and P reduction effectiveness standpoint) between grassed and woody buffers, and assuring that channel and streambank management practices are compatible with the long term maintenance of stream stability.

Projected cost: The cost of all needed riparian buffer installation and streambank repair in the Vermont portion of the Lake Champlain Basin, including technical assistance costs, was estimated by the Lake Champlain Basin Program (2000) to be $15.3 million. The additional cost of lost agricultural production over a ten-year period on land used as buffers would be approximately $4.6 million. The total funding need is therefore about $20 million. If funded under the CREP program, 80% would be provided as the federal share and 20% would be the state share. These program needs and costs were included in the previous section on agricultural nonpoint sources.

Projected benefits: Tens of millions dollars through implementation of permanent, sustainable agricultural practices in critical areas. Long-term benefits will accrue from assuring sustainable use and conservation of the most productive agricultural soils, protecting and restoring recreational values and ecological functions of fluvial systems and avoiding practices that have historically exacerbated rather than alleviated channel stability problems or physical adjustment processes. Benefits may exceed $25,000,000. Agriculture related reduction of fluvial erosion and soil loss and its associated phosphorus component will be reduced.

2. *An expansion of silvicultural Accepted Management Practices (AMP's) which distinguish, via slope and soil classifications, between land that can support bare ground harvesting operations vs. land that should only be worked when frozen or snow covered.* The surface water hydrology of certain large tracts of forest land can be significantly disturbed by a network of deep-rutted skidder trails across the drainage basins which translates into channel instability.

   Projected cost: 1.0 FTE in forest management programs (educational and AMP compliance) annually @ $75,000. Total of $75,000 annually.

   Projected benefits: Protection of forest hydrology, sustainable forest productivity, and prevention of de-stabilization of downstream stream channels. Will reduce the forest source related erosion and soil loss and its related phosphorus component.

3. *A commitment by emergency management agencies, local government, resource managers, and landowners to recognize the physical imperatives of fluvial systems in flood recovery operations and flood prevention or mitigation projects.* This involves taking a reach or watershed level approach to identification of the cause of channel instability rather than treating the symptom of erosion. Full participation by Vermont DEC River Management Program staff in flood recovery and prevention operations would help accomplish this goal.

Projected cost: 1.0 FTE @ $75,000 annually in the DEC River Management Program to support this recommendation.

Projected benefits: Benefits are largely captured in Assessment (1 & 2) and Protection (1 & 2) above.

Restoration

While the most egregious and highly unstable channels may be threatening public infrastructure or private property and may be resulting in very large sediment and phosphorus discharges, restoration of unstable riparian corridors to a natural, stable condition may be one of the most expensive components of a phosphorus reduction strategy. Nevertheless, the social and commerce driven imperatives to carry out restoration projects provide tremendous opportunities to reduce sediment-carried phosphorus discharges and to restore aquatic ecosystems. Implementation of an effective and comprehensive riparian corridor and watershed restoration strategy will involve the following elements.

1. *Training and enabling in-state consultants and contractors to evaluate geomorphic stream restoration alternatives and to design and implement natural stable stream restoration projects.*

   Projected cost: 0.25 FTE annually for 5 years for training purposes ($18,750 annually).

   Projected benefits: Builds a technical constituency that can economically provide technical services where demands far exceed agency resources. Benefit may exceed $100,000 annually after five years. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

2. *Completing restoration demonstration projects based on natural channel design techniques throughout the Lake Champlain basin.* The Vermont DEC has completed six natural channel restoration projects, including three within the Lake Champlain Basin. Dozens of large scale project opportunities exist. The public education value of high profile restoration demonstration projects of this type are invaluable in terms of re-framing the public's perception of its relationship with fluvial systems.

   Projected cost: $500,000 as seed funding to support 5-10 large natural channel restoration projects in high priority, high profile areas annually for 10 years plus 2.0 FTE as a Project Coordinator/Manager and a Restoration Projects Technician in the DEC River Management Program @ $150,000 annually, for total of $750,000 annually.

   Projected benefits: $20,000,000 dollars in protection of infrastructure and property from flood loss, restoration of recreational values and ecological functions, and aesthetic and intrinsic benefits. Will reduce fluvial erosion and soil loss and its associated phosphorus component.

Education

The physical functions within a watershed relating to stream channels, floodplains, and riparian corridors, are not commonly understood. To implement the protection, management, and restoration strategies outlined above will require a multimedia watershed education program targeted at landowners, municipalities, consultants, watershed associations, public sector scientists and engineers, and other parties interested in the basin planning process. A watershed education program that effectively builds the constituency necessary for reducing fluvial sources of phosphorus will involve the following elements.

1. *A stream stability field and computer assessment course centered in the Lake Champlain Basin to train the broad range of professional, student, and volunteer technicians that will be involved in stream stability assessments.*

   Projected cost: $25,000 start-up cost and 0.1 FTE annually to support @ $7,500.

   Projected benefits: Builds and supports technical infrastructure throughout stakeholder organizations partnering in implementation of previous recommendations. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

2. *Animated video presentations that can demonstrate the spatial and temporal adjustments of stream channels to historic channel, floodplain, and land use practices.*

   Projected cost: $60,000 production costs plus 0.33 FTE of technical support through production @ $25,000/year over three years.

   Projected benefits: Increased public awareness of human relationships with fluvial systems. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

3. *A fact sheet series available on the internet that addresses a range of stable stream science and management related topics.*

   Projected cost: 0.5 FTE @ $37,500 for one year plus $10,000 operational outlays for a total of $47,500.

   Projected benefits: Supports development and implementation of fluvial conflict avoidance, management, restoration and education strategies and increases public awareness of human relationships with fluvial systems. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

4. *A comprehensive economic analysis of different channel and floodplain management and land use alternatives that examines the short and long term costs associated with various erosion control, flood hazard mitigation, and phosphorus reduction strategies.*

   Projected cost: 0.25 FTE @ $18,750 for one year plus $5,000 operational outlay. Total of $23,750.

   Projected benefits: Builds public support for riparian corridor management initiatives. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

5. *Technically and financially support sustainable research partnerships between academia and state government in the area of fluvial processes.* Much needs to be learned about how to successfully manage the fluvial/human investments conflicts. There are many unanswered questions about how to sustainably manage fluvial functions and resources within the social and cultural context or our landscape and economy.

   Projected cost: $100,000 annually over 10 years including 0.25 FTE @ $18,750/year and research funding.

   Projected benefits: Builds and supports technical infrastructure throughout stakeholder organizations partnering in implementation of previous recommendations. Supports development and implementation of fluvial conflict avoidance, management, restoration and education strategies and increases public awareness of human relationships with fluvial systems. Will indirectly influence the reduction of existing and avoidance of future increases in fluvial erosion and soil loss contributing to a reduction in erosion related phosphorus loading.

Wetland Protection and Restoration

One of the most commonly cited functions of wetlands is their ability to maintain and improve the water quality of adjacent streams, rivers, and lake. This is largely due to their unique position in the landscape, with many wetlands located between upland areas and streams, rivers, or lakes. Surface runoff often flows through riparian wetlands prior to discharging into streams, rivers and lakes. Phosphorus-containing sediment is deposited in riparian wetlands as surface runoff flows through dense wetland vegetation. The associated pollutants can then be absorbed by the vegetation through nutrient uptake.

The importance of riparian wetlands in the retention and removal of significant amounts of sediment and phosphorus from runoff has been well documented in the scientific literature. The importance of wetlands in nutrient uptake is now widely recognized, and artificial wetlands are often created to mimic the water quality benefits of natural wetlands.

Implementation

The measures listed below will help protect and restore wetlands that have an important role in reducing phosphorus loading into Lake Champlain.

1. *Improve the staffing of state programs that protect wetlands.* The State currently has jurisdiction over riparian wetlands through a variety of regulatory programs, including the Vermont Wetland Rules, Act 250, and the 401 Water Quality Certification. These existing programs can be use to maintain the water quality benefits of riparian wetlands. However, the State Wetlands Program is inadequately staffed to undertake the additional work necessary to fully address the needs of the Lake Champlain Phosphorus TMDL, such as proactive work and educational and planning efforts. Additional staffing would allow the program to protect wetland resources to the maximum extent allowable, while affording time for critical educational and planning efforts.

   $75,000 per year to fund one full-time position at the Agency of Natural Resources to review projects that impact wetlands in the watershed, conduct outreach and education, and participate in planning studies.

2. *Develop and implement a wetland restoration plan.* A significant acreage of wetlands in the Lake Champlain Basin has been impacted by land use practices. These impacts can impair the ability of the wetland to act as a filter for pollutants such as phosphorus. Highly impaired wetlands can become a source of phosphorus. A study should be undertaken to identify impaired wetlands in the watershed that have the greatest potential to act as a sink for phosphorus. Once these wetlands are identified, restoration plans should be developed and implemented to restore impaired functions.

   $80,000 to prepare the study.
   $500,000 for initial stages of implementation, with additional funding to be sought in the future.

3. *Develop and implement a wetland acquisition plan.* In 1994, the "Lake Champlain Wetlands Acquisition Study" was published. This study identified wetlands that should be considered for acquisition based on a number of factors, including water quality protection. This study and other existing studies can be used, and expanded upon, to identify wetlands that should be acquired based on their potential for retaining phosphorus. Once these wetlands are identified, funding should be provided so that these wetlands can be preserved.

   $1,000,000 per year in acquisition funds for the first three years, with additional funding to be sought in the future.

St. Albans Bay

St. Albans Bay has been subject to excessive phosphorus loading from point and nonpoint sources over a period of several decades, and poor water quality conditions have prevailed in the bay as a result of summer algae blooms (Hyde et al. 1994). A major phosphorus removal upgrade of the St. Albans City Wastewater Treatment Facility in 1987 sharply reduced phosphorus loading to the bay. However, phosphorus concentrations in the bay did not decline significantly as expected after the treatment plant upgrade. Internal phosphorus loading from phosphorus stored in the bay sediments was found to be responsible for the continued high phosphorus concentrations in St. Albans Bay. It was believed that this internal source of phosphorus would decline over time as the historic residue of phosphorus in the sediments became depleted.

Phosphorus sampling and modeling studies were conducted in St. Albans Bay to provide a better understanding of the internal phosphorus loading mechanisms and the time period over which a recovery might be expected.. A mass balance modeling study by Smeltzer et al. (1994) found that approximately 700 acres of sediment area in the northern end of St. Albans Bay were releasing phosphorus during the summer and causing the elevated water column phosphorus concentrations. An associated sampling and modeling analysis by Martin et al. (1994) found that sediment phosphorus levels had declined between 1982 and 1992. The modeling analysis predicted that internal phosphorus loading rates and phosphorus concentrations in the bay would decline gradually after the treatment plant upgrade, with most of the ultimate decline occurring by 2015 (Martin et al. 1994).

The phosphorus modeling analysis used to derive the total loading capacity for the St. Albans Bay in the TMDL assumed that net internal loading to the bay would decline to zero over time (Vermont DEC and New York State DEC 1997). This assumption was considered to be conservative since the other Lake Champlain segments have negative net internal loading rates (i.e., there is net sedimentation of phosphorus). However, the fact that phosphorus concentrations in St. Albans Bay have not yet declined in the 14 years since the treatment plant was upgraded indicates that some additional management intervention may be necessary to attain water quality standards in the bay. The studies by Smeltzer et al. (1994) and Martin et al. (1994) indicated that restoration of acceptable water quality in St. Albans Bay will not occur until the internal phosphorus loading is reduced.

Smeltzer et al. (1994) recommended that sediment phosphorus inactivation using aluminum compounds such as alum be evaluated as a means to control internal loading in St. Albans Bay. An in-lake treatment to control internal phosphorus loading in St. Albans Bay would need to be a large-scale project involving about 700 acres of bay and wetland area. Preliminary cost estimates for an aluminum treatment of St. Albans Bay were in the range of $350,000 to $525,000, not including the costs of necessary feasibility studies and treatment design work. Additional feasibility studies would need to be conducted before an aluminum treatment could be technically justified. Feasibility studies, possibly including pilot treatments of small areas, are needed to determine the potential for re-suspension and loss of aluminum floc from the shallow, well-mixed areas of the bay, and to evaluate possible adverse effects of an alum treatment on the bay, wetland, and human users, for environmental permitting purposes. The cost of feasibility studies would probably be on the order of $50,000-100,000.

