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PREVIEW OF VERMONT JOURNAL OF ENVIRONMENTAL LAW, VOLUME 17, ISSUE 4: THE "LAKE CHAMPLAIN EDITION"

Joseph Simpson

Dear Readers,

Welcome to Volume 17, Issue 4 of the Vermont Journal of Environmental Law. To those of you who regularly look to our journal for novel ideas in environmental law, thank you for your continued loyalty and support. To those of you who may be coming across our journal for the first time, we hope we provide you with expert legal analysis and arguments that you find useful to your research and arguments. With articles covering major environmental statutes, international environmental agreements, comparative approaches to environmental regulation, and original policy proposals, the Journal hopes to provide quality reading for everyone from the casual legal scholars to the front-line policy experts.

This specific issue focuses on the recently approved Lake Champlain Phosphorus Total Maximum Daily Load ("TMDL") for twelve Vermont segments of Lake Champlain. Each segment has its own TMDL, but the authors within the issue will typically refer to the TMDLs as a singular TMDL because of the single controlling framework. Unlike a standard issue of a legal journal that has articles written almost exclusively by lawyers, law professors, and law students, this issue also provides articles written by scientists, engineers, and policymakers who had direct influence on the development of the 2016 Lake Champlain TMDL. These authors provide a rare opportunity to combine into one book the first-hand knowledge of a major regulatory framework.

Throughout this issue, the authors and editors intend to provide historical, scientific, policy, and legal analysis of the development of the 2016 Lake Champlain TMDL. While the Clean Water Act and many other key environmental statutes are passed by the United States Congress, the implementation of those environmental laws happens from the ground on up. This issue uses the 2016 Lake Champlain TMDL to show how the implementation of a major regulatory framework depends on the intertwined relationship between the regulated community, nonprofit organizations, and many branches of state government to be successful. By providing all of this analysis in one source, readers should walk away with a greater understanding of the legal and non-legal intricacies that go into implementing a major regulatory framework. We hope you enjoy this story of a small state that got a big win for clean water.

Sincerely,

Volume 17 Editorial Board and Staff
Vermont Journal of Environmental Law

FOREWORD: RESTORING AND MAINTAINING THE ECOLOGICAL INTEGRITY OF LAKE CHAMPLAIN

***David K. Mears and Trey Martin*[1]**

"Q: What do you call 100 lawyers at the bottom of Lake Champlain?
A: A good start."

—Popular joke in Vermont.

"There are two things that interest me: the relation of people to each other, and the relation of people to the land."[2]

—Aldo Leopold

INTRODUCTION

The genesis for this issue of the Vermont Journal of Environmental Law ("VJEL") was a dynamic and informative symposium held on October

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1. David Mears is currently Vice Dean for Faculty and Professor of Law. He was Commissioner of the Department of Environmental Conservation within the Vermont Agency of Natural Resources while the Lake Champlain Phosphorus TMDL and implementation plan were being developed by the U.S. Environmental Protection Agency and the Department. Trey Martin is Deputy Secretary of the Vermont Agency of Natural Resources where he has worked since 2012 as an attorney and in his current capacity. The views expressed in this article are theirs alone and do not necessarily reflect the position of the Vermont Law School or the State of Vermont.

2. CURT MEINE, ALDO LEOPOLD: HIS LIFE AND WORK (Madison: Univ. of Wis. Press, 2010).

23, 2015 at Vermont Law School ("VLS"). The symposium was entitled *TMDLs 2.0: Charting a Course for Clean Water* and included presentations from and dialogue among an impressive array of scholars and practitioners in the arena of water-quality-protection policy and law. At a time when the health of some of our most treasured waterbodies across the nation is declining, with significant environmental and economic consequences, the panelists at the symposium discussed the unfulfilled promise of the use of total maximum daily loads ("TMDLs") under Section 303(d) of the federal Clean Water Act ("CWA").[3]

I. SUMMARY OF THE SYMPOSIUM

Two major themes emerged from the conversations at the symposium. In one strand of discussion, the participants asked and debated whether litigation that has driven the development of TMDLs has in turn led to positive results for our nation's waters. In another, the symposium's speakers and the audience also explored ways in which we can reimagine the ways we live on the land in a manner that accommodates a human presence while meeting our shared goal of protecting clean water.

Vermont was an ideal location for this discussion given the state's proud history on environmental issues, engaged citizenry, and a broadly shared desire in this state to protect and promote a landscape of prosperous cities and villages in which our communities are supported by working fields and forests, surrounded by green hills and silver waters.[4] The symposium discussion was also enriched by the fact that the Environmental Protection Agency ("EPA") and the State of Vermont were, at the time of the symposium, in the final stages of the process of adopting a major new TMDL and implementation plan addressing nutrient pollution into Lake Champlain. Additional wind in our sails was the passage of Act 64, referred to as "Vermont's Clean Water Act," in the 2015 legislative session.

As a brief aside, it is worth noting that over the last forty years, and especially the last fifteen, Vermont state officials, legislators, and advocates have given intense focus to the complex environmental, fiscal and practical problems that prevent even small states like Vermont from making progress on large watershed problems like phosphorus pollution in Lake Champlain.

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3. 33 U.S.C. § 1313(d) (2012) ("Each state shall establish . . . the total maximum daily load . . . at a level necessary to implement the applicable water quality standards . . . .").

4. VT. COUNCIL ON RURAL DEV., IMAGING VERMONT: VALUES AND VISION FOR THE FUTURE 25–27 (2009), http://vtrural.org/sites/default/files/content/futureofvermont/documents/Imagining_Vermont_FULL_Report1.pdf [https://perma.cc/AQ9S-VFST].

This experience greatly influenced the legal approach Vermont took in negotiating the new Lake Champlain TMDL with EPA. Vermont also drew heavily on lessons learned around the country including the Chesapeake Bay region. The symposium provided a perfect forum at an ideal time to reflect on Vermont's experience and that of other regions of the country.

On one hand, the TMDL symposium highlighted that recent TMDLs developed for Chesapeake Bay and Lake Champlain are breaking new ground.[5] On the other, participants also discussed the fact that research to date suggests that EPA and state environmental agencies have not been able to demonstrate sufficiently meaningful results even after many thousands of TMDLs have been completed.[6] Other participants critically evaluated whether the major pollution issues in the Mississippi River Basin, toxic chemicals in the sediment of the Spokane River, or pollution associated with agricultural operations could even be addressed using TMDLs.[7] Most

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5. A panel moderated by Vermont Law School Professor John Echeverria entitled *American Farm Bureau v. EPA: Protecting the Chesapeake* featured: Jon A. Mueller, Vice-President for Litigation, Chesapeake Bay Foundation; Richard E. Schwartz, Partner, Crowell & Moring; Nina Bell, Executive Director, Northwest Environmental Advocates; and Mary Jane Angelo, Professor of Law, Alumni Research Scholar, and Director, Environmental and Land Use Law Program, University of Florida Levin College of Law. Vermont Law School, *American Farm Bureau v. EPA: Protecting the Chesapeake*, YOUTUBE (Nov. 25, 2015), https://www.youtube.com/watch?v=8LEaupBEMpo [https://perma.cc/9AXB-Y5XZ].

Another panel, moderated by Vermont Law School Professor Laurie Ristino entitled *The Lake Champlain TMDL* featured: Deborah Markowitz, Secretary, Vermont Agency of Natural Resources; Chuck Ross, Secretary, Vermont Agency of Agriculture, Food & Markets; Stephen Perkins, Aquatic Ecosystems Program Manager, U.S. Environmental Protection Agency, Region 1; Chris Kilian, Vice President and Director, Conservation Law Foundation Vermont; and author David Mears. Vermont Law School, *October 23, 2015 VJEL Symposium: The Lake Champlain TMDL*, YOUTUBE (Dec. 1, 2015), https://www.youtube.com/watch?v=d5oI57qMjhw [https://perma.cc/63WE-YGG2].

6. Dave Owen, Professor of Law, University of California Hastings College of the Law, delivered the morning keynote presentation *After the TMDLs*, with a data rich exploration of the results achieved through TMDLs thus far. Vermont Law School *Oct23 2015 VJEL Symposium Morning Keynote: After the TMDLs*, YouTube (Dec. 9. 2015), https://www.youtube.com/watch?v=koCsT0xHuP8 [https://perma.cc/FT5V-ACU2]; *see also* Dave Owen, *After the TMDLs*, *infra* p.845.

7. One panel, entitled *Cutting Edge Litigation I: Exploring the Gulf of Mexico and Toxics in Washington State* and moderated by Vermont Law School Professor Jack Tuholske included: Richard A. Smith, Managing Partner, Smith & Lowney, PLLC; Richard E. Schwartz, Partner, Crowell & Moring, LLP; and Matt Rota, Senior Policy Director, Gulf Restoration Network. Vermont Law School, *Oct23 2015 VJEL Symposium Litigation I*, YouTube (Nov. 30, 2015), https://www.youtube.com/watch?v=bPuknydJdIs [https://perma.cc/4868-S3WG].

