

## Monitoring and Research

### The Problem

The ultimate goals of the Lake Champlain Phosphorus TMDL implementation plan are to take all the actions necessary to attain the loading limits specified in the TMDL for each sub-watershed, and to achieve the in-lake phosphorus water quality criteria for each lake segment. Long-term water quality and land use monitoring is needed to determine whether these targets are being achieved, and to understand the reasons when goals are not being met.

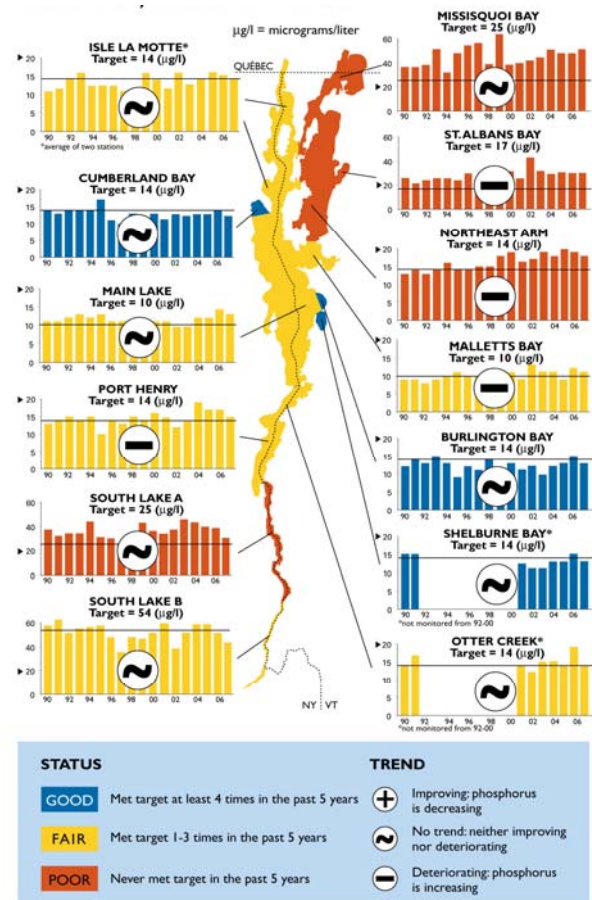
Act 130 of the 2008 Legislative Session requires the Agency of Natural Resources to revise the Vermont Implementation Plan for the TMDL to improve the targeting and tracking of phosphorus reductions in the Lake Champlain Basin. Specifically, Act 130 requires the ANR to develop a process for identifying critical source areas for nonpoint source pollution in each subwatershed, and to develop a method of accounting for changes in phosphorus loading to Lake Champlain due to implementation of the TMDL and other factors.

### Program Accomplishments

Much of the monitoring and research work related to the Clean and Clear program is being done in close cooperation with the Lake Champlain Basin Program. A summary of the major monitoring and research projects operating during 2008 is provided below.

#### Lake Champlain Long-Term Water Quality and Biological Monitoring Program

The states of Vermont and New York jointly conduct the Long-Term Water Quality and Biological Monitoring Program on Lake Champlain with support from the Lake Champlain Basin Program. The program measures phosphorus and many other parameters in the lake and its tributary rivers. The tributary monitoring results are analyzed with data from the network of stream flow gauges in the basin operated by the U.S. Geological Survey. Water quality monitoring continued during 2008 on Lake Champlain and its tributaries. This information is made freely available on the Lake Champlain Long-Term Monitoring Program website<sup>5</sup> to researchers, students, consultants, and the general public. The monitoring data were analyzed and presented in the



Status and trends in phosphorus concentration in Lake Champlain. From the Lake Champlain Basin Program 2008 State of the Lake Report<sup>6</sup>.