Phosphorus concentrations in the tributary streams draining to St. Albans Bay are among the highest in the Lake Champlain Basin because of nonpoint sources in the bay's watershed (Vermont DEC and New York State DEC 1997). Ongoing, excessive nonpoint source loading may be partly responsible for the delay in the bay's recovery. If external phosphorus sources are not adequately controlled, the duration of the effectiveness of an alum treatment will be limited. For this reason, it is essential that every effort be made to reduce phosphorus loads to St. Albans Bay from agricultural and developed land sources, using the full range of nonpoint source implementation programs discussed above. Progress in reducing nonpoint source phosphorus loading to St. Albans Bay should be a prerequisite before any alum treatment is attempted.

Phosphorus Trading

Watershed-based pollutant trading is sometimes promoted as a means to comply with a TMDL while providing dischargers with greater flexibility and economy in meeting their loading limits (USEPA 1996). A properly implemented trading program may produce greater environmental benefits at less cost than traditional regulatory approaches (National Wildlife Federation 1999, Faeth 2000).

Point/Point Trading

Trading between point sources (i.e., point/point source trading, USEPA 1996) is one way that new or increased discharges in Vermont may be accommodated within the Lake Champlain Phosphorus TMDL. Once the TMDL is established, any new or increased phosphorus discharge will need to acquire the necessary loading allowance from some other point source within the same lake segment watershed.

Trading agreements may be negotiated between municipalities or industrial discharges for a redistribution of the wasteload allocation using a 1:1 trading ratio between two equivalent point sources. However, under the Vermont Wasteload Allocation Process, such a reallocation requires oversight and approval by the Vermont Agency of Natural Resources. The Agency would also have the authority under the Wasteload Allocation Process to reallocate loads to accommodate a new discharge if a trading agreement could not be successfully negotiated. The discharge permits for facilities involved in the reallocation or trade would be modified to incorporate the revised loading limits. The total wasteload allocation for wastewater discharges in each lake segment watershed (Table 10) would not change with point/point source trading.

Point/Nonpoint Trading

The Vermont DEC gave serious consideration to the issue of whether trading between point and nonpoint sources should also be allowed as a means to comply with the Lake Champlain Phosphorus TMDL. However, the Vermont DEC determined that point/nonpoint source trading is not an appropriate policy for achieving phosphorus reduction in the Lake Champlain Basin, for reasons discussed below.

Point/nonpoint source trading involves a much more difficult set of issues and considerations than does trading between two point sources (USEPA 1996). The phosphorus reduction effectiveness of nonpoint source controls is not always well known. This is particularly true for most of the nonstructural BMPs for agricultural and developed land that are considered essential to achieving phosphorus reduction goals for Lake Champlain (Lake Champlain Basin Program 2000a). Unlike point source effluent monitoring which can be done simply and routinely, water quality monitoring to ensure compliance of nonpoint source BMPs is technically difficult and usually impractical. Uncertainty about the effectiveness and compliance of nonpoint source BMPs can be dealt with through the use of trading ratios (typically 2:1 or 3:1), but the true load reduction from BMPs generally remains unknown.

A point/nonpoint source phosphorus trading program in the Lake Champlain Basin would entail some significant administrative and institutional challenges (USEPA 1996). Because nonpoint sources are not regulated in the same manner as point sources, special arrangements would need to be made within the discharge permits of the point source partner to a trade in order to ensure accountability for implementation of the nonpoint source BMPs. A system for oversight and tracking of all trades would need to be established. Technical guidance from the Vermont DEC would need to be developed to indicate the types of BMPs that are appropriate for trading and the phosphorus reduction credits allowable for each BMP. Such technical guidance has been very difficult to develop for agricultural and developed land BMPs in the Lake Champlain Basin because of the relative lack of quantitative information about their effectiveness.

A point/nonpoint source phosphorus trading program would take advantage of the most opportune BMPs to offset a point source load increase, while leaving the nonpoint source portion of the TMDL to be accomplished by the fewer remaining available BMPs at the more difficult and expensive sites. Overall progress toward meeting the nonpoint source target loads would become more difficult as a result.

Nutrient trading programs have been implemented in other regions, apparently overcoming many of these technical and administrative difficulties (Faeth 2000). However, the Vermont DEC determined that point/nonpoint source trading was not an appropriate policy for phosphorus in the Lake Champlain Basin for a more fundamental reason. Such a program would run a high risk of trading a point source loading increase for a nonpoint source phosphorus reduction that is actually necessary to meet the nonpoint source portion of the TMDL. The major responsibility for future phosphorus load reductions necessary under the Lake Champlain Phosphorus TMDL will fall on nonpoint sources. Existing BMP programs are not sufficient to attain the required nonpoint source loading reductions in some watersheds (Lake Champlain Basin Program 2000a). In fact, the scope of nonpoint source control programs necessary to meet the target loads for the lake is so extensive that nearly every feasible BMP is likely to be needed in some watersheds in order to attain the nonpoint source portion of the phosphorus load allocation. If point/nonpoint source trading were allowed under these circumstances, meeting the phosphorus loading targets for the lake could become impossible.

Vermont Implementation Summary

The Lake Champlain Basin includes nearly half the land area of Vermont and more than half of Vermont's population. Implementation of a phosphorus TMDL for Lake Champlain will therefore involve programs that are statewide in scope in some cases. A summary of implementation needs for the Vermont portion of the Lake Champlain Phosphorus TMDL is given below.

Basin Planning

Planning for phosphorus reduction in the Lake Champlain Basin will be an on-going process that will continue after the TMDL is adopted. It is likely that necessary changes or additions to the implementation items presented in the TMDL will be identified as the planning process continues. On a basin-wide level, the States of Vermont and New York, the Province of Quebec, and many other cooperating groups and agencies have committed to participate in the Lake Champlain Basin Program, which has identified phosphorus reduction as one of the top priorities for basin plan implementation. On a more local level, the Vermont DEC has committed to the river basin planning process which will involve all the Vermont watersheds draining to Lake Champlain. With the adoption of the Lake Champlain Phosphorus TMDL, point and nonpoint source management to reduce phosphorus loading will become an important topic for river basin plans in watersheds where substantial phosphorus reductions are required by the TMDL. In order to achieve the goals of the basin plans including the TMDL phosphorus load allocations, a Watershed Coordinator/Implementor position will be required for each of the seven major planning watersheds draining to Lake Champlain from Vermont.

Wastewater Discharges

Vermont has already accomplished major reductions in point source phosphorus loading to Lake Champlain through upgrades of wastewater treatment facilities for phosphorus removal as required by current state law. The wasteload allocation for the TMDL incorporates additional phosphorus removal requirements that are practical and cost-effective. The statutory exemption for aerated lagoon facilities should be removed. An annual load limit based on an effluent phosphorus concentration of 0.6 mg/l should apply to a list of 25 facilities. The capital cost for facility upgrades required by the TMDL should be funded by 100% state grants. Changes to10 V.S.A. §1266a and §1625e should be made to implement these recommendations.

Agricultural Nonpoint Sources

Implementation of the required nonpoint source phosphorus load reductions from agricultural land will require a sustained and enhanced commitment to existing state and federal cost-share programs which help farmers comply with the Vermont Accepted Agricultural Practices and install best management practices. Other practices to reduce phosphorus loading by restoring and protecting critical riparian zones are also an essential part of meeting the agricultural load allocations. Sustained and expanded program efforts are needed to implement the existing AAP Rules, provide permitting oversight of large farm operations, implement more non-structural BMP measures within the basin, and review the existing AAPs for possible revisions.

Developed Land Sources

Runoff from developed land is a growing source of phosphorus loading in Vermont. Only a small percentage of the developed land in Vermont is in heavily urbanized uses such as commercial or industrial sites. Most of the developed land area is in more rural residential uses and backroads. Therefore, meeting the wasteload allocation for developed land will require program efforts that go well beyond stormwater discharge permitting, which applies to a relatively minor portion of the developed land area in Vermont. Expanded efforts are needed that involve erosion control at construction sites, better backroad maintenance, and local municipal actions to protect water quality. These efforts must be sufficient to offset the phosphorus load added by new sources resulting from development and land use conversion, and to bring about net reductions in phosphorus loading from developed land in Vermont.

Permitted Stormwater Discharges

A portion of the phosphorus reduction responsibility under the TMDL wasteload allocation for developed land will be borne by permitted stormwater discharges. The Vermont DEC Stormwater Management Program will require new sites and re-developed sites to meet the stricter site design and stormwater treatment standards presented in the new technical guidance manual. Restoration of existing sites will be focused, at least initially, on the 19 small Vermont watersheds in the Lake Champlain Basin that are listed as impaired by urban stormwater runoff. Phosphorus reduction will be one of the benefits of the Watershed Improvement Permits for these impaired waters.

Construction Sites

Landowners and contractors have a responsibility under the TMDL to control phosphorus loading from erosion at construction sites. The General Permit for Stormwater Runoff from Construction Sites will be extended to apply to all sites disturbing more than one acre of soil. These construction projects must meet a specific set of program criteria designed to limit erosion. The *Vermont Handbook for Soil Erosion and Sediment Control on Construction Sites* needs to be updated to provide better guidance. Additional staff are needed to provide an adequate level of permit review, technical assistance, education, training, site inspection, and enforcement to support the necessary erosion control requirements.

Backroads

Municipalities have a responsibility under the TMDL to reduce phosphorus loading from backroads. Technical assistance and small grant funding have been available to towns through the Vermont Local Roads Program and the Vermont Better Backroads Program. In order to meet the entire need for better backroad maintenance under the TMDL, these efforts need to be expanded. Increases in grant funding and staffing for technical assistance will be required. In addition to providing phosphorus reduction benefits, these investments can produce significant cost savings to municipalities by preventing water related damage to road infrastructure.

Local Municipal Actions

Municipalities have a responsibility under the TMDL to reduce phosphorus through local ordinances and other actions. Provisions should be established for erosion control at small construction sites not under the jurisdiction of the state General Permit. Capital budget planning for road infrastructure improvements and proper highway access policies represent local decisions that are needed to prevent and reduce phosphorus loading from backroads. Towns should adopt in their zoning bylaws or district standards a minimum construction setback and vegetated buffer requirement along streams and lakeshores. Local subdivision regulations should be structured to minimize the creation of new impervious surfaces through proper site design. An additional staff position at an appropriate organization is needed to promote these types of local actions and to provide technical assistance to Vermont municipalities undertaking revisions to their zoning regulations or other municipal ordinances for better water quality protection.

Forest Nonpoint Sources

Forest land represents a relatively small portion (6%) of the total nonpoint source phosphorus load to Lake Champlain from Vermont. Some of this forest load is naturally occurring background load, and some is added by silvicultural activities. Landowners and loggers have a responsibility under the TMDL to minimize phosphorus loading by adherence to the Vermont *Accepted Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*.

Stream Stability

Streambank and stream channel erosion in unstable rivers represent a potentially enormous source of phosphorus loading to Lake Champlain. The problem occurs on rivers flowing through all types of land use areas, including forests, agricultural land, and developed land. Problems of stream instability and resulting phosphorus loading are especially acute in the Missisquoi Bay watershed, but concerns exist throughout the Lake Champlain Basin. Attainment of the phosphorus load allocation in the TMDL will require major attention to the problem of unstable streams through a comprehensive river management program including the elements of assessment, protection, management, restoration, and education. The cost of a comprehensive, basin-wide program to protect and restore stream stability is very large, but the cost savings in prevention of flood damage to property and infrastructure will more than offset the cost of the program over the long term. Protection of existing stable streams is far less expensive than restoration of unstable reaches.

Wetland Protection and Restoration

Riparian wetlands play an important role in intercepting and trapping phosphorus in runoff before it can enter streams or lakes. Additional staffing is needed in the Vermont Wetlands Program to work proactively on outreach and planning efforts that promote wetland protection. A wetland restoration plan needs to be developed and implemented for impaired wetlands in locations critical for phosphorus removal. Funding for wetland acquisition is needed, with priority given to wetlands having the greatest potential for phosphorus removal.