Another panel, entitled *Cutting Edge Litigation II: Agricultural Tile Drains and the Effectiveness of TMDLs* moderated by Vermont Law School Professor Laura Murphy included: Charlie Tebbutt, Law Offices of Charles M. Tebbutt, P.C.; Debora K. Kristensen, Partner, Givens Pursley, LLP; Jerry Anderson, Richard M. and Anita Calkins Distinguished Professor of Law, Drake University Law School; and Mark James, Global Energy Fellow in Vermont Law School's Institute for Energy and the Environment. Vermont Law School, *2015 VJEL Symposium: Cutting Edge Litigation II: Agricultural Tile Drains . . .TMDLs*, YOUTUBE (Dec. 1, 2015), https://www.youtube.com/watch?v=2mSP98G_BvU [https://perma.cc/GYM3-VNA8].

participants likely left the symposium partly uncertain whether our national clean water policy is on the right track, but also armed with a rich array of ideas and tools to support a course correction.

II. WHAT IS A TMDL?

Professor Oliver Houck of Tulane University School of Law, one of the nation's preeminent scholars of the CWA and a keynote speaker at the symposium, describes TMDLs as "a water-quality based strategy for waters that remained polluted after the application of technology-based standards."[8] More specifically, he explains the process as follows:

> States would identify waters that remained polluted after the application of technology-based standards, they would determine the total maximum daily loads (TMDLs) of pollutants that would bring these waters up to grade, and they would then allocate these loads among discharge sources in discharge permits and state water quality plans. If the states did not do it, EPA would.[9]

In the strictest sense of the CWA, TMDLs are a regulatory pollution diet born out of a largely mathematical exercise of calculating the necessary reductions in pollutant loads into those waters that are not meeting clean water standards. The acronym (and the underlying phrase) has come to mean much more, encapsulating the obligations of industry, farmers, and landowners subject to the plans, aspirations of clean water advocates, and planning efforts of regulatory agencies, municipal leaders, and state legislators. These groups and others must work together under EPA's jurisdiction to give life to the mathematical requirements of the TMDL, which are often given flesh in implementation plans state regulatory agencies develop in addition to TMDLs in order to achieve the necessary pollution reductions. It was in the spirit of this broader meaning that the TMDL symposium's participants explored opportunities for using this provision of the law to do a better job of addressing the most persistent and difficult challenges facing us as we seek to fulfill the promise of the CWA to "restore and maintain the chemical, physical and biological integrity of the Nation's waters."[10]

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8. OLIVER HOUCK, THE CLEAN WATER ACT TMDL PROGRAM: LAW, POLICY, AND IMPLEMENTATION 3 (1999).

9. *Id.* at 5.

10. 33 U.S.C. § 1251(a).

III. BRIEF INTRODUCTION TO THE LAKE CHAMPLAIN TMDL

In Vermont, we start the second half of the 2010s following an intensive conversation and effort over a period of almost four decades to define a more effective path for protecting Lake Champlain using a TMDL-centered approach.[11] The most recent chapter of this conversation was triggered by an EPA decision issued in January 2011, just days after Professor Mears was appointed Agency of Natural Resources, Department of Environmental Conservation ("DEC") Commissioner by Vermont Governor Peter Shumlin, to disapprove the 2002 State of Vermont Lake Champlain Phosphorus TMDL.[12] EPA's decision was driven, in turn, by a lawsuit filed by the Conservation Law Foundation challenging EPA's approval of the 2002 TMDL.[13] While states typically issue TMDLs, EPA is required by the CWA to issue its own TMDL in the event that it disapproves one issued by a state.[14] EPA and Vermont elected, within that legal framework, to cooperate in the development of the TMDL and redeveloping of the state's implementation plan, sharing information and ideas throughout the process.

Eric Smeltzer and Kari Dolan provide, in two of the articles in this issue, a more detailed explanation of how Vermont and EPA have sought to use the TMDL process to bring Vermonters together in a shared understanding of the data, science, and policy challenges facing the state and region.[15] Smeltzer describes the use of updated data and computer modeling to illustrate the choices necessary to achieve the required pollution load reductions. Dolan describes the public process and collaboration between Vermont and EPA leading to the choices reflected in the state's implementation plan.

As Dolan explains, in addition to technical challenges, legal positioning, and legislative efforts, a major part of the process in the development of the Lake Champlain Phosphorus TMDL and accompanying

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11. *Restoring Lake Champlain*, VT. DEP'T ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/cwi/restoring [https://perma.cc/H8YA-GAN8] (last visited July 8, 2016); Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts*, *infra* p. 615.

12. STATE OF VT., VERMONT LAKE CHAMPLAIN PHOSPHOROUS TMDL PHASE I IMPLEMENTATION PLAN 18 (2015), http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/Ph%201_plan_Version_4.pdf [https://perma.cc/G3XT-67XA].

13. *Id.*

14. 33 U.S.C. § 1313(d)(2).

15. Eric Smeltzer, *Technical Explanation of the 2016 TMDL Issued by EPA*, *supra* p. 650; Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *infra* p. 663.

implementation plan was outreach to the public. EPA and Vermont state agencies met with people representing a wide array of perspectives from across the watershed. Participants in the process had the opportunity to offer their ideas for improving the lake, ask practical questions, and express concerns about the feasibility, cost, or desirability of action. Perhaps not surprisingly, the common theme that emerged from those conversations was that Vermonters love Lake Champlain, they grasp the environmental significance, economic cost, and health risks associated with allowing its continued decline and they have many good, some competing, ideas for protecting the lake. Working within this context, state and federal officials worked to develop an approach that was based in science and data, targeted at the most significant sources of pollution, in order to produce measurable results and a healthier Lake Champlain.

Another theme that emerged—less romantic and more specific, but consistent with public expectations for targeted actions—was the shared desire of Vermonters to tackle the major challenge in the Lake Champlain Watershed, namely polluted stormwater runoff. This type of water pollution flows from many sources, including paved and other impervious surfaces in developed areas, unpaved roads, roadside ditches, farm fields, and streambank and bed erosion. Nearly every human activity on the landscape, if not done with care, has the potential to increase the volume and intensity of runoff, carrying nutrient, sediment, and other pollutants, that inexorably finds its way to Lake Champlain. Tropical Storm Irene arrived during the development of the Lake Champlain Phosphorus TMDL and reinforced for the public and government officials the growing scientific consensus that the Lake Champlain region is getting wetter and facing more frequent and intense precipitation events, both rainfall and snowmelt. During Tropical Storm Irene, when three to seven inches of rain fell on Vermont in a twenty-four-hour period, excess stormwater overwhelmed already flooding streams and rivers, streambanks eroded, and massive sediment loading occurred at the mouths of all of Lake Champlain's tributaries.[16]

As is discussed in several of the articles, the fact that polluted stormwater control is still a problem over forty-five years after the passage of the CWA should not be a surprise given that the Act was not clear on the precise mechanism for controlling this category of pollution. Congress did not provide a detailed set of specific technology-based controls as it did for point-sources, such as municipal and industrial wastewater treatment plants. While states are clearly free to enact protections that go beyond the

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16. David K. Mears & Sarah McKearnan, *Rivers and Resilience: Lessons Learned from Tropical Storm Irene*, 14 VT. J. ENVTL. L. 177, 178 (2013).

congressional scheme, the Act does not provide specific direction for states nor a clear mechanism for EPA oversight of state action.[17]

Learning that polluted stormwater runoff is the major challenge facing Lake Champlain is also not surprising when you learn that the Lake Champlain Watershed has one of the highest ratios of land to water of any major waterbody in the United States. Nearly ninety percent of the water flowing into Lake Champlain flows across a landscape of farms, working forests, and developed land through a system of rivers that have been significantly altered over time.[18] While the parts of Vermont, New York, and Québec that are in the Lake Champlain Watershed are largely rural, the landscape of this region has been intensively touched by human hands over its history and most of that activity has taken place without an understanding of the impact that land use and development can have on a receiving water like Lake Champlain or regard to practices that might mitigate those impacts. Indeed, Vermont is still learning how to balance development and economic growth with protection for water resources.

The fact that the sources of pollution into the Lake Champlain Watershed are so diffuse and spread across such a wide area can seem overwhelming, but the work of many of the authors in this issue suggest that it should be possible to change the way in which we touch the landscape, such that pollutant loads are reduced to levels that the watershed can assimilate and remain healthy. While returning Vermont's landscape to some pristine state that existed before European settlement is not the goal established by the state or federal clean water laws, there are opportunities to restore the natural functions of many parts of the watershed through conservation and improved methods of building and managing the built environment. Restoring these natural functions through, for instance, allowing more rainfall to infiltrate into the ground, show great promise in reducing pollution. The authors in this issue have collectively identified significant opportunities to invest in protecting Lake Champlain through strategic investments in policies that use this type of approach to protect and preserve Vermont's landscape.

The authors also describe a process for implementing these policies in a manner that creates transparency and accountability. From a "tactical basin planning" process used by DEC to an "accountability framework" imposed by EPA, the State of Vermont has worked with EPA to establish a process that is oriented to action and results. As described in these articles, the

17. 33 U.S.C. § 1251.