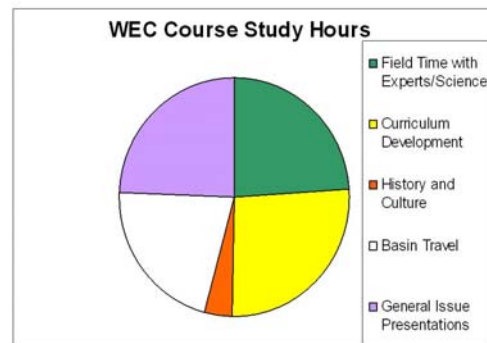
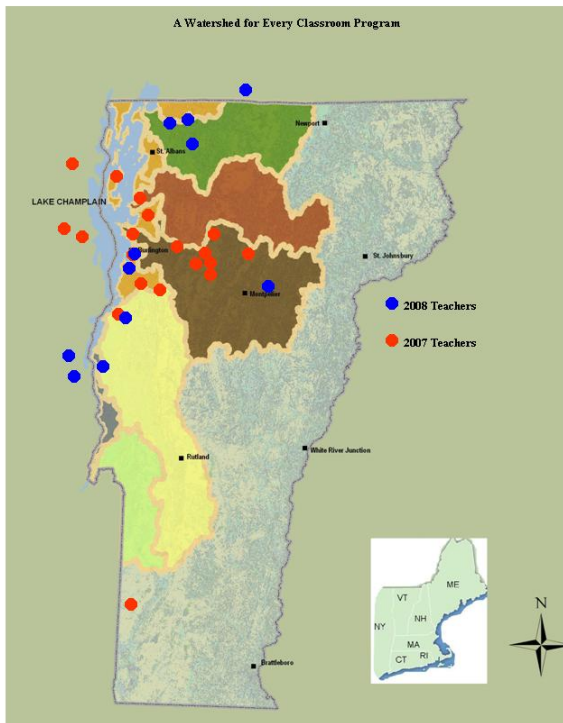
<sup>5</sup> Lake Champlain Long-Term Monitoring Program website. [http://www.anr.state.vt.us/dec/waterq/lakes/htm/lp\\_longterm.htm](http://www.anr.state.vt.us/dec/waterq/lakes/htm/lp_longterm.htm)

Lake Champlain Basin Program’s 2008 State of the Lake Report<sup>6</sup> to show the current status and long-term trends in phosphorus levels in Lake Champlain and its tributary rivers.

### Lay Monitoring Program

The Vermont Lay Monitoring Program is a cooperative effort between the Vermont DEC and volunteer lake monitors. Volunteers are trained and equipped to take weekly lake samples during June, July, and August. In 2008, the Lay Monitoring Program celebrated 30 consecutive years of this unique partnership for collecting nutrient enrichment data on Lake Champlain and many other lakes throughout Vermont. A statistical trend analysis of the long-term Secchi water disk water clarity, total phosphorus, and chlorophyll-a data is shown in the graph below. These findings were sent to all Lay Monitors and their affiliated watershed groups to enhance their understanding and encourage their support for local efforts to control nonpoint source pollution.

Additionally, results from the Lay Monitoring Program and the Lake Champlain Long-Term Water Quality and Biological Monitoring Program were incorporated into the year-long, teacher professional development course called “*A Watershed for Every Classroom*.” This course is designed specifically about the Lake Champlain watershed, and trains fourth grade through high school teachers to engage their students in learning about the basin.

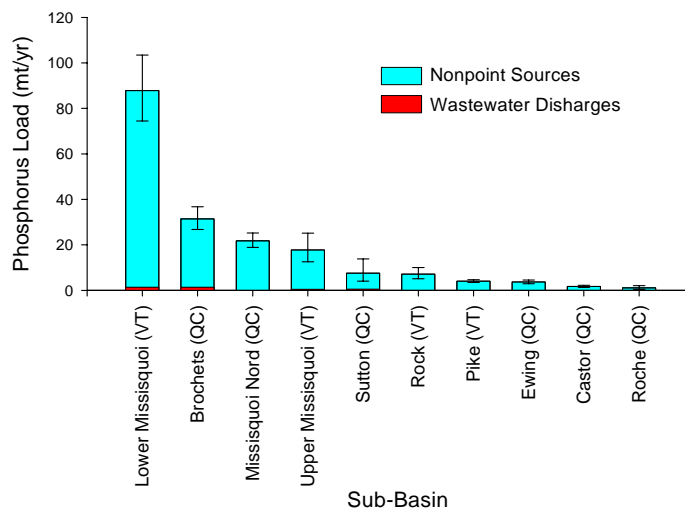


<sup>6</sup> Lake Champlain Basin Program. 2008. State of the Lake and Ecosystem Indicators Report. Grand Isle, VT. <http://www.lcbp.org/lcstate.htm>