St. Albans Bay

St. Albans Bay is a special case among the segments of Lake Champlain in that attainment of the phosphorus loading targets may not result in meeting the in-lake phosphorus concentration criteria in the bay because of internal phosphorus loading from the sediments in the bay. An in-lake nutrient inactivation treatment may be needed to secure the benefits of point and nonpoint source phosphorus reductions in the watershed. Feasibility studies should be undertaken to determine whether such a treatment would be successful in St. Albans Bay and whether any adverse environmental impacts of a chemical treatment would be acceptable. Progress in reducing nonpoint source phosphorus loading to St. Albans Bay should be a prerequisite before any alum treatment is attempted.

Level of Implementation Required

The implementation discussion relating to nonpoint sources does not include a quantification of the specific load reduction amounts (e.g., in mt/yr) that will result from each program activity. The reason for this is a lack of adequate scientific data and literature in most cases to support this specific level of quantification.

The agricultural BMP phosphorus credit system used for planning purposes by the Lake Champlain Basin Program has never been confirmed with field data, and the procedure yields negative loads or other unrealistic results when applied in some watersheds (Lake Champlain Basin Program 2000a). Efforts are underway to improve the agricultural credit procedure, but validation of the approach will require further monitoring.

The phosphorus reduction effectiveness of engineered stormwater treatment systems has been well documented, at least within broad ranges. However, there is little or no quantitative information available to provide either a basin-wide inventory of needs, or estimates of the phosphorus load reductions attainable from the kinds of nonpoint source control practices that apply on most of the developed land in Vermont, such as erosion control at constructions sites, better backroad maintenance, riparian buffer protection, local municipal ordinances, and restoration of stream stability.

The lack of quantitative information on these nonpoint source phosphorus control practices should not preclude aggressive efforts to implement these programs in order to attain the load allocations in the TMDL. All of the recommended implementation actions in the TMDL are aimed at reducing known sources of phosphorus in the basin, and the expectations of phosphorus reduction benefits from these actions are supported by simple observation and common sense.

Monitoring will be necessary to determine when implementation efforts have succeeded. A comprehensive, long-term monitoring program (discussed below) will be needed to determine when the loading targets and in-lake criteria have been achieved, and to redirect program efforts if necessary.

These limitations of scientific knowledge mean that it is not possible to define, in advance, specific levels of implementation or endpoints (e.g., number of sites to be treated or miles of river to be restored) necessary to attain the load allocations for each watershed and each land use category in the TMDL. However, there are a number of good reasons, listed below, why the fullest possible implementation effort would be the best strategy to adopt.

1. Some of the implementation programs are statewide in mandate and scope, such as regulatory programs involving stormwater discharge permitting and erosion control at construction sites. In these cases, it would not be feasible to limit program efforts in one watershed in order to give exclusive priority to another watershed where phosphorus reduction needs are more acute.

2. Many of the nonpoint source control actions identified in the TMDL implementation plan reduce pollutants other than phosphorus that are having adverse effects on Vermont waters. For example, sedimentation is a major source of water quality impairment to streams throughout the Lake Champlain Basin, and sediment will be reduced by nonpoint source actions designed to control erosion from construction sites, backroads, and unstable streambanks and channels.

3. Many of the nonpoint source control actions identified in the TMDL have economic benefits that justify their implementation, regardless of their environmental benefits. Agricultural best management practices such as proper manure storage, barnyard runoff improvements, and field nutrient management provide economic benefits to the farm operation. Protection and restoration of stream stability can prevent devastating property loss and damage to infrastructure during flood events. Better backroads practices can reduce recurring maintenance costs to municipalities caused by improper road drainage.

4. In order to achieve the phosphorus load allocations specified in the TMDL, management actions must be sufficient to offset the effects of new development and bring about overall net reductions in phosphorus loads. Since development and urbanization is proceeding in many areas of the Lake Champlain Basin, additional phosphorus reduction actions are needed to offset the continual creation of new phosphorus sources by land use conversion and development.

5. Directing the fullest possible implementation effort in each watershed will help offset unavoidable program shortcomings and treatment failures resulting from the many uncertainties inherent in nonpoint source phosphorus management.

Offsetting New Growth and Development

The Lake Champlain Basin Program (2000a) report noted that new growth and development is occurring in portions of the basin, and that conversion of land into higher phosphorus-yielding uses could interfere with attainment of the target phosphorus loads in some watersheds. In order to achieve the loading targets, phosphorus reduction activities must be sufficient not only to reduce existing loading sources, but also to offset any phosphorus loading increases caused by new development.

Most of the implementation actions discussed in this plan have benefits in reducing existing phosphorus sources, as well as preventing or mitigating future loading increases as land use change occurs. The approach taken in the Vermont TMDL Implementation Plan is to promote universal implementation of all the action items listed in the plan at all sites in the basin where they are applicable. The level of implementation should not be limited to the minimum actions necessary to meet the loading targets in each watershed under current land use conditions. Additional implementation efforts are needed to offset future growth in phosphorus loads caused by new development.

The difficulty in quantifying phosphorus reductions resulting from most nonpoint source practices means that it is not possible to identify a set of implementation actions that are specifically targeted at offsetting the effects of new growth. Universal implementation will be used to reduce both existing and future phosphorus sources. The success of this approach will be evaluated through a comprehensive monitoring program (see section below) that includes tracking of land use changes as well as measurements of phosphorus loading from the watersheds.

Vermont Implementation Cost Summary

The costs identified in the Vermont TMDL implementation plan are summarized in Table 21. The funding schedule shown in Table 21 covers the period of 2003-2016, corresponding to the remainder of the 20-year time frame established by the Lake Champlain Management Conference (1996a) for achieving the phosphorus reduction targets for the lake. The costs represent additional funding needs, beyond current levels. The costs are presented in current year dollars, without adjustment for inflation. The total 14-year cost to implement the Lake Champlain Phosphorus TMDL in Vermont is estimated to be $139 million, with an average annual funding need of $9.9 million over this period.

The cost estimates presented in Table 21 represent the funding needed to achieve the necessary phosphorus load reductions in Lake Champlain. However, as discussed in detail in the Vermont Implementation Plan section, investments in the actions listed in Table 21 will, in many cases, result in cost savings and other economic benefits that more than offset the costs. Pollutants in addition to phosphorus will be reduced. Water quality impairments to waters beyond Lake Champlain will be corrected.

Funding will be needed from a variety of sources and programs at the federal, state, and local level. It is clear from the magnitude of the funding needs given in Table 21 that a major federal contribution will be essential. A staff position for program administration has been added in Table 21 to ensure proper coordination, management, and accountability of a Lake Champlain Phosphorus Reduction Program.

Other Public Policy Considerations

The Lake Champlain Phosphorus TMDL establishes allowable pollutant loadings of phosphorus from all contributing sources in order to assure attainment of applicable water quality standards. The document also summarizes an implementation plan which describes actions that must be taken to achieve reductions in phosphorus loadings mandated by the TMDL.

Table 21. Funding schedule for the Vermont TMDL implementation plan.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	TOTAL
River Basin Planning Process															
Watershed Coordinator - Poultney Mettawee	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Otter Creek	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Lower Lake Champlain Direct	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Upper Lake Champlain Direct	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Missisquoi	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Lamoille	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Watershed Coordinator - Winooski															
Point Sources															
Aerated lagoon upgrades		344,000													**344,000**
Optional selector zone upgrades	1,575,000	1,925,000			950,000	650,000									**5,100,000**
Agricultural Sources															
BMP implementation - federal share (65%)	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	2,911,071	**40,755,000**
BMP implementation - state share (20%)	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	895,714	**12,540,000**
Riparian protection (CREP) - federal share (80%)	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	1,142,857	**16,000,000**
Riparian protection (CREP) - state share (20%)	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	285,714	**4,000,000**
AAP outreach	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
LFO permitting	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	**2,100,000**
Erosion Control at Construction Sites															
Training and inter-agency coordination	75,000	75,000	25,000	25,000	25,000										**225,000**
Permit review, enforcement, and compliance	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	**2,100,000**
Implement General Permit	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Erosion Control Handbook revision	50,000						50,000					50,000			**150,000**
Better Backroads															
Better Backroads Program grants	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	25,000	25,000	25,000	25,000	**700,000**
Better Backroads grants program staff support	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	**262,500**
Local Roads Program circuit rider	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	**262,500**
Local Roads Program workshop expenses	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**140,000**
NRCD and RPC workshops	17,000	17,000				17,000	17,000				17,000	17,000			**102,000**
Publication update	15,000				5,000				5,000				5,000		**30,000**
AMP development	8,000	10,000				10,000				10,000				10,000	**48,000**
Equipment sharing pilot		22,000													**22,000**
Agency program staffing	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	**105,000**
Local Municipal Actions															
Technical assistance	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**

Table 21 (cont.)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	TOTAL
Stream Stability															
Geomorphic assessments	83,500	83,500	83,500	83,500	83,500	83,500	83,500	83,500	83,500	83,500					**835,000**
Fluvial database	75,000	37,500	37,500	37,500	37,500	37,500	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	**412,500**
Fluvial assistance capacity		18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750	18,750				**187,500**
Fluvial hazard maps	87,500	87,500	87,500	87,500	87,500	87,500	87,500	87,500	87,500	87,500					**875,000**
Land use incentives	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	**7,000,000**
Enhance forestry AMPs	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Flood hazard mitigation	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Restoration design capacity	18,750	18,750	18,750	18,750	18,750										**93,750**
Restoration projects implementation	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000	750,000					**7,500,000**
Fluvial assessment course	32,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	**130,000**
Educational videos	55,000	55,000	55,000												**165,000**
Fact sheet publications	47,500														**47,500**
Economic analysis	23,750														**23,750**
Research partnerships	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000					**1,000,000**
Wetland Protection and Restoration															
Outreach, education, and planning	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
Wetland restoration plan preparation		80,000													**80,000**
Wetland restoration plan implementation			500,000												**500,000**
Wetland acquisition			1,000,000	1,000,000	1,000,000										**3,000,000**
St. Albans Bay															
Feasibility studies		100,000													**100,000**
Treatment (if recommended)				525,000											**525,000**
Monitoring															
Long-term Monitoring Program	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	290,000	**4,060,000**
Lay Monitoring Program	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	**420,000**
USGS stream flow gages	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000	**2,940,000**
Agricultural BMP tracking	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	**1,904,000**
BMP effectiveness studies	146,500	146,500	146,500	146,500	146,500	146,500									**879,000**
Land use data	2,000,000					1,000,000					1,000,000				**4,000,000**
Research	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	**2,800,000**
Program Administration	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	**1,050,000**
TOTAL	**13,226,357**	**11,944,357**	**10,896,357**	**10,866,357**	**11,296,357**	**10,974,607**	**9,199,357**	**9,132,357**	**9,137,357**	**9,142,357**	**9,093,357**	**8,124,607**	**8,062,607**	**8,067,607**	**139,164,000**

What the TMDL document does not address is public policy choices which can be made by others, including the Vermont General Assembly, to assure and perhaps accelerate attainment of water quality standards. Such choices which others may want to explore include the following.

1. Implement green taxation which provides incentives to reduce pollutant loadings while providing resources to restore Vermont's waters.

2. Provide incentives to support traditional development patterns and discourage sprawl into undeveloped areas.

3. Establish a basinwide riparian buffer policy to reduce pollutant loading and stabilize streams.

4. Support local planning commissions and conservation commissions to protect water quality at the local level.

5. Support conservation easements along lakes, rivers, and streams which will protect water quality.

Some of these policy choices may reduce the cost of implementing the necessary phosphorus reductions in Lake Champlain. However, it is not the intent of this document to recommend or support choices such as these, but rather to challenge Vermonters to search for innovative solutions to water quality problems in the Lake Champlain Basin.

New York Implementation Plan

Point Sources

SPDES permits which contain phosphorus limits are based on meeting the 95th percentile of the existing effluent load. This load in most cases will meet the annual load-based TMDL waste load allocation.

Upon issuance of the TMDL/WLA, SPDES permits in the Lake Champlain drainage basin which do not have a phosphorus limit or do not meet the WLA will be re-evaluated in accordance with NYSDEC's Environmental Benefit Permit Strategy (EBPS). The EBPS priority score will increase to reflect the requirements of the TMDL/WLA. As a result, the overall position of the Lake Champlain permits relative to the statewide SPDES priority ranking list will increase.