18. *Where does the Phosphorous in Lake Champlain Come from?*, LAKE CHAMPLAIN BASIN PROGRAM, http://sol.lcbp.org/Phosphorus_where-does-p-come-from.html [https://perma.cc/3L5E-FBE2] (last visited July 8, 2016).

TMDL and implementation plan achieve this goal through a system of reporting and feedback with consequences for failing to implement the plan.

Ultimately, for Vermont, the question about the effectiveness of TMDLs can, somewhat cynically, be translated into the more specific question: Have lawyers and decades of legal battles have been good for Lake Champlain? It is true that litigation has driven the development of two TMDLs, one in 2002 by the State of Vermont and one just issued by EPA on June 17, 2016. The immediate outcomes of this litigation, in the form of EPA's recent TMDL and the associated Vermont implementation plan, show promise. If successful, the development of these documents suggest that the CWA can indeed provide a framework for restoring the quality of Lake Champlain. What remains to be determined is a longer-term question: Can the TMDL serve as an effective catalyst for adopting new land use and watershed management approaches that will serve as lasting solutions and not just short-term fixes?

IV. ORIGINS OF THIS VJEL ISSUE

At the conclusion of the symposium, authors David Mears and Trey Martin agreed that the dialogue that took place was important—both for Vermonters working to address Lake Champlain's pollution problems and for those across the country trying to use TMDLs in similarly challenging circumstances. With the Lake Champlain Phosphorus TMDL now complete and the experience of working with EPA, other state agencies, communities, and organizations across the state still fresh in our minds, we also wanted to capture the energy of other participants in the process.

Participants in the symposium heard a tension—one that we hope is expounded in this VJEL issue—between some of the recent successes in using TMDLs to drive action, such as in the Chesapeake Bay and Lake Champlain on the one hand and a lack of success when viewing the effects of TMDLs nationally. In Vermont, for example, the dialogue has been a constructive one. As is described in the articles contained in this issue, EPA and Vermont are engaged in the most ambitious program yet undertaken to restore Lake Champlain. Though it is a program that will require a sustained focus of time and resources to be successful, the Lake Champlain TMDL and state implementation plan represent important progress.

In contrast, at the national level, the uncertainty about the effectiveness of TMDLs has become a topic for debate and calls into question the effectiveness of the effort by clean water advocates to galvanize states to more effectively protect clean water using TMDLs.[19] Further, questions about the effectiveness of TMDLs, combined with litigation and controversy surrounding the Chesapeake Bay TMDL, have become part of a broader political discourse about the role of the federal government in protecting clean water.[20] The adoption of new federal rules defining CWA jurisdiction,[21] the legal challenge to the Chesapeake Bay TMDL,[22] legislation being considered in Congress to rollback CWA protections,[23] and lawsuits across the country challenging federal efforts to protect clean water[24] all reflect this broader debate about the role of the federal government and implementation of the CWA.

Underlying the conversations at both the state and federal level is an ideological struggle over the role of the federal government in decisions that involve the intersection of national interests in streams, rivers, and lakes and local interests in the land use decisions that impact those waters. Professor Mears touches on the issue of the appropriate balance between federal, state, and local authority in describing the ongoing litigation over the Chesapeake Bay TMDL, but for the most part, the articles in this issue do not side one way or the other on this debate. Our own assumption is that

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19. Dave Owen, *After the TMDLs*, *infra* p. 845.

20. U.S. GOV'T ACCOUNTABILITY OFFICE, CLEAN WATER ACT: CHANGES NEEDED IF KEY EPA PROGRAM IS TO HELP FULFILL THE NATION'S WATER QUALITY GOALS 17, 22, 26–37 (2013), http://www.gao.gov/assets/660/659496.pdf [https://perma.cc/Y6KA-PDK4].

21. *See, e.g.*, Russell Wilson, *Wetlands Determinations – Uncertainty for the Clean Water Rule?*, JDSUPRA BUS. ADVISOR (July 7, 2016), http://www.jdsupra.com/legalnews/wetlands-determinations-uncertainty-for-15857/ [https://perma.cc/5GX9-QFEV] (discussing Supreme Court precedent and rulings that have shaped EPA's and the Army Corps of Engineers' jurisdiction under the CWA)

22. *See, e.g.*, Karl Blankenship, *Supreme Court Refuses To Hear Bay Cleanup Challenge*, BAY J. (Feb. 29, 2016), http://www.bayjournal.com/article/supreme_court_refuses_to_hear_bay_cleanup_challenge [https://perma.cc/NZQ8-N3W8] (recapping the American Farm Bureau Federation's challenge alleging that the Chesapeake Bay TMDL is the "federal government [] effectively seizing land use authority from state and local governments")

23. *See, e.g.*, *House Looks To Roll Back Clean Water Protections*, S. ENVTL. L. CTR. (Jan. 11, 2016), https://www.southernenvironment.org/news-and-press/news-feed/house-looks-to-roll-back-clean-water-protections [https://perma.cc/W5MS-7VJW] (discussing bills in the U.S. House of Representatives that would effectively prevent EPA and the Army Corps of Engineers from moving forward with the new Clean Water Rule and prevent them from clarifying the waters that are under CWA jurisdiction)

24. *See, e.g.*, Sabrina Eaton, *Ohio Sues U.S. Environmental Protection Agency over New Water Regulations*, CLEVLAND.COM (June 29, 2015), http://www.cleveland.com/open/index.ssf/2015/06/ohio_sues_environmental_protec.html [https://perma.cc/Q5CF-3VFY] ("The lawsuit DeWine submitted to the United States District Court for the Southern District of Ohio is among a flurry of challenges to the rule that were filed today in federal courts."); Press Release, Ctr. for Biological Diversity, Lawsuit Challenges Loopholes in New EPA Rule Exempting Wetlands and Streams from Clean Water Act Protections (July 22, 2015), https://www.biologicaldiversity.org/news/press_releases/2015/clean-water-act-07-22-2015.html [https://perma.cc/S7XC-U4KB].

collaboration among local, state, and federal officials is critical to ultimate success and, consequently, that federal authority and resources will remain an important backdrop to meaningful progress, even as state and local officials, legislators, and advocates work to implement both federal and state laws in a cost-effective and strategic manner.

This issue also reflects our bias that limiting the dialogue to just the legal and policy considerations is insufficient. It is axiomatic that solving environmental problems requires an interdisciplinary approach. This is nowhere more true than in large watersheds where technology and innovation, law, policy, and science must all come into play to forge successful outcomes. While lawyers have an important role to play, the work of scientists in understanding the nature of the water pollution challenges we face is fundamental to ensuring that our policies and laws are targeted correctly. Sophisticated policy experts and dedicated public officials and legislators are needed who will listen to both scientists and to the broader public in order to develop effective solutions that can maintain long-term investments in governmental authority and resources. Finally, the dialogue is incomplete without the foundation for action by developers, builders, forest managers, and farmers developed by engineers, planners, and others responsible for designing the landscape-scale solutions we need to fully restore our nation's waters.

V. Goals of this VJEL Issue

This issue is designed to broaden the dialogue started at the symposium in October of 2015 to incorporate perspectives and ideas from as many of the relevant professions as possible within the constraints of time and space. As you peruse the list of articles, you will see contributions from a diverse collection of authors including scientists, engineers, and public policy experts from a range of backgrounds including public, private, and non-profit organizations. These authors are, in addition to being innovators in their fields, also fully engaged in both designing and implementing the work of restoring Lake Champlain. As editors, we have not so much strived to represent a diversity of public policy perspectives or ideologies as to gather a diversity of perspectives based on our contributors' professional backgrounds and hands-on experience with the topic.

If not already evident, we want to be clear that we have assumed that our readers share our perspective that it is important and necessary to find ways to achieve the goals of the CWA to restore and maintain the ecological integrity of our nation's waters. It may also be evident that we share a strong sense of optimism that Vermont is on the right track for restoring Lake Champlain. In full disclosure, we are personally invested in the success of the state's current path given our participation in its development.

The ultimate goal for the editors and authors of this issue is to contribute meaningfully to a dialogue that has been underway for several decades in Vermont and nationally about how to restore clean water to our most precious estuaries, bays, lakes, and river systems. Each of the articles is intended to stand alone, but together, they offer a glimpse into the deeper levels of and connections between the legal, policy, scientific, and other areas of inquiry necessary to understand the challenges and opportunities of the Lake Champlain watershed.

This issue does not— and could not—accomplish our greatest aspiration: a compendium of all of the information necessary to solve all of the challenges facing those who would restore Lake Champlain. For one thing, though our understanding is growing by leaps and bounds, much of that information does not yet exist. We will continue to learn from our mistakes and continue to refine our approaches to adapt to what we learn. Another reason this issue cannot serve as a complete instruction manual is that we would fill a set of volumes approaching a full set of the *Encyclopædia Britannica* if we tried to capture the full array of knowledge necessary to address water pollution across a landscape as large and complex as the Lake Champlain Watershed. As it is, we leave gaps in important areas such as cost-benefit and macro-economic analyses, forest management and health, consideration of invasive species, atmospheric deposition of pollutants, and the effects of pharmaceuticals and endocrine-disrupting toxins. We hope, however, that readers find this a useful start and find both inspiration and helpful insights for their own work, whether in the Lake Champlain Watershed or elsewhere. We also hope, and expect, that others will develop responses and provide information to fill gaps in perspective and knowledge.