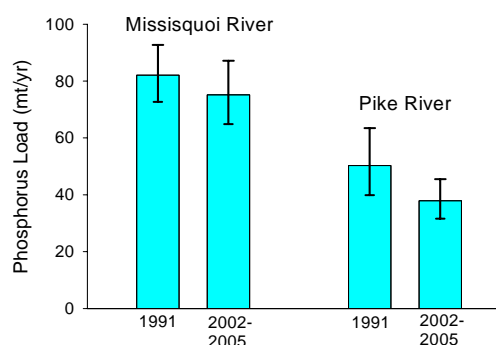
## Missisquoi Bay Watershed Phosphorus Load Monitoring

A Vermont/Quebec Water Quality Agreement signed in 2002 committed the two governments to monitor phosphorus loads within the Missisquoi Bay watershed. As a result of this agreement, Vermont DEC and the Quebec Ministry of Sustainable Development, Environment, and Parks (MDDEP) have been jointly operating a Missisquoi Bay Watershed Phosphorus Load Monitoring Program since 2002. The network of sampling and flow gage stations in the watershed has been substantially enhanced to serve this purpose.

Vermont DEC and Quebec MDDEP issued a joint report<sup>7</sup> in 2008 presenting the results of phosphorus load monitoring in the Missisquoi Bay watershed over the period of 2002-2005. Average phosphorus loading rates from ten Vermont and Quebec sub-basins within the Missisquoi Bay watershed were presented in the report (see Figure). The total phosphorus load to Missisquoi Bay continued to exceed the TMDL limit during this time period. However, a statistical analysis found that if hydrologic conditions had remained comparable to what they were during the 1991 base year, phosphorus loads would have actually declined in the Missisquoi and Pike Rivers. These findings suggest a possible beneficial effect of the wastewater treatment plant upgrades and nonpoint source management efforts that have taken place since 1991, especially in the Pike River watershed.



Phosphorus load (metric tons per year) from Vermont and Quebec sub-basins in the Missisquoi Bay watershed, 2002-2005<sup>7</sup>. Error bars are 95% confidence intervals.



Changes in phosphorus loading rates between 1991 and 2002-2005 in the Missisquoi and Pike Rivers if hydrologic conditions had remained as they were during 1991<sup>7</sup>. Error bars are 95% confidence intervals.

## Rock River Watershed Monitoring

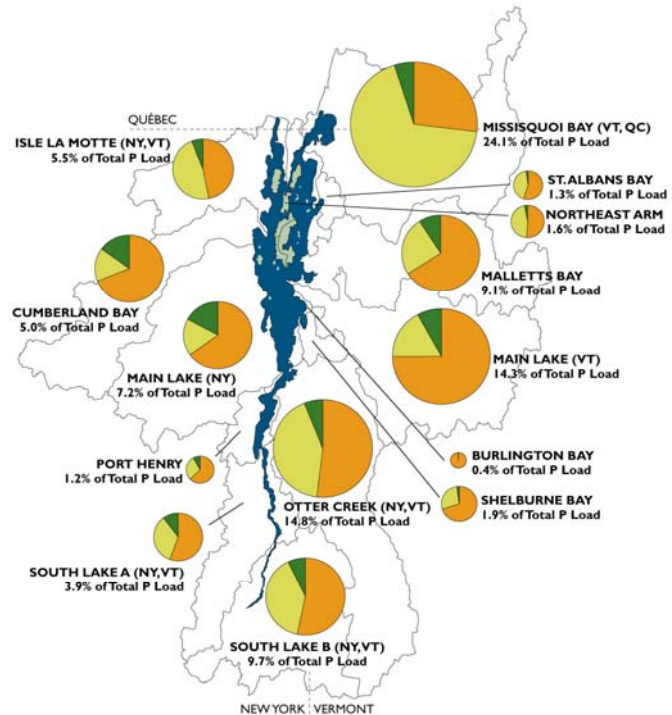
The Center for Clean and Clear conducted a special one-year Rock River Watershed Sampling Program during 2008 to help identify tributaries to the Rock River within the Missisquoi Bay watershed that are contributing the highest amounts of phosphorus and other pollutants. A total of 22 sites were sampled for total phosphorus, total nitrogen, and total suspended solids