When the Lake Champlain SPDES permits fall within the top ten percent of the statewide priority ranking list, NYSDEC will institute a comprehensive modification review for those permits. As part of this comprehensive review, SPDES conditions to implement the TMDL/WLA will be analyzed and incorporated into the permits.

It is projected that 23 of the 29 permitted point source discharges will need revised phosphorus limits or have limits added to their permits to meet TMDL allocations. Based on current EBPS scores it is estimated that within three years, one-half of the permits will be brought into compliance, within five years three-quarters of the revisions will be completed, and all permits will contain the appropriate phosphorus limits within 10 years.

As discussed earlier under the WLA setting process, certain storm water related sources will have point source permitting programs ongoing and implemented during the implementation phase of the TMDL. CSO's are currently being permitted under the New York State DEC SPDES program. There are also general storm water SPDES permitting programs in operation for CAFOs, and construction and industrial activities. These programs require the performance of BMPs to insure that the least amount of pollutants possible are released into the environment. The continued aggressive implementation of these programs in the Lake Champlain Basin will insure that the TMDL targets for phosphorus reductions are exceeded.

Nonpoint Source Management Program Goals

In accordance with Section 319 of the Clean Water Act, the New York DEC has prepared a Nonpoint Source Assessment and a Nonpoint Source Management Program. The Nonpoint Source Assessment was initially completed in 1988 and approved by the Environmental Protection Agency in July 1989. An update of this assessment has been prepared every two years. The latest assessment is in the 1996 Priority Waterbodies List.

The Nonpoint Source Management Program was approved by EPA in January 1990. The Management Plan was updated and approved by EPA in October, 2000. Copies of the Management Program are available from Gerry Chartier, (518) 402-8244.

New York State's Nonpoint Source Management Program is charged with the control, reduction or treatment of polluted runoff through the implementation of structural, operational or vegetative management practices. It administratively coordinates various state agencies and other interested partners having regulatory, outreach, incentive-based, or funding programs that foster installation of management practices for any of the identified sources of nonpoint pollution threatening or impairing the waters of New York. Local implementation and statewide coordination and evaluation are conducted on a watershed basis.

New York's Nonpoint Source Management Program Update incorporates the federal, state and local changes since 1990 and makes recommendations for further activities needed to address nonpoint source pollution in New York.

At the federal level, the Nonpoint Source program under Section 319 of the Clean Water Act remained substantially unchanged since proposed amendments to the CWA were not passed. However, increases in funding through 1998 provided for the implementation of many nonpoint source management practices and projects. The 1996 Farm Bill and the 1996 Amendments to the Safe Drinking Water Act (SDWA) have both highlighted the need for better, or at least more strategically located, nonpoint source management practices.

At the state level, the New York Nonpoint Source Coordinating Committee (NPSCC) was created and continues as New York's forum for collaboration on NPS issues. The New York State Soil and Water Conservation Committee (NYSSWCC) and the New York State Department of Environmental Conservation (NYSDEC) brought County Water Quality Coordinating Committees (WQCCs) from an idea to reality. By 1992, each county had a WQCC. The Clean Water / Clean Air Bond Act was a new state funding source passed by voters in November 1996. The Environmental Protection Fund (EPF) has supplemented 319 funding since 1995. Numerous agricultural and non-agricultural projects have been funded.

At the local level, County WQCCs have developed water quality strategies for every county. The county strategies serve to focus locally based implementation efforts. As of 1998, over 250 local projects using federal, state or local dollars were under way across the state. New York City Department of Environmental Protection (NYCDEP) and the City of Syracuse, as part of SDWA filtration avoidance, have established programs to address all sources of nonpoint pollution in the watersheds that supply drinking water for their cities.

Nonpoint source pollution usually is best prevented or remediated by employing one or more management practices. A management practice is a means of preventing or reducing the availability, release or transport of substances which adversely affect surface and groundwaters. It is a practice used to prevent or reduce the impact of nonpoint pollutants usually from a specific source category.

New York has developed a series of ten Management Practices Catalogues each containing management practices for a particular source category. From this list of tested and approved practices, the best practice should be selected and used by individuals or groups wherever needed to diminish the impact of nonpoint source pollution. They can be used without a formal planning process or without an identification of a specific problem. They make good environmental sense. Use of appropriate management practices helps build environmental responsibility.

One of the most significant recommendations that was achieved, was the development of the SPDES General Permit for stormwater runoff from construction activities. The January 9, 1998, draft EPA Phase II Stormwater Regulations has resulted in DEC having to revise much of its stormwater program including the SPDES General Permits for stormwater, both construction and industrial. This is discussed further in the Urban Runoff section.

Highlights of other recommendations that were fully achieved include developing a procedure for counties to use in preparing water quality strategies, producing a handbook that describes a watershed planning process for control of nonpoint source pollution and developing a series of 10 management practice catalogues for each significant category of nonpoint source pollution in New York.

Cooperation of local agencies such as Soil and Water Conservation Districts or county health departments has been required to implement many of these programs. Organizations such as the New York State Association of Conservation Districts and the Soil and Water Conservation Society have also been called on to assist in implementation. The seven long-term goals of New York's Nonpoint Source Management Program are listed below:

1. Establish a five year planning cycle for updating the New York State Nonpoint Source Management Plan.

2. Coordinate statewide federal, state and industry programs that address aspects of NPS pollution.

3. Establish and foster partnerships to coordinate county and local activities to address NPS pollution.

4. Identify and evaluate NPS water quality problems.

5. Encourage and assist all landowners with guidance documents, incentives and funding to implement management practices to control NPS pollution.

6. Where regulatory programs exist, identify management practices approved for use in New York, and track progress of their implementation/installation for the control of NPS pollution.

7. Address NPS pollution from all categories geographically by watershed.

The above are general goals for the Nonpoint Source Management Program. In addition, DEC and partner agencies have developed statewide Long- and Short-Term Goals for reduction of nonpoint source pollution. These are as follows:

Statewide Long-Term (15 year) Goals

LT1 By 2015, restore designated best uses in 25 percent of New York State waters where pollution from nonpoint sources other than atmospheric deposition and contaminated sediments has had the most severe impacts.

LT2 By 2015, New York State will fully implement CZARA Nonpoint Management Measures in the 6217 management area designated by NOAA/USEPA. Many programs, such as the management of onsite wastewater treatment systems, will be Statewide.

LT3 By 2015, New York State will implement all commitments identified in Watershed Restoration and Action Protection Strategies in all basins.

Statewide Short-Term (5 year) Goals

ST1 Water Restoration: By 2005, restore designated best uses to 10 percent of the waters currently listed on the Priority Waterbodies List (PWL) as *precluded* or *impaired* from nonpoint sources other than atmospheric deposition and contaminated sediments.

ST2 Water Quality Impairment Verification: By 2005, assess 50 percent of waters that currently need verification of impairment so that they are either verified and noted in the PWL or moved to a listing of a known impairment.

ST3 Water Quality Assessment: By 2005, assess 50 percent of waters currently unassessed.

ST4 Natural Resource Information: By 2005, increase the amount and type of natural resource information covered by the PWL.

ST5 Coastal Zone NPS Program: New York State will work towards full approval of the Coastal NPS Program.

ST6 Watershed Strategies: By 2006, all waters currently identified as precluded or impaired in the PWL will be reviewed. The cause and source of the impairments will be confirmed. New York State will develop Watershed Restoration and Action Protection Strategies to correct these impairments for all basins.

ST7 Section 303(d) List: By 2002, New York State will update the 303(d) list which includes TMDL's for waters that have a nonpoint source component.

ST8 TMDL's: By 2008, New York State will develop TMDL's for all waters impaired by nonpoint sources.

ST9 TMDL's: Within 10 years after development of a TMDL with a nonpoint source component, New York State will implement NPS management measures in that area.

ST10 New York State will periodically review progress towards goal attainment.

Potential Nonpoint Source Management Practices

Management practices are used to prevent or minimize the availability, release or transport of substances that degrade water quality. Best management practices (BMPs) are defined as the most effective and practicable means of limiting the quantity of phosphorus exported from a site and transported downstream. This list of BMPs is designed to assist in the selection of appropriate management measures to control nonpoint sources of phosphorus generated by agricultural, urban and forestry land uses in the Lake Champlain watershed. Each practice should be evaluated for compatibility with the site, cost, pollutant removal abilities and maintenance needs. The ultimate selection of one or a combination of BMPs must consider all water quality goals, pollutant treatment capabilities, site conditions, cost, maintenance, and federal, state, or local regulatory requirements and programs.

There are many excellent compilations on BMPs for various land uses, which give extensive information on design specifications, maintenance procedures and other details (New York State DEC 1996). It is not our intent to reproduce these publications. Instead, this document summarizes those BMPs which are effective in reducing phosphorus, with special consideration to implementation in the

Lake Champlain watershed. A brief description of each BMP is given, along with any particular advantages or disadvantages if used in the Lake Champlain watershed. Some management practices are applicable to more than one land use category (e.g. riparian buffers). These will only be discussed once.

Urban Management Alternatives

Urban centers are often considered the best locations to achieve nonpoint phosphorus reductions. Phosphorus loading is obviously more concentrated than for other nonpoint source categories such as forest land or open spaces. Reducing or preventing increases in phosphorus loads in urban watersheds requires careful planning, thorough watershed assessments and coordinated implementation of a comprehensive program that addresses retrofit and new development needs. An integrated approach that uses a combination of cost-effective BMPs will achieve the maximum phosphorus reduction possible (Table 22).

Extended Detention

An extended detention pond temporarily detains and stores peak runoff flows after a storm event. During extended detention, some pollutants settle out and peak flows are gradually released from the pond. Detention ponds are normally dry between storm events and do not contain permanent standing water. Extended Detention ponds typically consist of an excavated area with an embankment dam, a principal spillway (riser) with an extended detention control device, an emergency spillway and a velocity dissipation device at the riser outlet. Ideal detention time for pollutant removal is 40 hours or greater.

Wet Ponds/Multiple Pond Systems

Wet ponds or retention basins are designed to store and retain runoff. They maintain a permanent pool of water for partial infiltration and evaporation. Ponds are typically excavated according to design needs and contributing drainage areas. They usually have a shallow inlet area 0.5 to 2 feet deep and a permanent pool 3-8 feet in depth. A dam and emergency spillway also control peak runoff and detain stormwater for 2-14 days.

Retention is the preferred method of stormwater management when the water table, bedrock, or soil conditions preclude the use of infiltration. Retention improves stormwater quality by settling, naturally occurring chemical flocculation and biological uptake. They also provide a habitat for wildlife and can be an aesthetic benefit to the surroundings. Retention ponds can reduce the peak discharge during storms to pre-development levels, but they are not effective in controlling post-development increases in the total runoff volume. Use of existing natural wetlands for stormwater management purposes often requires approval from federal, state and local agencies, and care must be exercised so that the wetland is not negatively impacted.

Table 22. New York generic urban best management practices summary.

MANAGEMENT PRACTICES	RELATIVE COST	LIMITING CONDITIONS	MAINTENANCE	ADVANTAGES	DISADVANTAGES	SPECIAL CONSIDERATIONS
Extended Detention Basins	Low	None of special concern, serves drainage areas of 10-400 acres	Frequency: Moderate Cost: Low	Controls peak discharge rate and downstream bank erosion	Poor aesthetics, potential for nuisance	Prone to clogging, difficult to achieve detention times, permits may be required
Retention Ponds and Artificial Wetlands	Moderate	Base flow required, drainage area served depends on type of pond or wetland	Frequency: Moderate Cost: Moderate	Controls peak discharge rate, provides wildlife habitat, recreation, aesthetics.	Becomes nuisance if poorly maintained	Requires careful planning, 14-day detention time needed for phosphorus removal, permits may be required
Infiltration Basin	Varies according to design	Depth to water, rock and hardpan soil permeability, serves drainage areas up to 50 acres	Frequency: High Cost: Moderate/High	Serves large developments, provides groundwater recharge, can be adapted to control peak rate and volume resulting from large storm	High rate of failure due to unsuitable soils and lack of maintenance, prone to clogging.	Requires effective pretreatment to prevent overloading with sediment and clogging
Infiltration Trench	Moderate	Depth to water, rock and hardpan soil permeability, serves drainage areas < 10 acres	Frequency: High Cost: High	Preserves natural topography, provides groundwater recharge, can be adapted to control peak rate and volume resulting from large storm	High failure rate due to lack of maintenance, requires careful construction, potential for groundwater contamination	Requires effective pretreatment to prevent overloading with sediment and clogging
Sand/Peat/Organic Filter Systems	Moderate/ Expensive	Serves drainage areas of ½-50 acres	Frequency: High Cost: Moderate	Effective end-of-pipe retrofit for urban areas, minimal land requirement	Requires frequent maintenance	Shut down peat filters during winter freeze
Vegetated/Grassed Swales	Low	Flow velocity, soil permeability	Frequency: Low Cost: Low	Some infiltration; nutrient/sediment removal	Limited capacity	Best used in combination with other practices

Table 22. (cont.)