CONCLUSION

The CWA and the litigation leading up to the establishment of a new TMDL for Lake Champlain, along with the Vermont implementation plan are an important, but insufficient, part of the progress to date. Municipal governments, transportation agencies, farmers, developers and business owners, watershed groups, conservation districts, and many others have taken important steps to reduce pollution into Lake Champlain over the past decade.

The ultimate long-term success of the Lake Champlain Phosphorus TMDL depends, however, upon on a much larger number of organizations and citizens across the Lake Champlain Watershed to engage, building on past lessons and rolling up their sleeves, to solve the real but manageable challenges facing us as we implement the plans developed under the auspices of federal and state clean water law. This is also true for other major and minor watersheds across Vermont and the nation. Our hope is that this issue provides a helpful explanation of how this work can be done for Lake Champlain and other waters across the country. We also hope that we have contributed ideas for ways that other states and the federal government can adapt and improve the existing structure established by the CWA.

A NATURAL AND HUMAN HISTORY OF LAKE CHAMPLAIN

Mike Winslow[*]

INTRODUCTION

Lake Champlain is a glacially carved water body in the St. Lawrence River drainage.[1] The lake sits in the low point of a valley between the Adirondack Mountains of New York and the Green Mountains of Vermont.[2] The border between New York and Vermont follows the deepest part of the lake.[3] A small portion of the lake resides in Quebec.[4] Land use in the basin is 64.3% forest, 16% agriculture, and 5.6% developed land with the remainder being wetlands and open water.[5] Relatively flat, fertile lands extend to the east between the lake and the Green Mountains.[6] This area has

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* Staff Scientist, Lake Champlain Committee.

1. RICHARD W. LANGDON ET AL., FISHES OF VERMONT 6 (2006).
2. *Physiographic Regions*, LAKE CHAMPLAIN BASIN ATLAS, atlas.lcbp.org/PDFmaps/nat_geologyA.pdf [https://perma.cc/CZV3-9TLD] (last visited Apr. 24, 2016).
3. 10 VT. STAT. ANN. § 114(a) (defining the border between Vermont and New York).
4. *Political Boundaries*, LAKE CHAMPLAIN BASIN ATLAS, http://atlas.lcbp.org/PDFmaps/nat_political.pdf [https://perma.cc/SP7X-CC28] (last visited Apr. 24, 2016).
5. *People and Economy: Basin Landscape*, LAKE CHAMPLAIN BASIN ATLAS, http://atlas.lcbp.org/HTML/so_landuse.htm [https://perma.cc/DC7H-NGV2] (last visited Apr. 12, 2016).
6. *Geological History of the Champlain Valley*, U. OF VT., http://www.uvm.edu/~shelburn/nature/geology.html [https://perma.cc/2M6A-3CH9] (last visited Apr. 3, 2016).

the highest concentration of agricultural lands.[7] To the west, the Adirondacks are much closer to the lakes shore.[8] As a result, the Vermont portion of the basin has a higher population density and more farmland than does the New York portion.[9]

Lake Champlain is within the Laurentian Mixed Forest Ecoregion.[10] As such, it shares a similar climate, topography, forest type, and soil type with the Great Lakes, St. Lawrence Valley, central and western New York, and northern Pennsylvania.[11] Precipitation ranges from 760 to 1020 mm; snowfall averages 1,020 to 1,520 mm in the Champlain Valley.[12] Mean annual temperature ranges from 39 to 45 °F (4 to 7 °C).[13] The growing season generally lasts about 160 days.[14] The Lake Champlain drainage basin to lake volume ratio (19:1) is quite high for a glacially carved lake.[15] It is reasonable to expect areas of Lake Champlain with higher watershed to lake area ratios to have greater issues with cyanobacteria and other plant growth. Larger watersheds generate more nutrient pollution.[16] The ratio of a lake's drainage area to its surface area is positively correlated to external inputs of nutrients, thus to increasing primary productivity.[17] Missisquoi Bay and the South Lake have the highest watershed to lake area ratios.[18]

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7. *Phosphorus Loading by Land Use*, LAKE CHAMPLAIN BASIN PROGRAM, atlas.lcbp.org/PDFmaps/is_pnps.pdf [https://perma.cc/V369-ZXHL] (last visited Apr. 24, 2016).

8. *Physiographic Regions*, *supra* note 2.

9. *What the 2012 U.S. Census Estimates Tell Us About the Adirondack Park's Population and the State of Rural America*, PROTECT THE ADIRONDACKS, www.protectadks.org/2013/03/What- the-2012-U.S-Census-Estimates-Tell-Us-about-the-Adirondack-Park's-Population-and-the-State-of-Rural-America [https://perma.cc/MMG8-VPX6] (last visited Apr. 3, 2016); *People & Economy*, LAKE CHAMPLAIN BASIN PROGRAM, atlas.lcbp.org/HTML/so_pop.htm [https://perma.cc/89ND-FBP2] (last visited Apr. 3, 2016).

10. *Ecological Subregions of the United States*, U.S. FOREST SERV., http://www.fs.fed.us/land/pubs/ecoregions/ch14.html#212E [https://perma.cc/284R-RC5N] (last visited Apr. 9, 2016).

11. *Id*.

12. *Id*.

13. *Id*.

14. *Id*.

15. *Watershed Wise*, U. OF VT. WATERSHED ALL., http://www.uvm.edu/watershed/watersheds [https://perma.cc/8PXX-WZ8Z] (last visited Apr. 19, 2016).

16. Simone R. Alin & Thomas C. Johnson, *Carbon Cycling in Large Lakes of the World: a Synthesis of Production, Burial, and Lake-Atmosphere Exchange Estimates*, 21 GLOBAL BIOGEOCHEMICAL CYCLES 1, 7 (2007).

17. *Id.*

18. U. OF VT. WATERSHED ALL., *supra* note 15.

I. PEOPLE IN THE BASIN

Approximately 600,000 people live in the Champlain Basin.[19] Population is centered in Chittenden County, Vermont and Clinton County, New York. In Chittenden County, the largest communities by population according to the 2010 U.S. Census are Burlington (42,417), Essex (19,587), South Burlington (17,904), and Colchester (17,067).[20] Plattsburgh, at 19,740 people, is the largest community in Clinton County.[21] In the southern part of the basin, Rutland, Vermont has 16,495, and Queensbury, New York, which is only partially in the basin, has 27,901.[22]

Lake Champlain provides drinking water for approximately 145,000 people.[23] In total, there are 73 public water supply systems drawing from the Vermont side of the lake and 26 on the New York side.[24] By far, the largest water suppliers are the city of Burlington, Vermont, serving 42,000 people, and the Champlain Water District, which serves 70,000 in a number of cities and towns in Chittenden County, Vermont.[25] Public drinking water suppliers comply with the Federal Safe Drinking Water Act, which requires monitoring for 84 potential contaminants.[26]

The lake serves as a major recreational and tourist draw for the region. Vermont's four main lakeside counties generate approximately $300 million in tourist revenue annually.[27] Fishing related expenditures for the basin were estimated at $104 million in 1997.[28]

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19. WILLIAM G. HOWLAND ET AL., LAKE CHAMPLAIN EXPERIENCE AND LESSONS LEARNED BRIEF ¶ 2, http://www.worldlakes.org/uploads/07_Lake_Champlain_27February2006.pdf [https://perma.cc/Y874-V2QM] (last visited Apr. 3, 2016).

20. U.S. DEP'T OF COMMERCE, VERMONT: 2010 CENSUS OF POPULATION AND HOUSING 16, 11, 28, 29 (2010), https://www.census.gov/prod/cen2010/cph-2-47.pdf [https://perma.cc/ZTV6-RAAV].

21. U.S. DEP'T OF COMMERCE, NEW YORK: 2010 CENSUS OF POPULATION AND HOUSING 15 (2010), https://www.census.gov/prod/cen2010/cph-2-34.pdf [https://perma.cc/E4XM-BHNM].

22. VERMONT CENSUS 2010, *supra* note 20, at 13.

23. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEMS INDICATORS REPORT 16, http://sol.lcbp.org/images/State-of-the-Lake_2015.pdf [https://perma.cc/EY8K-WGD6] (last visited Apr. 4, 2016).

24. *Id.*

25. *Welcome to Champlain Water District*, CHAMPLAIN WATER DIST., http://www.champlainwater.org/ [https://perma.cc/58VB-9W9Q] (last visited Apr. 3, 2016).

26. Safe Drinking Water Act, 42 U.S.C. § 300f (1974).

27. BRIAN VOIGT ET AL., AN ASSESSMENT OF THE ECONOMIC VALUE OF CLEAN WATER IN LAKE CHAMPLAIN 3 (2015), http://www.lcbp.org/wp-content/uploads/2013/03/81_VoigtEconomicsFinalReport1.pdf [https://perma.cc/JP6N-B8VQ].

28. GILBERT, ALPHONSE HENRY, LAKE CHAMPLAIN ANGLER SURVEY 1997: A REPORT SUBMITTED TO THE FISHERIES TECHNICAL COMMITTEE, LAKE CHAMPLAIN FISH AND WILDLIFE COOPERATIVE (2000).