<sup>7</sup> Smeltzer, E. and M. Simoneau. 2008. Phosphorus loading to Missisquoi Bay from sub-basins in Vermont and Quebec, 2002-2005. Vermont DEC, Waterbury, VT and Quebec MDDEP, Quebec City, QC. Prep. for Lake Champlain Steering Committee. <http://www.lcbp.org/techreportPDF/P-Load-Missisquoi-Bay-25Nov2008-en.pdf>

concentrations on 10 dates during 2008. The results will be used as one possible method for identifying sub-basins within the Rock River watershed that are the most critical sources of these pollutants.

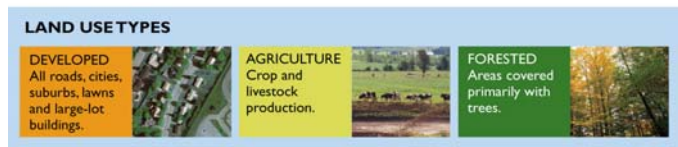
### Updated Land Use and Phosphorus Loading Predictions

Clean and Clear funds supported a project at the University of Vermont to provide updated land use data and phosphorus loading predictions for the Lake Champlain Basin, and to identify areas of the basin where changing land use has affected phosphorus export rates. The final report<sup>8</sup> completed in 2007 found that, on average basinwide, 53% of the nonpoint source phosphorus load to Lake Champlain came from urban or developed land, 39% from agricultural land, and 8% from forest land, although these proportions varied greatly among sub-watersheds.



### Phosphorus Accounting System

Clean and Clear funds are being combined with additional funding from the Lake Champlain Basin Program to support a research project at the University of Vermont on *An Environmental Accounting System to Track Nonpoint Source Phosphorus Pollution in the Lake Champlain Basin*. The purpose of the project is to develop a framework and model that can be used to account for major sources and potential reductions of phosphorus across the landscape. This project is intended to help Vermont ANR address the requirement in Act 130 to develop a method of accounting for changes in phosphorus loading to Lake Champlain due to implementation of the TMDL and other factors.

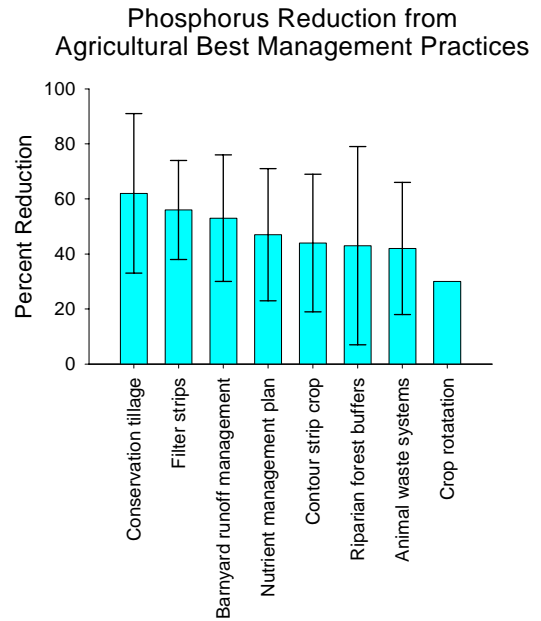


Phosphorus loading from different land use categories in sub-watersheds within the Lake Champlain Basin. From the Lake Champlain Basin Program 2008 State of the Lake Report<sup>6,8</sup>.

<sup>8</sup> Troy, A., D. Wang, and D. Capen. 2007. Updating the Lake Champlain Basin land use data to improve prediction of phosphorus loading. Prep. for Lake Champlain Basin Program. Grand Isle, VT. 116 pp. [http://lcbp.org/publication\\_detail.aspx?id=211](http://lcbp.org/publication_detail.aspx?id=211)

The investigators submitted an interim report<sup>9</sup> in 2008 on Year 1 of this research. The report presented a modeling framework that will be used during Year 2 to produce a comprehensive final report covering: (1) findings on the potential for phosphorus reduction from agricultural sources in the Rock River watershed, (2) a discussion of how the modeling system can be extrapolated to other similar watersheds throughout the Lake Champlain Basin, and (3) a discussion of how this approach might be integrated with a similar approach for urban/suburban land uses and to consider stream restoration for phosphorus reductions.