MANAGEMENT PRACTICES	RELATIVE COST	LIMITING CONDITIONS	MAINTENANCE	ADVANTAGES	DISADVANTAGES	SPECIAL CONSIDERATIONS
Filter Strips	**Low Serves drainage areas # 5 pervious acres**	**Flow velocity, slopes # 15%**	**Frequency: Moderate Cost: Low**	**May be applied at any stage during development**	**Limited capacity**	**Best used in combination with other practices**
Streambank Stabilization	**Varies with BMP employed**	**May exacerbate erosion if stream geomorphology isn't accounted for**	**Frequency: varies Cost: varies**	**Provides wildlife habitat, aesthetics if bioengineering is used**	**No control of peak rate, limited pollutant removal, may exacerbate erosion elsewhere.**	**Natural stabilization techniques preferred over structural techniques where practical; may require permits**
Nutrient Management	**Low - moderate, varies with tactic**	**Applies to landscaped portion of site**	**Frequency and cost depend on soil fertility needs**	**Reduced chemical use and potential for impacting water quality, improves system's ecology**	**Must evaluate soil fertility needs yearly**	**Tailor soil fertility to landscape needs**
Site Restoration/ Reclamation	**Varies with BMP employed**	**Varies with BMP employed**	**Varies with BMP employed**	**Flexibility, well-established watershed retrofit technique that can be applied pre- or post-construction**	**Varies with BMP employed**	**Generally, a combination of tactics is most effective**

Stormwater Wetland Systems

Constructed stormwater wetlands comprise shallow pools that are designed and constructed to provide suitable growing conditions for marsh plants, and to simulate water quality functions of a natural wetland. These can be newly constructed wetlands, or restored/enhanced wetlands that have been degraded. Stormwater wetlands are not usually designed to replicate all of the ecological functions of natural wetlands. Stormwater wetlands require sufficient baseflow (groundwater) to support the wetland vegetation, and so may not be appropriate at many sites. The maintenance burden is especially high for the first three years, and can be expensive. Wetland regulations may prevent placement of a stormwater wetland in a natural wetland system. These systems also have highly variable, site-specific phosphorus removal capabilities, and are best used for final polishing of the stormwater.

Infiltration Systems

Infiltration systems are excavated areas in which runoff is temporarily collected and stored until it gradually percolates through the permeable soils of the basin or trench floor. Infiltration systems remove pollutants through sorption, precipitation, straining and bacterial breakdown.

Infiltration basins can treat the peak flow rate and volume from large storms, and provide necessary groundwater recharge. However, they are expensive to install, have a high failure rate due to a lack of maintenance and have specific requirements for soil type and maximum slope, depth to groundwater and to bedrock. Properly functioning infiltration systems are most effective in removing pollution.

Grassed Swales

Swales are small vegetated earthen conveyances constructed on permeable soils, usually used to provide pretreatment before runoff is discharged to another BMP. Swales intercept and focus the diffuse overland sheet flow, control peak discharge, provide some detention and limited infiltration. Stormwater pollutants are removed by settling and filtration through vegetation and soil. Vegetative swales are typically applied to single-family residential developments and highway medians as an alternative to curb and gutter drainage systems.

Grassed swales are inexpensive to install and have low maintenance costs. Unfortunately they do not control soluble pollutants effectively. They are best used in conjunction with other methods of stormwater BMPs.

Filter Strips

Filter strips are areas of land with vegetative cover that are designed to accept and attenuate overland sheet flow runoff. Dense vegetative cover facilitates sediment settling and pollutant removal. Filter Strips are appropriate for agricultural practices, such as along the side of a field. Unlike grassed swales, filter strips are only effective for overland sheet flow, not for concentrated flows. Filter strips cannot treat high velocity flows or provide enough storage or infiltration to effectively reduce peak discharges to pre-development rates for design storms. During the growing season they are most effective on low to moderate slopes. Filter strips are recommended for low density development and can be effectively used as one component of an integrated stormwater management system.

Streambank Stabilization/Stream Corridor Protection

Minimizing streambank and streambed erosion can reduce phosphorus loadings especially if riparian and floodplain areas have been in agricultural land use, or if riparian (stream-related) areas are used as septic leach fields. Minimizing stream erosion must be based on a systematic evaluation of natural stream channel stability that identifies the cause(s) of the exacerbated erosion rather than simply treating the symptoms (i.e., stabilizing eroding streambanks). Generally, several BMPs are used together to increase stream channel stability, diminish peak velocities and shear stresses on channel bed and banks. BMPs include managing stormwater, realigning stream reaches (slope, width to depth ratio), restoring floodplain and riparian areas, and stabilizing selective streambanks.

The strips of healthy riparian vegetation along streams (called riparian "buffer" areas) are crucial to maintaining stable streambanks and minimizing the natural lateral shifting of stream channels. Streambank stabilization techniques that integrate natural stream vegetation are preferred, because in addition to stabilizing the bank, they restore the natural water quality protective functioning of riparian areas. Well vegetated riparian buffers slow stormwater runoff from farm fields as well as urban areas, and provide an opportunity for roots to take up nutrients dissolved in surface and groundwater. Phosphorus removal rates depend on land-use and the management techniques employed.

Nutrient Management

Nutrient management involves the rate, timing, and placement of fertilizer to encourage maximum nutrient recycling, minimize the expense of fertilizing, and provide optimum soil fertility for the planted landscape. Nutrient management is a low cost method for reducing phosphorus runoff from heavily managed properties such as golf courses or commercial developments. Lower overall maintenance costs are often achieved by a reduction in the quantity of fertilizer required. The soils must be tested annually and the results interpreted by a qualified analyst.

New York State Stormwater Permits

Final Phase 2 Stormwater Regulations were adopted by USEPA in October 1999 these regulations will significantly affect how New York State regulates stormwater discharges. New York State DEC is currently developing a Stormwater Program in order to meet the federal requirements. The new regulations for storm water permits will increase the scope of the current stormwater permitting program. For example, facility coverage under the regulations includes construction sites greater than one acre. The proposed regulations also would include expanded conditions for protecting endangered species and historic properties, and requirements for public notification and pollution prevention plan performance objectives.

While the proposed requirements will not impose a performance standard, EPA believes storm water management measures required under the regulations will remove at least 80 percent of total suspended solids from construction site runoff. The agency said that by controlling total suspended solids the measures, or practices, will also control other pollutants, including heavy metals, oxygen demanding pollutants, and nutrients commonly found in stormwater discharges.

There are basically three groups of activities that will be affected by the new stormwater permits:

1. Phase I activities;
2. Construction activities disturbing between 1 and 5 acres; and
3. Small municipalities in designated “urbanized areas” identified by USEPA.

New York State is developing criteria and a process for designating additional “urbanized areas” for inclusion into the stormwater program. Sensitive waters requiring special protection from stormwater will be considered for designation. New York State will also consider the possibility of public petitions for designating additional municipal candidates.

Permits for designated small municipalities would need to be issued by New York State by March 1, 2002 and would require programs which focus on six (6) minimum areas:

- public education and outreach
- public involvement/participation in stormwater program development
- illicit discharge detection and elimination
- construction site runoff control
- post-construction stormwater management control including redevelopment
- pollution prevention for municipal operations

Agricultural Management Alternatives

Agricultural nonpoint source pollution is highly site-specific and depends on parameters such as the types of crops and the farming practices (Table 23). Since phosphorus is often bound to sediments, any agricultural practices that encourage erosion will contribute to the overall phosphorus load from an individual site. The agricultural management alternatives are numerous, and have been grouped into five general categories: structural methods, livestock management, nutrient management, land use modifications and tillage methods. Structural methods primarily address water movement from the farm to the stream. Livestock management attempts to keep livestock from directly degrading water courses. Nutrient management controls the location and use of fertilizer and manure to maximize the benefit to the farmer while minimizing the impact to the water bodies. Land use modifications involve riparian buffers and alternate field management techniques. Tillage methods reduce the runoff and erosion from tilled fields. Each general category will be discussed below. Details on each management alternative can be found in the state’s management practices catalogue (New York State DEC 1996).

Table 23. New York generic agriculture best management practices summary.

MANAGEMENT PRACTICES	RELATIVE COST	LIMITING CONDITIONS	MAINTENANCE	ADVANTAGES	DISADVANTAGES	SPECIAL CONSIDERATIONS
Field Diversion	$2 - $5 per foot	Slopes must be < 15% not suitable in high sediment producing areas	Periodic inspections	Takes only a small amount of land out of production easy to design and install	Little impact on runoff volumes	Cost may be offset by hay harvesting
Subsurface Drainage	$3.50 per foot				Root infiltration by hydrophyllic trees	
Grassed Waterway	$2 - $5 per foot	Not suitable where base flow exists, or areas with excessive sediment loads	Annual inspections	Easy to design and install; can also act as a filter strip	Can fill up with sediments; takes land our of crop production	
Filter Strip		Not effective in hilly areas	Regular inspections, mowing, sediment removal	Unobtrusive easy to install and maintain; benefits wildlife	Not effective with soluble forms of phosphorus or during winter; short lifetime (< 5 yr)	Sediment accumulation reduces effectiveness
Streambank Stabilization						
Barnyard Runoff Management	$3,000 - >$50,000		Varies - can be intensive	Improves herd health and milk production	Expensive; requires a high level of management skill	Overland flow systems are more effective than channelized flow systems
Fencing / Livestock Exclusion	$2 - $5 per foot		Regular inspections	Inexpensive but effective	Labor intensive to install	May require alternate water supply
Fertilizer Management	Minimal		Periodic update of plan, soil testing	Cost savings in fertilizer; cost effective approach	High level of management skills	

Table 23 (cont.)

MANAGEMENT PRACTICES	RELATIVE COST	LIMITING CONDITIONS	MAINTENANCE	ADVANTAGES	DISADVANTAGES	SPECIAL CONSIDERATIONS
Manure Management	**Minimal**		**Soil testing and manure analyses**	**Cost savings on commercial fertilizers**	**Requires intensive management**	
Equipment Calibration	**Minimal**		**Calibration should be performed regularly**	**Increases fertilizer application effectiveness reduces costs**		
Field Priorities	**Low cost**		**Periodic soil tests and manure analyses**	**Low cost, effective**	**Requires informed decision making increased costs in terms of time, resources and lab analyses**	
Cover Crops	**$20 - $25 per acre**		**Minimal**	**Cost effective erosion control program**		
Crop Rotation	**Minimal**		**Minimal**	**Improved soil structure; breaks insect , weed and disease cycles**	**Limits the years a commodity is grown**	
Conservation Tillage	**$20 - $40 per acre**	**Not suitable for all soils**	**Annual soil tests**	**Cost effective erosion control; time, fuel, labor savings**	**Reduced incorporation of fertilizers and chemicals; plant resid-ues can be easily buried**	
Strip Cropping	**$30 per acre**	**Not compatible with cash cropping enterprises**	**Minimal**	**Improves soil; breaks insect and weed cycle; inexpensive and easy**	**Limits the years and acreage of a commodity**	**Irregular field topography may prevent its use**

Structural Methods

Field Diversion. A diversion directs runoff away from a particular area of a farm, such as a barnyard or feedlot, where there are high concentrations of pollutants. It consists of an earthen channel constructed across the slope with a supporting ridge that collects and redirects the runoff entering the field. This prevents the contamination of clean water entering the area. Diversions are relatively easy to design and install and take little land out of active production. They are not suitable in areas with high sediment yields and have little impact on runoff volumes.