II. LAKE LEVELS

The minimum level of Lake Champlain is established by a bedrock sill overlain by silty moraine material downstream of the lake in the Richelieu River at St. Jean Sur Richelieu, Quebec.[29] This geologic feature prevents the lake from falling below 27.7 meters above sea level.[30] Alterations to the channel at the outlet of the lake have led to a 0.15 meter increase in lake level since the 1960s.[31] There are no structures that can be manipulated to control the lake's level.

Lake levels fluctuate by approximately 1.5 meters each year and there is over a 3 meter difference between the highest lake level recorded and the lowest.[32] Lake level typically peaks during the spring snowmelt, which represents a basin-wide contribution of a large volume of water.[33] In addition to accumulated winter snow pack melt, there is limited evapotranspiration during this period, so all precipitation that falls runs off quickly.[34] Lake levels recede through the summer months as evapotranspiration increases.[35] Summer storms tend to be localized with little watershed-wide impact.[36] Groundwater inputs to the lake are of minimum importance relative to runoff from the watershed.[37]

The lake is at flood stage when its level reaches or exceeds 30.48 meters.[38] The highest lake level ever recorded was approximately 31.5 meters on May 6, 2011.[39] The lowest lake level occurred in November of 1908 when the lake reached 28.16 meters.[40]

The International Joint Commission ("IJC") has been asked to study the impacts of flooding on Lake Champlain on three separate occasions. The IJC is "an international organization created by the Boundary Waters Treaty, signed by Canada and the United States in 1909" to prevent and

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29. James B. Shanley & Jon C. Denner, *The Hydrology of the Lake Champlain Basin*, *in* LAKE CHAMPLAIN IN TRANSITION FROM RESEARCH TO RESTORATION 41, 51 (Thomas O. Manley & Patricia L. Manley eds., 1999).
30. *Id*.
31. *Id.* at 58.
32. *See id*. at 56 (indicating the historic minimum level of Lake Champlain); *see also Advanced Hydrologic Prediction Service*, NAT'L WEATHER SERV., http://water.weather.gov/ahps2/hydrograph.php?gage=burv1&wfo=btv [https://perma.cc/E7X4-GZP3] (last visited Apr. 4, 2016) (indicating the historic maximum level of Lake Champlain).
33. Shanley & Denner, *supra* note 29, at 58.
34. *Id.* at 46.
35. *Id.* at 51.
36. *Id.*
37. *Id*. at 49.
38. NAT'L WEATHER SERV., *supra* note 32.
39. *Id.*
40. Shanley & Denner, *supra* note 29, at 56.

resolve disputes between the United States of America and Canada.[41] In the 1930s, IJC performed studies and presented a plan for and approved construction and operation of flood control works in the Richelieu River.[42] This led to the construction of the Fryers Dam in 1939, but the dam was never placed into operation.[43] In 1973, IJC studied the desirability of regulating Lake Champlain outflows using either Fryers Dam or new control structures.[44] They concluded that regulation was technically feasible but left assessments of whether such projects were desirable to the federal governments.[45] Neither government built a regulating structure.[46] Most recently, in 2013, IJC developed a plan of study to identify means of mitigating floods.[47] This effort led to production of static flood inundation maps and development of an approach for future flood forecasting and floodplain mapping.[48]

III. THE FIVE PRINCIPAL LAKE SEGMENTS

Lake Champlain is divided into five distinct basins with significant differences in morphology and land use from basin to basin.[49] The Main Lake holds the bulk of the water and sits in a deep narrow trough, stretching along a north south axis.[50] To the north, a series of large islands separates the Main Lake from the moderately deep Northeast Arm.[51] North of the Northeast Arm and draining into it, the broad shallow Missisquoi Bay straddles the Vermont-Quebec border.[52] South of the Northeast Arm and separated by a series of road and railroad causeways lays Mallets Bay.[53] At

41. *About the IJC*, INT'L JOINT COMM'N, http://ijc.org/en_/About_the_IJC [https://perma.cc/CS82-GTVA] (last visited Apr. 25, 2016).

42. INT'L JOINT COMM'N, A REAL-TIME FLOOD FORECASTING AND FLOOD INUNDATION MAPPING SYSTEM FOR THE LAKE CHAMPLAIN AND RICHELIEU RIVER 1 (2015), http://ijc.org/files/publications/Lake-Champlain-IJC-Report-to-Govts-Dec-2015-NEW.pdf [https://perma.cc/3ZGC-FLQN].

43. *Id.*

44. *Id.* at 1–2.

45. *Id.*

46. *Id.*

47. *Id.* at 2.

48. *Id.* at 2–3.

49. *Lake and Basin Facts*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-the-basin/facts/ [https://perma.cc/ZQM2-AAQN] (last visited Apr. 21, 2016).

50. VT. GEOLOGICAL SOC'Y, THE GEOLOGY OF THE LAKE CHAMPLAIN BASIN AND VICINITY 4 (1980), http://www.anr.state.vt.us/dec/geo/GMGVTSoc/VTGS_1980_1.pdf [https://perma.cc/BFW2-DMZ3].

51. *Id.*

52. *Id.*

53. *Id.*

the extreme south of the Main Lake is the long, shallow, almost riverine South Lake.[54]

The Main Lake covers over 680 square kilometers and contains over eighty percent of the lake's water volume.[55] This section stretches from the Crown Point Bridge to the lake's outlet in Rouses Point. At its deepest point, the Main Lake is 122 meters in depth and it averages over 30 meters in depth.[56] The population centers are on the shores of the Main Lake and it contains a multitude of bays and shallow areas around the periphery.[57]

The Northeast Arm covers over 265 square kilometers and reaches 49 meters at its deepest point.[58] Much of the Northeast Arm is clear and cold, though shallow bays like St. Albans are more weed filled. There are no major tributaries that drain to this lake segment, a factor which likely helps protect its water quality. The Northeast Arm is segmented by road and railroad causeways built in the 19th century.[59] These factors reduced sediment inputs into this basin for several decades.[60]

Missisquoi Bay fills a shallow basin at the northeastern-most portion of the lake—only 2.8 meters deep at its maximum, but covering over 7 kilometers in breadth.[61] Three significant tributaries discharge to Missisquoi Bay: the Pike River, the Rock River, and the Missisquoi River.[62] The Pike and most of the Rock watersheds sit within Quebec. High nutrient levels and extensive sedimentation from these rivers make Missisquoi Bay one of the murkier lake segments.[63] Missisquoi Bay, with less than 1% of the lake's water receives 24.2% of the total phosphorus load for Lake Champlain; only the Main Lake receives more.[64]

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54. *Id.*
55. *Id.*
56. *Id.*
57. *Id.* at 3.
58. *Id.*
59. Suzanne N. Levine et al., *The Eutrophication of Lake Champlain's Northeastern Arm: Insights from Paleolimnological Analyses*, 38 J. GREAT LAKES RES. 35, 36–47 (2012).
60. *Id.*
61. *Bathymetry (Lake Depths)*, LAKE CHAMPLAIN BASIN ATLAS, http://atlas.lcbp.org/PDFmaps/nat_depth.pdf [https://perma.cc/3QYF-F7SQ] (last visited Apr. 25, 2016).
62. VT. AGENCY OF NAT. RES., MISSISQUOI BAY BASIN WATER QUALITY MANAGEMENT PLAN 19 (2013), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_Basin06Plan.pdf [https://perma.cc/PY25-KYKV].
63. INT'L JOINT COMM'N, A PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED CHAMPLAIN-RICHELIEU FLOOD CONTROL PROJECT 18 (1973).
64. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 14 (2015), https://www.epa.gov/sites/production/files/2015-09/documents/phosphorus-tmdls-vermont-segments-lake-champlain.pdf https://perma.cc/M39S-M5XA].

Analysis of sediment cores from Missisquoi Bay indicate dramatic changes in inputs to the bay since 1900.[65] Deforestation and agricultural practices throughout the landscape have driven an increase in sedimentation rate and carbon inputs.[66] Sedimentation rates have increased to 0.7 cm/year as compared to approximately 0.02 cm/year before 1700.[67] As a result, Missisquoi Bay has become more eutrophic.

The accumulation of phosphorus and sediment over many years means that Missisquoi Bay has a massive reserve of nutrients.[68] Phosphorus mobilizes from the sediment under conditions of low pH and low oxygen.[69] When cyanobacteria bloom, the decomposition of cells reduces oxygen levels at the soil water interface, releasing more phosphorus and creating a positive feedback loop.[70] As a result, forty-three percent of the summer phosphorus in the water column of the Missisquoi Bay comes from the sediments.[71] The high concentration of sediment phosphorus means water column phosphorus concentrations in the bay are extremely resistant to changes in watershed phosphorus loading. A fifty percent reduction in watershed loads would cause only a minimal change in in-lake phosphorus concentrations over a thirty-year period.[72]

Mallets Bay is isolated from other parts of the lake by an abandoned railroad causeway to the west and a road causeway to the north.[73] Mallets Head and Red Rock Point pinch the bay into two distinct segments: an inner bay and an outer bay.[74] The Lamoille River, the bay's largest tributary, enters the outer bay.[75] The Winooski River delta forms much of the southern boundary, though the Winooski itself drains in to the Main

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65. Andrew T. Koff, A Multi-Proxy Paleolimnological Study of Holocene Sediments in Missisquoi Bay, USA-Canada 99 (Sept. 8, 2011) (unpublished thesis, University of Vermont) https://www.uvm.edu/geology/documents/Koffthesis.pdf [https://perma.cc/7LYP-2F4Y].

