Lake Champlain Water Quality: Missing Links

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Introduction

Late summers on Lake Champlain are typical of warm days, beautiful scenic views, and friendly passer-bys. But be warned – a swim in the lake may just become a dip in what is now known as Vermont's breeding grounds for algal blooms. Located within the jurisdictions of Vermont, New York, and Quebec, the waters of Lake Champlain bloom heavy with algae during mid to late summer. The water body has been polluted for over a century, occurring as a direct result from historical civilized and industrial development. Currently, the major problem within the lake is eutrophication – a process that should take thousands of years to occur. Eutrophication is the stage at which a lake is characterized by warm shallow waters and excess algal growth from the high abundance of growth-promoting nutrients. The nutrient of concern within the Lake Champlain Basin is phosphorus, which enters water bodies through untreated discharge and runoff during precipitation events.

Efforts to clean-up Lake Champlain and filter the water body of phosphorus have been apparent since the early 1940s, when the Vermont Legislature banned the act of polluting state waters (Lapping, et al., 1979). Yet even after nearly seventy years of clean-up strategies, the lake is still impaired. In 2002, the U.S. Environmental Protection Agency (EPA) approved Vermont's Total Maximum Daily Load (TMDL) plan to improve the quality of the lake (US EPA, 2002). Nine years later, the EPA withdrew its approval of the Lake Champlain Phosphorus TMDL and made the matter a national responsibility (US EPA, 2011). The withdrawal could not possibly come as a surprise, for a 2007 report by the Vermont Agency of Natural Resources (ANR) revealed that seventeen water bodies throughout the state were stormwater impaired (VT ANR, 2007). This past year, the Vermont ANR revealed that each of these seventeen water bodies is still impaired (VT ANR, 2012).

After nearly seventy years of working to restore the lake, it still remains impaired. Why is the lake still so polluted, and what can be done for further restoration? The objective of this report is two-fold: to (1) effectively display the ways in which early economies of Vermont advanced the process of sediment buildup in the lake; and to (2) provide insight to further mitigation strategies based on an analysis of federal and state water quality progress. Specifically, legislation and policies need to address three missing links: in-stream phosphorus loads, stormwater, and development located in lake and riverside floodplains.

Photo credit: Lake Champlain International

Methods

Over a period of three months, legislative, judicial and executive policies were collected regarding the water quality of Lake Champlain. Legal qualitative data was mainly collected through government websites, the UVM Special Collections room, and the Vermont State Archives. Stakeholder websites and databases were also accessed through the internet to gather information about historical water quality policy applying to the Lake Champlain Basin. Search hosts were also used for legal reviews, historical newspaper articles, historical census data and other peer-reviewed documents pertaining to Vermont industry and development.

To interpret the qualitative data, specific events were placed onto a timeline. From there, links were established to connect specific areas of federal and state progress toward restoring Lake Champlain's water quality. Once these links were established, the collected documents were placed into the Dedoose database. For each document, descriptors were attached to define the year an event occurred, and the horizontal and vertical separation of powers. Another set of descriptors was attached to each political event to establish the cause/source of an impact and the management objective. Each event was then coded for any relevance to: collaboration, public participation, flood management, funding, nonpoint source pollution, agricultural runoff, stormwater runoff, point source discharge, phosphorus loads, education, incentives, permitting, data collection, regulatory exemptions, river/stream quality, wastewater treatment, water quality and wetlands.

Results

Historical Development Patterns

Commercial and residential development throughout Vermont's history greatly accelerated the eutrophication and degradation of Lake Champlain. The state's large tourism industry and early manufacturing industries almost always required waterfront development. Extensive amounts of development within crucial floodplains were usually indicative of hydrologic modification. Consequently, development patterns transformed the state landscape to be one of heavy flooding and heavy sedimentation. Additionally, the state of Vermont did not begin treating its sewage until the mid-20th Century. Beforehand, raw waste was dumped directly into Vermont's rivers and tributaries, allowing for the flowing waters to serve as running sewers.

Tourism in Vermont began in the late 1800s when the Vermont Central Railway was constructed. Completed in 1873, the railroad ran a 360 mile-long route from the bottom of southern Connecticut all the way north to Montreal (American-Rails, 2007). By the early 1900s, tourism in the Lake Champlain region was booming. The Boston Globe explicitly exhibited this in 1902, when they released an article entitled, "Popular Lake Champlain: Resorts on America's Most Beautiful Lake Easily Reached." The article stated that hundreds of vacationists and tourists alike were flocking to the region daily. The news press even suggested "to leave Boston in the evening and be at a Lake Champlain resort in time for breakfast is possible through the splendid train service provided by the Central Vermont railway line." Just two years later, the Boston Globe published another article called, "Lake Champlain Trips: Central Vermont Railway Makes Low Price to Famous Vermont Resort," advertising the steam ride up to be "without a question the most fascinating water trip in America" (1904).