Subsurface Drainage. Subsurface drainage consists of a conduit, such as corrugated plastic tubing, tile or pipe, installed beneath the ground surface to collect and/or convey drainage water. The purpose is to improve the soil environment for vegetative growth, reduce erosion, and improve water quality by: intercepting and directing water movement away from wet areas, removing surface runoff, and removing water from heavy use areas, such as around barns, barnyards and animal watering facilities. Problems can be experienced by root infiltration by hydrophillic trees.

Grassed Waterway. A grassed waterway is a natural or constructed channel, with a parabolic or trapezoidal cross-section, that is below ground level and is established in suitable vegetation for the stable conveyance of runoff. This practice controls surface runoff by conveying it to protected outlets, thereby preventing gully erosion. Grassed waterways are relatively inexpensive and can effect significant phosphorus reductions. This practice does, however, take land out of crop production and is not suitable where there are high sediment loads or high water tables.

Livestock Management

Livestock Exclusion. Fencing excludes livestock from highly erodible areas, and limits access to drainage ways and water bodies, thereby limiting the detachment, transport and delivery of sediments, sediment bound pollutants, and the delivery of animal waste to surface waters. Fencing also allows prescribed grazing which improves livestock production and manure distribution. This method is inexpensive but labor intensive to install and may require an alternate water supply if livestock are fenced out of the streams.

Nutrient Management

Fertilizer Management. Fertilizer management is controlling the form, rate, timing, and placement of applications of fertilizer to encourage maximum nutrient recycling, minimize expense of fertilizing and provide optimum soil fertility conditions for the planted landscape. By carefully managing soil fertility and targeting fertilizer to species grown, plant growth will be optimized, nutrient losses to proximate waters will be minimized, and soil conditions will be maintained or improved. Periodic soil tests are required.

Manure Management. Manure management involves the collection, transportation and storage of manure until conditions are suitable for land application or the material is removed from the site. This reduces the quantity of manure and the associated phosphorus carried in the stormwater runoff. When manure is used as fertilizer for the fields, manure and soil testing is critical to ensure proper fertilization (see Fertilizer Management). Proper timing is also important to prevent washoff of the manure into proximal streams prior to its utilization by the plants and soil. The majority of manure management involves planning, however, some manure storage systems can be expensive.

Land Use Modifications

Field Priorities. Field prioritization refers to ranking farm fields according to their runoff, leaching or sediment yield potential, and managing them differently in terms of farming intensity and/or manure application. The purpose of this practice is to control farm losses of sediments and nutrients to water bodies while maintaining total crop production and to minimize manure losses while maximizing nutrient utilization in the context of a daily spreading program. This is an effective, low cost, planning tool.

Cover Crops. Cover crops are close-growing grasses, legumes, or small grains, grown primarily for temporary, seasonal soil protection and improvement. Cover crops are planted after harvesting a crop that leaves little residue on the soil or, when grown between trees and vines in orchards and vineyards. Cover crops protect exposed soil, thus control erosion, add organic matter and nutrients, suppress weeds, remove surplus nitrogen remaining in the soil after harvest, improve soil tilth and fertility. Cover crops are usually only grown for one year at most.

Crop Rotation. Crop rotation is a planned sequence of growing different crops in a recurring sequence on the same field in different years. Rotation is usually one component of a conservation management system that in part, reduces erosion, manages excess plant nutrients, and maintains or improves organic content in the soil. Crop rotation can break cycles of pests, require fewer chemicals, fewer applied nutrients, and ultimately provide greater yields.

Tillage Methods

Conservation Tillage. Conservation tillage refers to any tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting to reduce soil erosion. Types of conservation tillage include minimum-till and no-till. Minimum-till equipment (chisel plows, field cultivators, discs, rototillers, etc.) tills and roughens the soil surface without incorporating all the plant residue. A minimum of 30% of the crop residue remains on the soil surface. No-till provides only a narrow band of tillage in the seed zone. Crop residues remain on the soil surface, virtually undisturbed by the planting operation. This practice benefits water quality by reducing soil erosion, increasing infiltration and decreasing runoff. Conservation tillage is particularly effective at reducing phosphorus losses for row crops, which have large exports of phosphorus with conventional till methods.

Forest Management Alternatives

Timber harvesting, if not carefully planned, can result in significant erosion and nutrient transport to surrounding water bodies. Management practices, not previously discussed, are described below

(Table 24). In addition, an ecosystem approach to forest management can also be effective at reducing nutrient runoff. An ecosystem approach involves managing for different components of a forest, such as plant species composition and age-class distributions. Details on each management alternative can be found in the state's management practices catalogue (New York State DEC 1996).

Planned Harvest Operations

A harvest plan incorporates information about soil, slope and water resources to determine the spatial limits and intensity of the harvest so as to reduce the potential for erosion. This practice requires some additional time prior to harvest, but it improves the efficiency of the operation and protects the water quality.

Access Routes/Road Water Management

The proper design of logging roads and skid trail systems can significantly reduce erosion. Critical site features are topography, soils, rock outcrops, wetlands, watercourses, and the future needs of the area. Properly sited existing trails should be utilized as much as possible with a minimum of modification. Logging roads should have proper water management, such as drainage dips, cross-drain culverts or ditches. Care must also be taken not to damage drainage controls by heavy equipment and special attention should be made to roads on highly erodible soils. Properly designed and maintained drainage systems can prolong the useful life of the access road.

Riparian Buffers

See Urban Management Alternatives / Stream Corridor Management

Watercourse Crossings

Water crossings should be avoided unless absolutely necessary. Stable structures can be installed across watercourses to provide temporary access for logging operations to minimize the effects of the crossing. Bridges, culverts, or fords may be applicable depending on the site. The design of watercourse crossings must take into account fish spawning and migration, as well as protecting against increased channel erosion or flooding. All disturbed areas should be stabilized immediately after removal of the water crossing structures.

Sediment Barriers

Sediment barriers typically consist of silt fences and/or straw bale dikes installed as close to the limits of disturbance as possible, to reduce the velocity of sheet flow. These temporary measures can intercept and detail small amounts of sediment from disturbed areas during rain events. Sediment barriers can be installed near roads, skid trails, landings and other disturbed areas to minimize the impact on proximal waterbodies. There is a high percentage of failure if not installed correctly or properly maintained.

Table 24. New York generic forest best management practices summary.

MANAGEMENT PRACTICES	RELATIVE COST	LIMITING CONDITIONS	MAINTENANCE	ADVANTAGES	DISADVANTAGES	SPECIAL CONSIDERATIONS
Access Routes/Road Water Management	**Low**	**Avoid wet soils, steep slopes, rock outcrops and riparian buffer zones**	**Routine inspections, frequent mainten-ance during harvest season**	**Improves efficiency of operations, protection of wildlife**	**Requires planning time**	**Routes must be stabilized and stream crossings removed after harvest operations cease**
Riparian Buffer Protection	**Low**		**Boundaries marked before logging begins**	**Effective, easily implemented; benefits ecosystem**	**Loss of timber in buffer zone; longer road/trail network may be needed**	**Buffer distance varies according to soil type, slope, cover and season**
Watercourse Crossings	**Moderate to high**	**Natural resources may limit location and types of crossings; vehicle ac-cess requirements may restrict use**	**Periodic removal of debris**	**Bridges can be removed and reused**	**May interfere with fish spawning and migration; flooding and channel erosion may result from constrictions**	**No equipment should be operated in the watercourse; disturbed area after removal should be stabilized immediately**
Sediment Barriers	**Low**	**Not suited to large drainage areas**	**Regular inspections; clean out accumu-lated sediment**	**Easy to install, fences can be reused; straw bales can be used for mulch**	**High percentage of failure from poor maintenance**	**Soil particle size may limit effectiveness**
Planned Harvest Operations	**Low**		**Regular inspection of management practices, post-harvest inspection**	**Improves efficiency of operations, protection of wildlife**	**Requires planning time**	
Vegetation Establishment	**Site dependent**	**Large sites may require revegetation in stages**	**Protect area until vegetation is estab-lished; periodic topdressing of fertilizer may be needed**	**Food and cover for wildlife**	**Large sites may require special equipment**	**Soil tests, seed selection and amendments improve success**

Vegetation Establishment/Revegetation

Establishing vegetation on bare soils, particularly on steep slopes, can prevent severe erosion of sediment to surrounding watercourses. The vegetation may be a fast growing grass or legume, later followed by the planting of trees and shrubs. This management practice can also provide a habitat for wildlife. Areas with poor initial establishment should be re-seeded.

MONITORING PLAN

USEPA guidance (1999a, 1999b) recommends that TMDL submittals include a monitoring plan to determine whether implementation of the TMDL has resulted in attainment of water quality standards and to support any revisions to the TMDL that might be required. The Lake Champlain Management Conference (1996a) plan recognized the need for ongoing monitoring to evaluate the success of phosphorus reduction and other environmental management efforts in the Lake Champlain Basin.

The ultimate measure of the success of the Lake Champlain Phosphorus TMDL is the extent to which the in-lake total phosphorus criteria (Table 2) are achieved. Lake phosphorus concentrations can be monitored relatively easily and unambiguously. However, in-lake phosphorus concentrations may or may not respond as expected to phosphorus management programs in the watershed. A much more extensive monitoring effort is necessary in order to understand the reasons for any changes, or lack of changes, observed in lake phosphorus levels so that management efforts can be redirected if necessary. Figure 5 illustrates the many different factors that will influence the success of the Lake Champlain Phosphorus TMDL in achieving the in-lake phosphorus criteria. The relationships between these factors are discussed below.

Lake phosphorus concentrations are strongly determined by tributary phosphorus loads, which are the focus of the management effort. However, internal loading from phosphorus stored in lake sediments can delay the response of the lake to tributary load reductions. This may be especially true for shallow areas of the lake such as St. Albans Bay and Missisquoi Bay. Biological interactions within the lake such as zebra mussel infestation may also affect the phosphorus concentrations in the lake water through incorporation of phosphorus into zebra mussel biomass or by enhanced deposition of phosphorus to the sediments in zebra mussel feces. If lake phosphorus concentrations do not respond as expected to documented reductions in tributary loading, it will be important to understand the possible role of in-lake processes such as internal loading and biological effects.

Tributary phosphorus loads are highly variable from year to year as a result of natural differences in weather and runoff volumes. It is therefore necessary to obtain several years of monitoring data before making inferences about trends in tributary phosphorus loads.

Changes in tributary phosphorus loads will be influenced by point and nonpoint source management programs. If tributary phosphorus loads do not decline as expected, it will be important to understand the reasons for the lack of response. Point source phosphorus loads can be monitored by effluent sampling and flow measurements at all wastewater treatment facilities in the basin in order to verify compliance with the phosphorus wasteload allocation for each facility. However, it is impractical to directly monitor the phosphorus reduction effectiveness of each nonpoint source BMP installed throughout the basin. Instead, it will be essential to document the extent of BMP implementation, including the numbers and types of each BMP within each watershed, in order to confirm that the intended management effort has actually taken place. In addition, monitoring should be conducted at a few carefully chosen demonstration sites to verify that the agricultural and developed land BMPs in common use in the Lake Champlain Basin do, in fact, produce significant phosphorus load reductions.

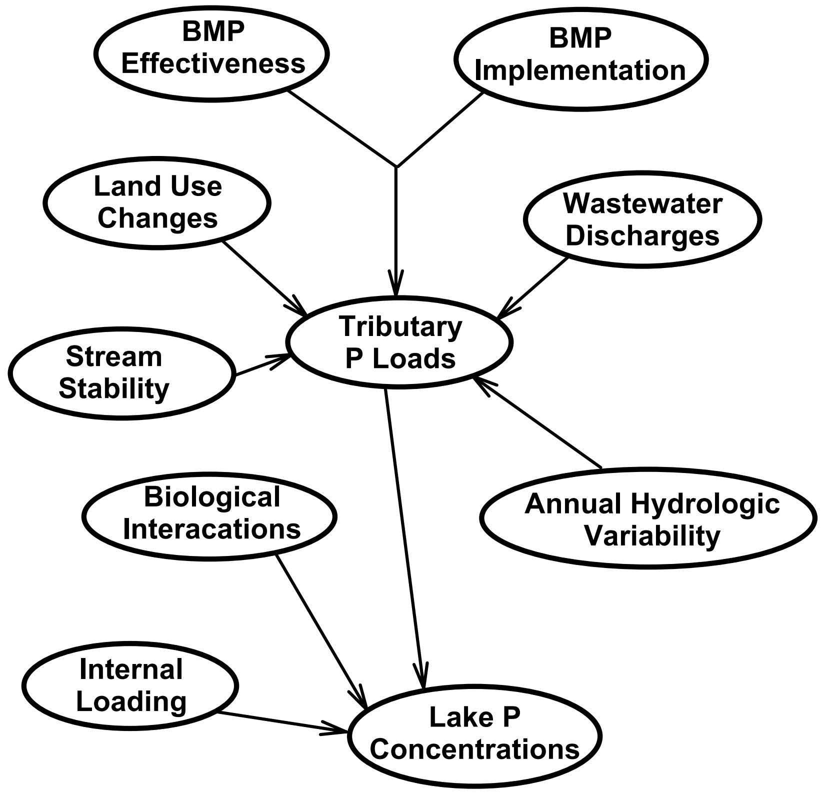

Figure 5. Monitoring phosphorus reductions in the Lake Champlain Basin.