66. *Id.*

67. *Id*.

68. U.S. ENVTL. PROT. AGENCY, *supra* note 64, at 39.

69. Christophoros Christophoridis & Konstantinos Fytianos, *Conditions Affecting the Release of Phosphorus from Surface Lake Sediments*, 35 J. ENVTL. QUALITY 1,181, 1,185 (2006).

70. Lydia Smith et al., *Relating Sediment Phosphorus Mobility to Seasonal and Diel Redox Fluctuations at the Sediment-Water Interface in a Eutrophic Freshwater*, 56 LIMNOLOGY & OCEANOGRAPHY 2,251, 2,264 (2011).

71. LIMNOTECH, DEVELOPMENT OF A PHOSPHORUS MASS BALANCE MODEL FOR MISSISQUOI BAY (2012), http://www.lcbp.org/wp-content/uploads/2013/03/65_PhosphorusMassBalanceModel_MissisquoiBay_2012.pdf [https://perma.cc/8WJY-FZY6].

72. *Id*. at 42–43.

73. LAKE CHAMPLAIN BASIN PROGRAM, MALLETTS BAY RECREATION RESOURCE MANAGEMENT PLAN 17 (1995).

74. *Id.* at iii.

75. *Lamoille Basin*, LAKE CHAMPLAIN BASIN ATLAS, http://atlas.lcbp.org/PDFmaps/nat_lamoille.pdf [https://perma.cc/4RGB-YMUQ] (last visited Apr. 24, 2016).

Lake. Mallets Bay is smaller in surface area than Missisquoi Bay, but contains greater than three times more water because of its depth.[76] Half the outer bay is over fifteen meters deep, but at the same time nearly forty percent of the bay is less than six meters deep.[77] In other words, the bay contains steep drop-offs to deep water. Nutrient levels, and thus cyanobacteria blooms, in Malletts Bay are comparable to the Main Lake and lower than other lake segments.[78] Because it is well sheltered from the weather, Mallets Bay hosts numerous marinas, making it a popular spot for boaters.[79] As a result, recreational conflicts between different types of lake users can be as much of an issue as environmental problems.[80]

The thin, narrow, nearly 50 kilometer stretch between Whitehall, New York and Crown Point, New York constitutes the South Lake.[81] In physical appearance, this area is more like a river than a lake, though there is limited elevation difference between the southern and northern end and thus there are minimal fluvial processes.[82] The South Lake receives most of its water from two tributaries: the Poultney and Mettowee Rivers.[83] In all, over 15% of the lake's watershed empties into this segment, which contains only 0.6% of the lake's water.[84]

IV. GLACIAL HISTORY

Lake Champlain is a product of the last ice age. Approximately 18,000 years ago, a sheet of ice over a mile-and-a-half thick sat on what is today the Champlain Valley and stretched as far south as Long Island.[85] Under the great weight of the ice, the land subsided into the underlying upper mantle of the earth, decreasing the entire region's elevation.[86] Additionally, the

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76. VT. GEOLOGICAL SOC'Y, *supra* note 50, at 4.

77. Welcome to the Watershed Management, AGENCY OF NAT. RESOURCES, http://www.vtwaterquality.org/mapp/docs/mp_Basin06Plan.pdf [https://perma.cc/TV9C-2XR4] (last visited June 17, 2016).

78. Eric Smeltzer et al., *Environmental Change in Lake Champlain Revealed by Long-Term Monitoring*, 38 J. GREAT LAKES RES. 6, 6–18 (2012).

79. *See* Alicia Freese, *Who Decides? New Buoys in Lake Champlain Roil Colchester Board*, SEVEN DAYS (July 22, 2015), http://www.sevendaysvt.com/vermont/who-decides-new-buoys-in-lake-champlain-roil-colchester-board/Content?oid=2758287 [https://perma.cc/SFD3-FRA9] (calling Mallets Bay a "boating mecca").

80. *Id.*

81. *Political Boundaries*, *supra* note 4.

82. *See Physiographic Regions*, *supra* note 2 (displaying the shape of the south lake and the elevation of the surrounding area).

83. VT. AGENCY OF NAT. RES., SOUTH LAKE CHAMPLAIN TACTICAL BASIN PLAN 18 (2014).

84. VT. GEOLOGICAL SOC'Y, *supra* note 50, at 4.

85. MIKE WINSLOW, GLACIERS AND THE CHAMPLAIN WATERSHED 2 (2009).

86. *Id.*

movement of the glaciers along lines of weakness in the bedrock caused tremendous erosion, carving out deep trenches.[87] The erosive force of the ice and associated rubble, along with the freshwater flowing into the low-point in the landscape created by land depression, created Lake Champlain.[88]

As the glacier retreated beginning about 13,500 years ago, meltwater pooled to the south.[89] Meanwhile, the northern outlet, via the St. Lawrence River, was blocked by the still extant ice sheet.[90] The pooled water formed a precursor to Lake Champlain—Lake Vermont—which discharged to the south via the Hudson River.[91] Shorelines of Lake Vermont have been identified over 180 meters higher than today's lake, meaning much of Lake Champlain's current basin was once underwater, and the shores of the lake would have sat as far to the east as the base of the Green Mountains.[92]

The Champlain Sea, a saltwater body, followed Lake Vermont about 11,500 to 12,000 years ago.[93] The Champlain Sea formed when the ice blocking what is now the St. Lawrence River melted.[94] The northern portion of the watershed was still lower in elevation because the sheer weight of the glaciers had depressed the land 150 to 190 meters into the earth's mantle.[95] Meanwhile, sea levels were also rising as the water locked in the glaciers was released.[96] Instead of freshwater Lake Vermont draining away, salt water rushed in. The Champlain Sea was approximately 100 meters lower in elevation than Lake Vermont, but still substantially higher than present day Lake Champlain.[97] The Champlain Sea persisted for about 1,500 and 2,000 years until the land rebounded from the weight of the glaciers and the bedrock sill in St. Jean rose above sea level.[98]

The rebounding of land from the weight of the glaciers was not uniform. Southern portions of the basin rebounded earlier than northern portions because the ice melted there sooner.[99] Over the last 10,000 years, the elevation of the lake has increased by about eight meters.[100] As the land rose, the lake got deeper; the bedrock sill increased in height above sea

87. LANGDON ET AL., *supra* note 1, at 6.
88. *Id.*
89. *Id.*
90. *Id.* at 9.
91. *Id.*
92. CHARLES W. JOHNSON, THE NATURE OF VERMONT 22 (1998).
93. LANGDON ET AL., *supra* note 1, at 9.
94. *Id.*
95. JOHNSON, *supra* note 92, 22.
96. *Id*.
97. *Id.*
98. LANGDON ET AL., *supra* note 1, at 9.
99. JOHNSON, *supra* note 92, 22.
100. Koff, *supra* note 65, at 6.

level and thus held back more water. For example, about 10,000 years ago, before most of the rebound had occurred and when the bedrock sill was still nearly at sea level, Missisquoi Bay was dry or at least much more shallow than it is even today.[101]

The soils of the fertile Champlain Valley were deposited during the time of Lake Vermont and the Champlain Sea.[102] In the uplands, the glaciers scraped away topsoil and left behind a rocky mix of till.[103] In the lowlands, clays carried down from the mountains settled out over a period of centuries in the still waters of Lake Vermont and the Champlain Sea to be revealed when water levels fell.[104] The fertile soil combined with a relatively flat topography has led to the concentration of agriculture in the valley.

V. Changes in Forestry and Agricultural Practices

The population of the Champlain Valley increased dramatically in the years following the Revolutionary War.[105] Immigrants settled in the valleys to take advantage of rivers and lakes for transportation.[106] During this period of increasing development much of the Champlain Basin's forest land was cleared for timber, agriculture, and settlements.[107] Hillside farms lost their fertility in just a generation or two as cleared land eroded.[108]

In the valleys, various grasses grew well, leading many settlers to clear trees and raise livestock.[109] In the early 1800s, the predominant agricultural venture was raising sheep.[110] Merino sheep imported from Spain grew heavier fleeces in the cold northern climates than in their native land. In 1824, Congress put a tariff on imported woolen cloth, expanding the market for domestic production.[111] By 1840, there were six sheep for every person in Vermont.[112] The market for Vermont wool cratered after the 1840s.[113]

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101. Richard Henry Fillon, The Sedimentation and Recent Geologic History of the Missisquoi Delta (Feb. 1970) (unpublished master's thesis, University of Vermont) (on file with Vt. J. Envtl. L.).

102. David P. Stewart & Paul MacClintock, The Surficial Geology and Pleistocene History of Vermont 36–37, 60–61 (1969).

103. *Id.* at 25.