The beauty of the region was so astounding that in 1915 a novel tour guide proposed that families turn their vacations into reality. The tour guide to the "unspoiled nature" of the Green Mountains advertised the appeal of Vermont's lakeside development. According to *The Green Mountain Tour*, "Vermont abounds in desirable sites for summer houses, be they in mountains or along the shores of her three hundred and seventy-five lakes and ponds, or in the rich and fertile valleys" (Proctor & Olzendam). People from around the world flowed into Vermont to establish such summer homes and riverside or lakeside development. Although this trend proved to be beneficial for the state's tourism industry, it was detrimental to the condition of the lake.

Natural vegetation along lakeshores and riversides help to buffer damage from flooding by reducing the erosion of shorelands. Shore habitats become degraded when such natural vegetation is removed, as much was for the development of vacation resorts and lakeside homes in Vermont. When properties and lawns (instead of natural vegetation) are placed right next to the water's edge, floodwater is able to move at much greater velocities than before. Waterfront development throughout the state extensively parallels the negative consequences induced by extreme floodwaters. With the removal of much of the lake's extensive floodplains, the water body became subject to detrimental impacts on aquatic life, surface water contamination, and phosphorus pollution from runoff (McKearnan, 2011).

With the expansion of the tourism industry and the increased development of towns and villages, Vermont's rivers and streams underwent intense hydrologic modification. The loss of natural riparian habitats and floodplains enabled floodwaters to significantly alter the habitability of the state's towns. As floods increased in intensity, towns modified stream flow in an effort to reduce residential damage. In broad terms, the Agency of Natural Resources states that "the instability of Vermont's rivers is the result of a centuries-old effort to engineer and contain stream flow. Thirty to fifty percent of Vermont's river and stream miles have been straightened" (McKearnan, 2011). Towns constructed levees and berms to control stream flow, armored stream banks and removed much of the riparian vegetation in the state.

Although early Vermonters certainly put in great effort to mitigating flood damage, it has come at a great expense. Since 2004, over eight thousand miles of Vermont's rivers and streams were analyzed for stability. Of these miles, a vast seventy-five percent are unstable. Containment structures such as levees and berms often enable rivers to erode their beds. As channels deepen, rivers are no longer able to dissipate onto their original floodplains during high precipitation events. Major storm events allow for the speed and volume of a stream's flow to build, threatening infrastructure downstream. These erosive high flows then "send substantial quantities of sediment and phosphorus pollution to downstream lakes" (McKearnan, 2011).

Such significant sedimentation has been witnessed by Vermonters many times over the past century. Since 1973, large-scale flooding has devastated the entire southern half of Vermont three times. Additionally, regional flooding has occurred throughout Vermont twenty-five times since 1973. Within the past year even, Vermonters saw sediment pour into the Lake on two separate occasions. On a single day in April of 2011, "the Winooski River carried more phosphorus to Lake Champlain from storm runoff than the annual combined discharges of all sixty of Vermont's wastewater treatment plants" (McKearnan, 2011). Heavy flooding from Tropical Storm Irene later in the season did virtually the same. By the end of the year, average phosphorus concentrations throughout the lake were the highest recorded since the initial monitoring program began in 1992. The intensity of this sedimentation left Lake Champlain researchers in awe, as they began to focus of ways to reduce sediment displacement in the future.

Historical Policy Trends

Progress for restoring the nation's waters was largely recognized after point source discharge became regulated by the state and federal governments. Point source discharge was a popular pollution abatement target in the early to mid-20th Century. However, point source pollution no longer remains an issue of high demand. The decrease in the number of tags for point source pollution directly mirrors that of wastewater treatment (Figure 1). These two areas of watershed management have been greatly successful, thus leaving the minds of those who create and enact laws and regulations.

The decreasing prevalence of point source discharge and wastewater treatment tags is directly associated with issues of increasing historical dominance. Code-words such as collaboration, public participation, nonpoint source runoff, stormwater, planning and phosphorus appeared at more frequent rates in the examined literature throughout the late 20th Century (Figure 1). Each of these subjects is of increasing concern as the State of Vermont works toward developing a watershed management strategy with optimal outcomes.