Geomorphic changes in unstable rivers can contribute significant loads of phosphorus through processes such as streambank erosion. Changes in stream channel conditions may affect phosphorus loading in a manner that is independent of watershed phosphorus control efforts. A basin-wide stream stability assessment is needed that identifies the physical condition, sensitivity, and adjustment process of each stream reach. A program to develop assessment protocols and reference data is being piloted by the Vermont DEC. The stream stability assessment database should be used to identify reaches having the highest potential for phosphorus loading, and to track major changes in stream stability within the basin.

If phosphorus loads do not decline in a tributary even though all necessary point and nonpoint source phosphorus reduction practices have been widely and effectively implemented, it is possible that land use conversion to more developed uses may be offsetting the benefits of the management programs (Lake Champlain Basin Program 2000a). Monitoring of land use changes throughout the basin will be necessary to determine the extent to which urban growth and development may be interfering with attainment of the TMDL. Changes in human population and the density of farm animals in the basin should also be considered.

In-stream storage of phosphorus may create a time lag between the implementation of loading reductions in the watershed and the loading response measured at the tributary mouth. However, a study of in-stream phosphorus transport in the LaPlatte River (Hoffman et al. 1996) indicated that the stream channel was not a long-term repository for stored phosphorus in that system. Storage of phosphorus in flood plain or reservoir sediments could be a factor in some rivers. Annual hydrologic variability is factor that requires the collection of at least several years of consistent monitoring data before statistically significant trends in tributary loads can be documented.

The Lake Champlain Basin Program and the States of Vermont and New York are supporting several related monitoring programs that address the factors illustrated in Figure 5. The following programs will be used to evaluate the success of the Lake Champlain Phosphorus TMDL.

Lake Phosphorus Concentrations

The Lake Champlain Long-Term Water Quality and Biological Monitoring Program (Vermont DEC and New York State DEC 2002) has operated since 1992. This program includes systematic sampling for a number of eutrophication parameters including total phosphorus at 14 stations in the lake. The lake sampling station network includes at least one centrally located sampling station within each of the 13 lake segments. The cost of operating the Lake Champlain Long-Term Water Quality and Biological Monitoring Program is currently $290,000 per year. This program also provides data on lake tributary and wastewater treatment facility phosphorus loads (discussed below), as well as a variety of other water quality and biological measurements.

Long-term eutrophication monitoring data are also available from the Vermont Lay Monitoring Program which has sampled stations throughout Lake Champlain since 1979 (Picotte 2001). Data from these programs will be used to assess phosphorus concentration trends in the lake and compliance with the in-lake phosphorus criteria. The cost of operating the Lay Monitoring Program on Lake Champlain is currently $30,000 per year.

In-Lake Processes

The Lake Champlain Basin Program has supported research and modeling studies on internal phosphorus cycling in the lake. Models developed by Martin et al. (1994) and HydroQual, Inc. (1999) are available to analyze the effects of internal processes on the response of Lake Champlain to phosphorus loading reductions.

The Lake Champlain Zebra Mussel Monitoring Program (Eliopoulos and Stangel 2001) is conducted concurrently with the Long-Term Water Quality Monitoring Program and provides information on the distribution of zebra mussels throughout the lake. Data from these programs and other related research will be used to assess the effects of zebra mussels and other biological interactions on phosphorus concentrations, phytoplankton populations, and water clarity in the lake.

Tributary Phosphorus Loads

The Lake Champlain Long-Term Water Quality and Biological Monitoring Program (Vermont DEC and New York State DEC 2002) includes sampling for total phosphorus and other parameters near the mouths of 18 major tributary rivers. Continuous flow gages are operated on each of these rivers by the U.S. Geological Survey or the Quebec Ministry of the Environment. The flow gages provide data that are essential to the estimation of tributary phosphorus loads. The tributary sampling program is designed to support analysis of trends in phosphorus loads. A special appropriation of $210,000 per year (FY 2002) to the U.S. Geological Survey has been necessary to supplement the long-term stream gaging program in the Lake Champlain Basin.

The 18 monitored tributaries represent 87% of the Lake Champlain drainage basin, including the lake segment watersheds where most of the phosphorus load reductions are targeted. However, there is little or no tributary monitoring conducted in some of the smaller lake segment watersheds (South Lake A, Port Henry, Burlington Bay, Northeast Arm, St. Albans Bay). It will not be possible with the existing monitoring program to directly evaluate tributary loads from these small lake segment watersheds.

The Missisquoi Bay Phosphorus Reduction Task Force (2000) report recommended an expansion of the tributary phosphorus monitoring and flow gaging efforts in the Missisquoi Bay watershed so that loads can be estimated separately for the Vermont and Quebec portions of the watershed. To implement this recommendation, the Quebec Ministry of the Environment will increase the sampling frequency at six recently established monitoring stations in Quebec near the border crossings on the Missisquoi, Pike, and Rock Rivers. The Quebec Ministry of the Environment will also add new continuous flow gages on the Rock and the Ewing Rivers. The Vermont DEC will increase the sampling frequency at the existing long-term monitoring stations near the mouths of the Missisquoi River and the Pike River. The U.S. Geological Survey will install and operate a new continuous flow gage on the Pike River near the border in Vermont. A coordinated workplan will be developed between the Vermont DEC and the Quebec Ministry of the Environment to ensure that the data are collected and analyzed in a consistent manner in order to estimate phosphorus loads from each jurisdiction within the Missisquoi Bay watershed.

Wastewater Phosphorus Loads

Most of the 60 wastewater treatment facilities in the Vermont portion of the basin are currently required to conduct regular self-monitoring for total phosphorus under the terms of their discharge permits. Requirements to monitor phosphorus concentrations are being phased in at all Vermont facilities as their discharge permits are renewed.

All of the 29 wastewater treatment facilities in the New York portion of the basin either self-monitor or are monitored on a monthly basis by the New York State DEC. All plants will be required to monitor effluent total phosphorus as their discharge permits come up for renewal.

Effluent phosphorus and flow monitoring data at all wastewater treatment facilities will be compiled annually. The data will be used to calculate the phosphorus loads from each facility to confirm compliance with the wasteload allocation.

BMP Implementation

The Lake Champlain Basin Program and the U.S. Department of Agriculture is supporting agricultural BMP tracking projects at the Vermont Department of Agriculture, Food, and Markets and the New York Department of Agriculture and Markets. The purpose of these projects is to compile information on agricultural BMP implementation and other farm management activities within the Lake Champlain Basin. The data will be organized into geographic databases so that the extent of agricultural BMP implementation in each watershed can be documented and the corresponding phosphorus load reductions can be estimated. The current cost of the agricultural BMP tracking programs is $60,000 per year in Vermont and $76,000 per year in New York.

BMP Effectiveness

Agricultural Watersheds National Monitoring Program Project (Vermont)

The Lake Champlain Basin Agricultural Watersheds National Monitoring Program Project was conducted during 1994-2000 on tributaries to the Missisquoi River in Vermont, with funding from the USEPA (Meals 2001). The study employed a controlled, paired-watershed design to evaluate the effectiveness of livestock exclusion, streambank protection, and riparian restoration practices in reducing runoff of sediment, nutrients, and bacteria from agricultural land. Final results from three years of post-treatment monitoring confirm that significant reductions in total phosphorus concentrations and loads occurred in response to livestock exclusion and riparian restoration.

Englesby Brook and Little Otter Creek BMP Effectiveness Studies (Vermont)

Two other water quality monitoring projects are underway to evaluate the effectiveness of nonpoint source BMPs in the Lake Champlain Basin. These studies are being conducted by the U.S. Geological Survey, in cooperation with the Lake Champlain Basin Program, the Vermont DEC, and the City of Burlington. One study was initiated during 1999 in the urban Englesby Brook watershed in Burlington, Vermont. The Englesby Brook monitoring project was designed in anticipation of watershed-wide urban stormwater control projects planned as part of the Pine St. Barge Canal Superfund Site Cooperative Solution. A second study was started during 2000 at an agricultural site in the Little Otter Creek watershed in Ferrisburg, Vermont. Several agricultural BMPs are planned for the Little Otter Creek site. Both projects will operate for the next several years, and will measure and compare stream flows and concentrations of phosphorus and other pollutants before and after implementation of BMPs. The current cost of operating these to BMP effectiveness studies is $146,500 per year.

Little Ausable Watershed Management Plan (New York)

In 1994, a watershed planning process was initiated to identify nonpoint source delivery areas needing treatment in the Little Ausable watershed and to recommend BMPs and other management measures for specific sites in the watershed. The water quality problems to be addressed were both “in-stream” and “in-lake”. The in-stream problem was related to sediment deposition in the Little Ausable and its tributaries and the impact of this deposition on the fisheries resource. The in-lake problem related to the impact that phosphorus loading from the Little Ausable has on Lake Champlain.

The Main Lake segment of Lake Champlain, which receives runoff from the Little Ausable watershed, has a phosphorus concentration of 0.012 mg/l (Table 2) which places this segment of the lake in a slightly mesotrophic category.

The goals of the planning initiative were to:

1. Reduce phosphorus loading from the Little Ausable watershed by 0.84 metric tons per year (a 0.64 metric ton reduction of phosphorus loading was to be achieved by controlling nonpoint sources within the Little Ausable watershed, while a 0.20 metric ton reduction of phosphorus loading from the watershed was to be achieved through the control of point source discharges at the Village of Peru sewage treatment plant).

2. Enhance fisheries habitat in the Little Ausable River system by reducing sediment loading in the watershed so as to decrease embeddedness in the river to 10% or less.

The Little Ausable watershed contributes about 4.5 metric tons of phosphorus per year to Lake Champlain from point and nonpoint sources in the watershed. The Generalized Watershed Loading Functions (GWLF) model, a lumped parameter model, was employed to derive phosphorus loading estimates for various land uses in the watershed. The GWLF modeling study provided an annual phosphorus loading estimate of 3.77 metric tons from various rural and urban nonpoint sources within the Little Ausable watershed. The difference between 4.5 metric tons and 3.77 metric tons, i.e., 0.73 metric tons is the contribution of phosphorus loading to the lake from the that the Village of Peru sewage treatment plant, according to the model. The model estimated phosphorus loading from corn fields, on which manure was assumed to be spread from October to May, to be 1.85 tons per year based on 1993/1994 land use data. It was estimated that phosphorus loading from septic tanks in the watershed is 0.13 metric tons per year.

On the basis of the GWLF phosphorus loading estimates, farm plans were prepared for the major dairy producers in the watershed which included seven farms. The farm plans identified a variety of BMPs needed to control phosphorus and sediment loading from agricultural operations in the watershed. In addition to nutrient management plans that were prepared for each farm, BMPs included manure storage facilities, streambank fencing, control of barnyard runoff and others. To date, approximately $630,000 has been allocated from New York State Environmental Bond Act funds for BMP implementation in the Little Ausable watershed. To date, only one dairy producer has been unwilling to cooperate in the planning process to control nonpoint source pollution in the Little Ausable watershed.

Mouth of the river monitoring for phosphorus and total suspended solids was initiated in 1991 and it is continuing. It should be possible to determine from the monitoring over the next few years if there has been a reduction in phosphorus loading as a result of BMP implementation on farm lands in the watershed.