104. *Id.* at 37, 60–61.

105. Jan Albers, Hands on the Land: A History of the Vermont Landscape 84 (2000).

106. *Id.*

107. *Id*. at 99.

108. *Id.* at 145.

109. *Id.*

110. *Id.*

111. *Id.*

112. *Id.* at 146.

Wool tariffs were relaxed in 1841 and 1846 and railroads began to bring wool to the East from the West where it could be produced at a lower cost.[114]

Clearing trees for lumber and potash also transformed the landscape. Potash, a potassium based compound used in agriculture and industry, is produced by "burning huge quantities of wood, leaching the ashes, and boiling away the liquid to leave a gritty residue."[115] In 1791 alone, over two million pounds were shipped to Great Britain from Vermont.[116] In 1823, the Champlain Canal was constructed and offered an easy route for shipping lumber to markets.[117] Burlington was the third largest lumber port in the nation in the mid-1800s.[118] By 1840, the Champlain Valley was devoid of marketable trees.[119] By the late nineteenth century, Vermont was seventy-percent cleared and thirty-percent forested, the reverse of what it is today.[120]

The severity of erosion of topsoil and flooding brought on by forest clearing earned widespread attention. In 1864, Vermonter George Perkins Marsh wrote his seminal book *Man and Nature*, documenting changes in climate, soil erosion, flooding, and drought that resulted when forests were cleared.[121] In 1885, the New York state legislature established a Forest Preserve with the intent of keeping the lands forever wild.[122] This preserve became the Adirondack Park in 1892 and two years later the park received "forever wild" protection in the New York state constitution.[123] In 1925, the Vermont legislature approved funding purchase to land to help establish the Green Mountain National Forest.[124] These actions helped restore forest cover in large parts of the basin.

When sheep were no longer profitable, farmers turned to dairy cows. Between 1845 and 1860, dairy cows appear to have increased proportionally to the decline in sheep.[125] Refrigerated rail cars allowed the

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113. *Id.* at 148.
114. *Id.*
115. JOHNSON, *supra* note 92, at 60.
116. *Id.*
117. *Id.*
118. *History*, CITY OF BURLINGTON, VT., https://www.burlingtonvt.gov/CEDO/History [https://perma.cc/K887-HPXV] (last visited Apr. 1, 2016).
119. ALBERS, *supra* note 105, at 156.
120. *Id.*
121. *See generally* GEORGE PERKINS MARSH, MAN AND NATURE (David Lowenthal ed., Harvard Univ. Press 1961) (1864).
122. *History of the Adirondack Park*, ADIRONDACK PARK AGENCY, http://apa.ny.gov/about_park/history.htm [https://perma.cc/HDY3-CAMQ] (last visited Apr. 4, 2016).
123. *Id.*
124. *History of Forestry in Vermont*, DEP'T OF FORESTS, PARKS & RECREATION, http://fpr.vermont.gov/forest/vermonts_forests/history [https://perma.cc/73AP-LYGH] (last visited Apr. 1, 2016).
125. U.S. TARIFF COMM'N, THE WOOL-GROWING INDUSTRY 92 (1921).

transport of milk and milk products to burgeoning urban markets in New York and Boston.[126] Cows were much more difficult to raise than sheep, requiring winter forage and twice-daily milking.[127] However, high milk prices coupled with falling wool prices drove the transition.[128]

As dairy farming became more mechanized following World War II, the number of farms decreased even though milk production increased, a trend that continues today.[129] Marginally profitable hill farms were the most likely to go out of business.[130] The remaining farms have come to rely more and more on inputs of nutrients from outside the basin in the form of feed and fertilizer to sustain their herds.[131] Larger herds can also make animal waste management a greater challenge.[132] Specifically, "[e]nvironmentally sound recycling of manure from ever-larger herds requires greater energy and planning for transport and spreading."[133]

Agriculture changes the hydrology and pollutant loads in a watershed.[134] Herds of animals, such as sheep or dairy cows, generate waste that must be managed. Cultivation of land usually involves tilling. This changes flow paths for water and transpiration rates compared to a forested landscape.[135] Tile drainage of land transfers water movement and nutrient loads from surface to sub-surface.[136] Farmers add nutrients in the form of fertilizers and manure, which can promote unsightly algal blooms if the nutrients reach waterways.[137] Annual cropland has a greater impact than

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126. James A. Kindraka, *The Story of Milk Transportation by Rail*, 13 DISPATCH 17, 18 (1990).

127. F. H. BRANCH, THE PLACE OF SHEEP ON NEW ENGLAND FARMS 11 (1981) (explaining that dairy cattle are more costly to raise than sheep).

128. ALBERS, *supra* note 105, at 206–11.

129. Bob Parsons, *Moving from Sheep to Dairy Lands: Vermont as New England's Top Milk Supplier*, LANCASTER FARMING (Mar. 21, 2016), http://www.lancasterfarming.com/market_news/market_reports/market_movements_monthly/moving-from-sheep-to-dairy-lands-vermont-as-new-england/article_d2155ff9-fca4-5439-893e-ac22c7598380.html [https://perma.cc/H2QG-V9ZS].

130. *See id.* (stating that from 1965 to 2015, Vermont has lost more than 5,000 dairy farms).

131. Smeltzer et al., *supra* note 78, at 1, 7.

132. William L. Bland, *Impact of Land Use Fragmentation and Larger Herd Sizes on Manure Recycling Energy and Cost*, 62 J. SOIL & WATER CONSERVATION 119A, 119A (2007).

133. *Id.*

134. ANDREW N. SHARPLEY, AGRICULTURE, HYDROLOGY AND WATER QUALITY 4 (P.M. Haygarth & S.C. Jarvis eds., 2001).

134. R. HORTON ET AL., MECHANICS AND RELATED PROCESSES IN STRUCTURED AGRICULTURAL SOILS 187, 192 (W.E. Larson et al. eds., 1989).

136. Kevin W. King et al., *Contributions of Systemic Tile Drainage to Watershed-Scale Phosphorus Transport*, 44 J. ENVTL. QUALITY 486, 492–93 (2015).

137. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 9–10.

land in perennial vegetation, such as pasture, particularly if soil is left bare between plantings.[138]

In modern times, the basin has become more developed. Developed lands, including buildings, roads, and parking areas, contribute three to four times more phosphorus per acre than agricultural lands.[139] Once between ten and twenty percent of a landscape is impervious, meaning it sheds rather than absorbs water, surfaces become connected and water can channel directly to streams, lakes, and rivers sooner and with greater energy.[140] Thus, pollutants are transferred a greater distance and the water has greater erosive force once it reaches a receiving water.

VI. MANAGEMENT CHALLENGES

Perhaps the first report on ecological conditions in Lake Champlain was produced by the United States Geological Survey in 1905.[141] The principal concerns expressed in this report centered on disposal of sewage and sludge from paper making.[142] The author did comment on algal build up in the lake, noting that the "super abundance of algae of the offensive species" had been cited as evidence that "the lake is being damaged by municipal and industrial wastes," but the author did not find algae in excess of what "the natural conditions would warrant."[143]

Today, cyanobacterial blooms plague Lake Champlain's northeastern bays.[144] Cyanobacteria are naturally occurring photosynthetic organisms.[145] In the presence of warmer water and high nutrient levels, particularly nitrogen and phosphorus, cyanobacteria outcompete other algae and vascular plants.[146] Certain species form aesthetically unpleasing scums on

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138. Keith E. Schilling et al., *Impact of Land Use and Land Cover Change on the Water Balance of a Large Agricultural Watershed: Historical Effects and Future Directions*, 44 WATER RESOURCES RES. ¶ 28 (2008).

139. AUSTIN TROY ET AL., UPDATING THE LAKE CHAMPLAIN BASIN LAND USE DATA TO IMPROVE PREDICTION OF PHOSPHORUS LOADING 2 (2007), http://www.lcbp.org/wp-content/uploads/2013/04/54_LULC-Phosphorus_2007.pdf [https://perma.cc/2K4X-4U7B] (last visited Apr. 9, 2016).

140. Thomas R. Schueler, *The Importance of Imperviousness: The Practice of Watershed Protection*, 1 WATERSHED PROTECTION TECHS. 100 (2000).

141. MARSHAL O. LEIGHTON, PRELIMINARY REPORT ON THE POLLUTION OF LAKE CHAMPLAIN (1905), http://pubs.usgs.gov/wsp/0121/report.pdf [https://perma.cc/9D3T-9NEW].

142 *Id.* at 9.

143 *Id.* at 108, 110.

144. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 13.