The Year 1 report included an up-to-date scientific literature review and a compilation of results from multiple published studies comparing the phosphorus reduction effectiveness of eight common agricultural best management practices<sup>10</sup>. These practices typically reduced phosphorus loads by 40-60%, although there were large variations from site to site depending on factors such as slope, soil type, and location within the U.S. The findings from this literature review were encouraging because they demonstrated that substantial phosphorus reductions can be expected from some of the management practices being pursued in the Lake Champlain Basin.



Results from a scientific literature review on the phosphorus reduction effectiveness of eight agricultural best management practices<sup>10</sup>. The bars show average percent reductions, with standard deviations, among multiple published studies.

### **Critical Source Area Identification**

The Governments of Canada and the United States, in a formal request (known as a Reference) dated August 1, 2008, asked the International Joint Commission (IJC) to coordinate initiatives in both countries to reduce phosphorus loading to Missisquoi Bay. The Reference specifically asked the IJC to coordinate a number of tasks on the U.S. side of the border in partnership with the Lake Champlain Basin Program identify critical source areas of phosphorus pollution. The work on will focus on the Missisquoi Bay watershed in Vermont, but the methods and insights derived from the study are expected to be transferrable to other watersheds in the Lake Champlain Basin. Appropriations from the U.S. Congress totaling \$800,000 will support this work, to be completed by December 2011. This project will be of assistance to Vermont ANR in

<sup>9</sup> Ghebremichael, L. and M. Watzin. 2008. An environmental accounting system to track nonpoint source phosphorus pollution in the Lake Champlain Basin. First Year Report. University of Vermont. Prep. for Vermont Agency of Natural Resources. Waterbury, VT.  
[http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp\\_phosphorusaccountingchamplain.pdf](http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_phosphorusaccountingchamplain.pdf)

<sup>10</sup> Gitau, M.W., W.J. Gburek, and A.R. Jarrett. 2005. A tool for estimating best management practice effectiveness for phosphorus pollution control. *J. Soil Water Conservation*. 60(1):1-10.

responding to the legislative direction in Act 130 to develop a process for identifying critical source areas.

The major tasks to be completed by the project include the following:

- Define data requirements and methods through a series of technical workshops.
- Acquire new geophysical data for the Missisquoi Bay watershed.
- Conduct tributary monitoring.
- Conduct modeling to identify critical source areas of phosphorus loads.

### ***Vermont ANR and University of Vermont Joint River Management Research Program***

The Vermont ANR River Management Program and the University of Vermont Water Resources and Lake Studies Center have pooled resources in recent years in order to jointly support a Watershed and Water Quality Research Program. Clean and Clear funds are used to match federal USGS funds to support grants awarded by the Water Resources and Lake Studies Center through a competitive process. The general objectives of the program are to:

1. Advance scientific understanding of the dynamics, management, and contribution of sediment and nutrients derived from fluvial processes in Vermont's rivers.
2. Establish the socio-economic justifications, costs, and benefits associated with or represented by river corridor protection in Vermont.
3. Contribute to Vermont's river corridor management, restoration, and protection infrastructure.

Projects funded through this joint ANR and University of Vermont program that are currently in progress include the following:

- Improvement of Phosphorus Load Estimates through the use of Enzyme-Hydrolysis Measures of Phosphorus Bioavailability. University of Vermont School of Engineering.
- Quantifying Sediment Loading due to Stream Bank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT Using Advanced GIS and Remote Sensing Technologies. University of Vermont School of Engineering and Rubenstein School of Environment and Natural Resources.
- A Soil-Landscape Modeling Approach to Estimate Riparian Phosphorus Concentrations along Erodible Stream Corridors in Chittenden County, Vermont. University of Vermont Department of Plant and Soil Science.