In addition to the agricultural nonpoint source control initiatives, there have been two additional nonpoint source management initiatives. The Town of Peru Highway Department has cooperated in stabilizing eroding road banks and ditches at a critical site in the watershed, and Trout Unlimited and local girl scouts have joined forces in a planting project to restore riparian vegetation along nearly 1,000 foot stream segment in the watershed. It is anticipated that the restoration of riparian vegetation will continue with volunteer groups on an annual basis.

It appears, based on visual observation, that sediment embeddedness in the streams has improved, but clearly the goal to decrease embeddedness in the river to 10% or less has not been achieved.

Halfway Brook Watershed Management Plan (New York)

In 1998 the Warren and Washington County Soil and Water Conservation Districts applied for and received funding from the NYS DEC and the US EPA to study the Halfway Brook watershed. The results of this study were published as the Halfway Brook Watershed Management Plan in August 2000.

Halfway Brook is a successful trout fishery. In recent years there has been concern that nonpoint sources of pollution had caused the water quality of the stream to decline. As part of the study, eight (8) stations were established to measure biological and chemical levels along the length of the brook. Monitoring took place from October 1998 to May 2000. It was determined that water quality is influenced by runoff from both developed areas and agricultural lands. Phosphorus increases from the headwaters to confluence with the canal. Total suspended solids and fecal coliform levels vary depending on the season and sample location. Fish and macroinvertebrates are impacted throughout the stream, most noticeably by storm water runoff entering the brook between Route 9 and Meadowlands Road.

Implementation of the remedial measures contained in the Halfway Brook study would improve water quality in the brook, enhance the fishery environment and reduce the phosphorus loading to Lake Champlain proper.

Implementation of Miscellaneous Watershed BMP's (New York)

In the period 1995 - 1997, there were some 65 agricultural BMP's installed in the Lake Champlain Basin. These projects impacted approximately 20,000 animal units. From 1997 to date an additional 76 BMP's have been completed bring to 48,000 the total number of animal units treated. This latter period includes only projects funded with EPF and Bond Act funds and certainly does not account for the total agricultural BMP's installed in the watershed.

These projects will continue and other nonpoint source remedial efforts will be initiated in the basin. An accurate estimate of the phosphorus reduction is not possible until additional monitoring results are available.

Land Use Changes

A satellite based land use and land cover data set (ca. 1993) was acquired and processed for the entire Lake Champlain Basin (Millette 1997). These data were used to produce nonpoint source phosphorus loading estimates from each land use category (Hegman et al. 1999). It will be necessary to obtain updated and improved land use data for the basin periodically (e.g., every five years) so that phosphorus loading estimates can be refined and the effects of land use conversions on phosphorus loading can be evaluated.

High-resolution, multi-spectral satellite imagery should be acquired for the Lake Champlain Basin as soon as possible and analyzed together with existing geographic information coverages and appropriate ground truth data to produce a new land use and land cover data set for the basin. The U.S. Army Corps of Engineers has the technical capability to accomplish this work, at an estimated cost of $1.5-2.0 million. Repeating the analysis every five years would cost about $1.0 million each subsequent time. The land use and land cover data set produced by this work would support many other applications and needs in the basin in addition to assessment of phosphorus reduction progress.

Additional Research Needs

A major area of further research needed to support the implementation of the TMDL and the assessment of progress concerns the quantification of phosphorus load reductions from each nonpoint source management action. A list of short-term (one-year time frame) and long-term (multi-year project) research needs is given below. A research budget of $200,000 per year should be provided to support projects of this nature. These funds could be awarded through a competitive proposal process using existing Lake Champlain Basin Program funding mechanisms.

Short-Term Research

1. *Streambank Erosion*. Conduct a literature review to produce a range of values for stream erosion and associated phosphorus load. Use geomorphic assessment data and other information available to estimate the miles of eroding streambank in the watersheds of each lake segment or major tributary. Calculate total "potential phosphorus reduction" if the streams were stabilized. ($5,000)

2. *Backroad inputs*. Estimate the number of miles of unpaved backroads in selected watersheds. Solicit information from town managers about what percentage of these roads present management challenges. Estimate a reasonable sediment loss coefficient per mile of road. Multiply the miles of eroding roads by this loss coefficient and an average sediment phosphorus concentration to estimate total "potential phosphorus reduction." ($10,000)

3. *Construction site erosion.* Using data from building permits, estimate the average acreage under construction in each lake segment watershed each year. Using local building codes, estimate what percentage of these sites use a standard set of construction site BMPs. Using phosphorus loading coefficients available for construction site BMPs, estimate the average annual reduction in each lake segment watershed that might be achieved if all sites implemented a standard set of BMPs. ($20,000)

4. *Uncertainty analysis.* Estimate the statistical uncertainty associated with the Hegman et al. (1999) land use based phosphorus loading estimates. ($1,700)

5. *Population growth analysis for nonpoint source pollution.* Model the increased phosphorus load from suburban development using alternative methods. ($1,700)

Long-Term Research

1. Conduct a field research study to develop a sediment phosphorus budget for priority lake segment watersheds. Quantify sediment sources, transport and fate as well as attached phosphorus content. This is a major need everywhere in the country and is the only way to eventually separate sediment sources and amounts. ($200,000/year for five years in one watershed, then additional years to calibrate the specifics for other watersheds)

2. Use watershed modeling and field assessments to relate changes in land use patterns in the watershed to expected changes in stream geomorphology and phosphorus loading. ($200,000/year for five years)

3. Relate the stream geomorphic assessment data to sediment phosphorus loading expected in each major tributary watershed by measuring sediment loss and phosphorus inputs in selected stream reaches across a variety of conditions. ($150,000/year for three years)

4. Instrument new light urban/suburban stormwater management technologies to collect water and bed load samples for analysis in order to estimate the loading from this land use type. ($100,000 in first year for instrumentation, installation and initial sampling, $50,000/year afterwards for each year monitored)

PUBLIC PARTICIPATION

Lake Champlain Management Conference Process

The Lake Champlain Management Conference (1996a) plan *Opportunities for Action* that established the framework for the Lake Champlain Phosphorus TMDL was developed with extensive public participation. The in-lake phosphorus criteria were originally established for Vermont waters by the Vermont Water Resources Board through a public rule-making process. The preparation of the comprehensive plan for Lake Champlain, including the phosphorus reduction chapter and the watershed phosphorus loading targets, involved substantial public review and participation. The Lake Champlain Management Conference was advised by Citizens Advisory Committees in Vermont and New York. Numerous public input meetings, citizen perception surveys, and focus group discussions were used to identify issues and establish priority action items in the plan, including all aspects of the phosphorus reduction issue. Summaries of public input on drafts of the plan and program responses were provided by the Lake Champlain Basin Program Education and Outreach Committee (1995), and by the Lake Champlain Management Conference (1996b).

The Lake Champlain Phosphorus TMDL was developed in a manner consistent with the Lake Champlain Management Conference (1996a) plan, and involved additional opportunities for public participation in Vermont and New York, as summarized below.

Vermont Public Process

The Vermont DEC conducted substantial internal and inter-agency consultation prior to release of the first public draft of the TMDL. Review of working drafts and comments were provided by the Vermont Department of Agriculture, Food, and Markets, the Vermont Department of Fish and Wildlife, the Vermont Department of Forests, Parks, and Recreation, the New York State DEC, the Quebec Ministry of the Environment, and the USEPA.

The first public draft of the TMDL was released by Vermont DEC on June 22, 2001. The June 22, 2001 draft was a Vermont document, and did not include aspects specific to New York This draft was mailed to an extensive mailing list of over 400, along with a cover letter from the Vermont DEC Commissioner and a schedule of public briefing sessions. At the same time, the draft TMDL document, the cover letter, and a fact sheet were placed on the Water Quality Division website. The cover letter explained the context and importance of the TMDL as part of the phosphorus management strategy for Lake Champlain. The cover letter, draft TMDL document, and public meeting schedule were distributed to the following organizations.

- All municipalities in the basin
- All other direct wastewater discharge permit holders with phosphorus allocations
- Regional Planning Commissions
- Vermont League of Cities and Towns

- Major Vermont environmental groups
- Vermont Farm Bureau
- Vermont Association of Conservation Districts
- Natural Resource Conservation Districts
- Other statewide agricultural groups
- Associated Industries of Vermont
- Associated General Contractors of Vermont
- Natural Resource Conservation Districts
- Vermont Department of Agriculture, Food, and Markets
- Vermont Department of Housing and Community Affairs
- Vermont Department of Fish and Wildlife
- Vermont Department of Forests, Parks, and Recreation
- Vermont Agency of Transportation
- Vermont Water Resources Board
- New York State Department of Environmental Conservation
- Quebec Ministry of the Environment
- Vermont Lake Champlain Citizens Advisory Committee
- Lake Champlain Basin Program
- Local watershed groups
- All Vermont Legislators

The Vermont Agency of Natural Resources (ANR) issued a press release on June 25, 2001 announcing the Draft Lake Champlain Phosphorus TMDL. The press release explained the scope and importance of the TMDL and encouraged Vermonters to participate in the upcoming public meetings. An opinion column about the importance of the Lake Champlain TMDL written by the Vermont ANR Secretary was published in a major state daily newspaper on July 17, 2001. An article about the Lake Champlain Phosphorus TMDL was provided to Vermont newspapers as part of the Vermont ANR's "Reflections on the Environment" series on September 10, 2001. This article included the schedule of public meetings.

Nine public informational meetings were held in Vermont at various locations within the Lake Champlain Basin during August and September, 2001. At each meeting, a presentation was made by Vermont DEC staff giving an overview of the TMDL and an explanation of the wasteload allocation alternatives and other policy choices to be made. Participants at the meetings were encouraged to send follow-up written comments to the Vermont DEC for consideration as the draft TMDL was revised. The Vermont ANR provided a written progress report on the Lake Champlain Phosphorus TMDL to the Vermont Legislature in January 2002.

After considering public comments received on the June 22, 2002 draft and conducting further analysis, the Vermont DEC released a second public draft of the TMDL on April 29, 2002. The April 29, 2002 draft was a joint Vermont and New York document, and included allocations and implementation plans for both states. The April 29, 2002 draft also included revisions requested by the USEPA following informal technical review and consultation.

A letter from the Vermont DEC Commissioner announcing the April 29, 2002 draft TMDL was sent to the same mailing list described above. The letter established a public comment period extending to June 14, 2002 and provided a schedule of public meetings. Paid notices were placed in four Vermont daily newspapers, and the Vermont ANR provided a press release on the TMDL to state media outlets. Four public informational meetings were held during May 2002 at various locations in the Vermont portion of the Lake Champlain Basin. The new draft TMDL, the public meeting schedule, a summary of changes since the June 22, 2001 draft, and an updated fact sheet were placed on the Water Quality Division website.

The Vermont DEC considered all written comments received on the April 29, 2002 draft in making final revisions to the TMDL. All major public comments were compiled, and responses to each comment were provided in a Response Summary document.

New York Public Process

The availability of the Draft Lake Champlain Phosphorus TMDL for public review was noticed in the State Environmental Notice Bulletin dated May 1, 2002. Two (2) public meetings to discuss the TMDL were held on May 15, 2002 in Westport, NY and Plattsburgh, NY. Oral comments received at those meetings were considered with the same weight as written comments.

Written comments were received up to the end of the public comment period on June 14, 2002. Eleven (11) comment letters were received (Table 25), many of which contained the same comments, similar comments, and/or recurrent themes. A “Response to Public Comments on NYSDEC’s Draft Lake Champlain Phosphorus TMDL” has been issued August 30, 2002 to provide a collective answer where possible.

Upon completion of the Response to Comments, and coordination with the State of Vermont to address administrative issues with USEPA, The New York State DEC approved the Lake Champlain Phosphorus TMDL and submitted the documents to the USEPA for their approval. Upon approval by the USEPA, the Lake Champlain Phosphorus TMDL will become final.

Table 25. List of organizations that submitted comments to New York State DEC on the Draft Lake Champlain Phosphorus TMDL

1. Clinton County Water Quality Coordinating Committee
2. Essex County Board of Supervisors
3. City of Plattsburgh Environmental Services Department
4. Essex County Department of Community Development and Planning
5. International Paper, Ticonderoga Mill
6. American Forest and Paper Association
7. Boquet River Association, Inc.
8. Lake Champlain Committee
9. Champlain Watershed Improvement Coalition of New York
10. Town of Crown Point
11. New York State Department of Agriculture and Markets

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