Figure 2 represents a word cloud, indicating which words appeared with the most frequency throughout all of the examined documents. The larger the word is, the more frequently it was tagged within the documents. Thus, phrases that are smaller than others may require more attention in Vermont's watershed management practices. Subjects such as nonpoint source pollution, agricultural runoff, phosphorus, funding, stormwater, and river and stream quality will need to be incorporated into Vermont's water quality policy more frequently over the coming years.

Figure 1:
Popular watershed topics over the history of Lake Champlain

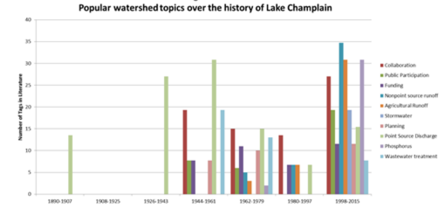

Figure 1 depicts the popular watershed topics addressed through law and regulation over a period of intervals. Topics with increasing popularity of the history of Lake Champlain include nonpoint source pollution, agricultural runoff, stormwater runoff, phosphorus, collaboration, and public participation.

Figure 2 depicts the prevalence of watershed management factors throughout the entirety of the examined literature. Phrases that are larger represent topics that have been addressed numerous times throughout Lake Champlain's history. Phrases that are smaller represent watershed management factors that still may need to be properly addressed.

Conclusions

In 2011, a report by the International Joint Committee on Lake Champlain indicated that forty percent of phosphorus carried downstream by the Missisquoi River originates from inside of the basin's riverbeds. Phosphorus embedded in stream banks is released during excessive erosion events typical of large storms (McKearnan, 2011). Such extensive erosion in the river sends high quantities of phosphorus downstream into Lake Champlain, adding onto the extensive amounts of sediment placed in the lake of the basin's history. Management bodies within the lake's jurisdiction need to address this in-stream phosphorus load, rather than simply blaming Lake Champlain's phosphorus impairment on the agricultural industry. Anthropogenically eutrophied lake ecosystems can be restored, as was exemplified in Germany just four years ago. German agencies subjected Lake Tiefwarensee to aluminum and calcium treatments over a period of five years. Within this short period, phosphorus concentrations in the lake declined by over eighty percent (Mehner, et al., 2008).

Management agencies should also consider developing a system from stormwater runoff treatment. In the 1950s, Vermont abated phosphorus pollution in the lake by diverting human waste to treatment centers. Unfortunately, stormwater drains were not connected to these treatment systems. The result of this is that stormwater from nonpermeable surfaces in cities and suburbs discharges directly into the rivers and tributaries of the lake. To clarify further, this discharge of stormwater runoff is not treated. By combing the infrastructure for wastewater treatment and stormwater runoff, Vermont may see significant reductions in the lake's phosphorus concentration.

Phosphorus loads can also be maintained through managing lakeshore and riverside development. Floodplains are becoming increasingly important, as climate change indicators suggest above average rainfall in short and powerful storm events. Riparian and lakeshore habitats should be maintained in the public trust to prevent damage from disastrous flooding events (as was seen with Hurricane Irene). However, there are many obstacles to properly maintaining such land – the largest being private property rights. Incentives such as tax deductions and other sources of funding should be considered when working to protect riparian and littoral floodplains.

By addressing just these three points of management within the lake ecosystem, Vermont could beneficially impact the condition of the lake. The fish of Lake Champlain need their habitat restored so that they may obtain oxygen during the late summer months. Recreationists and tourists alike want to use the lake without the concern of coming into contact with blue-green algae (a neurotoxin produced by eutrophication). Above all, the towns located on eutrophic segments on the lake would appreciate looking out onto the blue beauty of Champlain, rather than unpleasing green mounds of algae. With a greater focus of in-stream phosphorus loads, stormwater drainage and more stringent lakeshore and riverside development regulations, Vermont will be on its way to cleaner waters, better aesthetics, and increased desirability in the upcoming years.

Aerial view of the Montpelier 1992 flood.
Cover photo of the *Ice and Water* book.

Jim Cole, Associated Press
Copyright 1992 "Ice and Water" Committee
Photo credit: vtwaterquality.org

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Further information

To check out a detailed Lake Champlain policy timeline, go to prezi.com/explore and search: **"Federal and Vermont State Policies: Historical progress on cleaning up Lake Champlain."**