145. WALTER K. DODDS, FRESHWATER ECOLOGY: CONCEPTS AND ENVIRONMENTAL APPLICATIONS 131 (James H. Thorp ed., 2002).

146. Nathalie Fortin et al., *Toxic Cyanobacterial Bloom Triggers in Missisquoi Bay, Lake Champlain, as Determined by Next-Generation Sequencing Quantitative PCR*, 5 LIFE 1,346, 1,368 (2015).

the surface of the water, referred to as blooms.[147] Some species under some conditions can produce toxins, which have led to dog deaths and human illnesses.[148] The mechanisms behind toxin formation are not clearly understood and it is not possible to tell if a given bloom is toxic without analytical testing.[149]

Blooms occur intermittently in various places throughout Lake Champlain, but routinely strike Missisquoi Bay and St. Albans Bay in the Northeast Arm in late summer.[150] Both of these bays are somewhat shallow and have high nutrient levels—conditions that promote cyanobacterial blooms.[151] Blooms can become trapped in the bays by prevailing summer winds from the south.[152] Sediment cores from these bays show increasing growth of algae species typical of nutrient rich waters beginning in the early 20th century for St. Albans Bay and in the 1960s and 1970s for Missisquoi Bay.[153] For St. Albans Bay, the timing coincides with sewer installations and expansions in the watershed.[154] For Missisquoi Bay, with little direct discharge, the driver was more likely increasing intensification of agriculture.[155]

Attempts to control cyanobacterial blooms have focused on reducing inputs of phosphorus.[156] Agricultural operations have imported phosphorus in the form of fertilizer and animal feeds.[157] Such imports were necessary because the soil lost much of its fertility due to erosion caused by excessive grazing and the clearing of forests.[158] For many decades, imports (phosphorus) have exceeded exports (milk and other agricultural products) and the excess phosphorus accumulates in the soil. In Franklin County, Vermont, there has been an increase in the net import of phosphorus from

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147. DODDS, *supra* note 145, 131–32.

148. *Id.* at 133.

149. *Testing and Beach Closures*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/human-health/swimming-concerns/beach-closures/ [https://perma.cc/8KMD-BEHE] (last visited Apr. 22, 2016).

150. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 13.

151. MIKE WINSLOW, LAKE CHAMPLAIN: A NATURAL HISTORY: IMAGES FROM THE PAST (2009).

152. *Id.*

153. Levine, *supra* note 59, at 47.

154. *Id.*

155. *Id.*

156. DEP'T OF ENVTL. CONSERVATION, VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL PHASE 1 IMPLEMENTATION PLAN 1 (2014).

157. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 9–10.

158. *See* J. C. Anyanwu et al., *The Impact of Deforestation on Soil Conditions in Anambra State of Nigeria*, 4 AGRIC. FORESTRY & FISHERIES 64, 68 ("[D]eforestation leads to poor soil physical, chemical and biological conditions.").

14 tons/year in 1924 to 821 tons/year in 2007.[159] The total net import of phosphorus to Franklin County from 1924 to 2007 was 48,000 tons.[160] When the soil erodes, the phosphorus does too.

Additional inputs of phosphorus occurred when the element was added to laundry and dishwasher detergents.[161] Phosphates improve the cleaning effectiveness of detergents without increasing toxicity.[162] By 1959, essentially all laundry detergents in the U.S. contained seven to twelve percent phosphorus by gross dry weight.[163] Phosphorus was banned from laundry detergents in 1976 in New York and 1978 in Vermont.[164] It was banned from dishwasher detergents in 2010 in both states.[165]

In-lake water quality standards for phosphorus were established for thirteen different lake segments in the mid-1990s.[166] Since that time, extensive state and federal resources have been invested in reducing phosphorus exports from agricultural lands and reducing stormwater runoff from developed lands.[167] However, there have not been reductions in in-lake phosphorus levels.[168]

The impact of dramatic land use changes on water quality, such as those that have occurred in the Champlain Basin since European settlement, are difficult to reverse. The best predictor of present day biodiversity in streams is past, not present, land-use.[169] Application of best management practices to farms is not sufficient to reverse changes as any benefits can be overwhelmed by seasonality of a given lake's hydrology, time-lag effects,

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159. Russell F. Ford, Agricultural Phosphorus in Vermont's Missisquoi Bay Watershed: History, Status, and Solutions (2012) (unpublished M.S. thesis, University of Vermont), https://library.uvm.edu/dissertations/?search_type=item&bid=2471519 [https://perma.cc/H8EV-DMLB].

160. *Id.*

161. *See* LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 9 ("Regulations banning phosphorus in detergents have greatly reduced the amount of phosphorus entering treatment facilities.").

162. *See* Michael McCoy, *Goodbye, Phosphates*, C&EN (Jan. 24, 2011), https://pubs.acs.org/cen/coverstory/89/8904cover.html [https://perma.cc/VZ67-38Y6] (noting the cleaning properties of phosphates and their widespread use in detergent manufacturing).

163. Chris Knud-Hansen, *Historical Perspective of the Phosphate Detergent Conflict* (Univ. of Colo., Working Paper 94-54), http://www.colorado.edu/conflict/full_text_search/AllCRCDocs/94-54.htm [https://perma.cc/DZ5V-JMSU].

164. DAVID W. LITKE, REVIEW OF PHOSPHORUS CONTROL MEASURES IN THE UNITED STATES AND THEIR EFFECTS ON WATER QUALITY 6 (1999).

165. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 9.

166. VT. DEP'T ENVTL. CONSERVATION, VERMONT WATER QUALITY STANDARDS 43–44, 65–66 (2014).

167. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 14.

168. *Id.* at 6–7.

169. J. S. Harding et al., *Stream Biodiversity: The Ghost of Land Use Past*, 95 PROC. NAT. ACAD. SCI. 14,843, 14,844 (1998).

and a long history of agricultural use of the landscape.[170] Slow release of phosphorus from over fertilized soils can maintain eutrophication of lakes for centuries.[171]

Eutrophication is not the only challenge to Lake Champlain's ecology; invasive exotic species have also had a profound impact. The lake currently hosts fifty non-native species.[172] They have arrived in the lake via bait releases, aquarium releases, and transfer on boats.[173] However, the single most significant vector for invasive species are the canals that have connected Lake Champlain to the Great Lakes and St. Lawrence Rivers since 1823.[174] Species that have arrived via the Champlain Canal include zebra mussels (Dreissena polymorpha in 1993) and plants such as Eurasian watermilfoil (Myriophyllum spicatum in 1962) and water chestnut (Trapa natans in 1940) that clog boating channels and impair recreation.[175] The arrival of filter-feeding zebra mussels has led to an increase in water clarity,[176] which likely promotes expansion of plant growth by allowing photosynthesis at greater depths. Each of these species first arrived in the southern part of Lake Champlain where the Champlain Canal empties into the lake.[177]

The means of introduction for some more recently arrived species is unknown. These include the spiny waterflea (Bythotrephes longimanus in 2014)—the first invasive zooplankton to reach the lake—and the alewive (Alosa pseudoharengus in 2003), which competes with rainbow smelt as the dominant forage fish in the lake.[178]

Climate change is expected to play a role in promoting future species invasions. A warmer lake will support species from southern climates that could not compete at this time.[179] Flooding events can help species spread from one water body to another and a warming climate is anticipated to

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170. Nolan J.T. Pearce & Adam G. Yates, *Agricultural Best Management Practice Abundance and Location Does Not Influence Stream Ecosystem Function or Water Quality in the Summer Season*, 7 WATER 6,861, 6,861 (2015).

171. Stephen R. Carpenter, *Eutrophication of Aquatic Ecosystems: Bistability and Soil Phosphorus*, 102 NAT'L ACAD. SCI. 10,002, 10,005 (2005).

172. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 2.

173. MARK MALCHOFF ET AL., FEASIBILITY OF CHAMPLAIN CANAL AQUATIC NUISANCE SPECIES BARRIER OPTIONS 3 (2005).

174. *Id.* at 16.

175. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 25.

176. J. Ellen Marsden et al., *Influence of Environmental Factors on Zebra Mussel Population Expansion in Lake Champlain*, *1994-2010*, *in* QUAGGA AND ZEBRA MUSSELS: BIOLOGY, IMPACTS, AND CONTROL 33, 34, 49, 50 (Thomas F. Nalepa & Don W. Schloesser eds., 2d ed. 2012).

177. MALCHOFF ET AL., *supra* note 173, at 8.

178. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 24.

179. Frank J. Rahel & Julian D. Olden, *Assessing the Effects of Climate Change on Aquatic Invasive Species*, 22 CONSERVATION BIOLOGY 521, 529 (2008).

have more intense storms.[180] Climate change can disrupt ecological connections between predators and prey in aquatic systems and this can present an opportunity for invasive species.[181]

Climate change already impacts the physical character of Lake Champlain. Though the lake routinely froze during the winters, now full lake freezes are sporadic at best.[182] When it does freeze, the freeze-over date is roughly two weeks later than it was in the early 1800s.[183] During the summer, the average August surface water temperature has increased by as much as 6.8 °F since 1964.[184] Increased water temperatures can shift the timing of breeding for aquatic organisms.[185] A warmer climate is expected to generate more intense storms throughout the basin which would lead to increases in nutrient loading, combined sewer overflows, and streambank erosion.[186] More nutrients and a warmer climate increase the competitiveness of potentially toxic cyanobacteria.[187]

Cyanobacteria are not the only source of toxins for Lake Champlain. Like other waterbodies around the country, Lake Champlain faces challenges from the addition of potentially toxic substances from industry and consumers. Both Vermont and New York have consumption advisories for some fish species as a result of high PCB and mercury levels.[188] PCB production has been banned in the United States since 1979, but the chemicals persist.[189] Mercury sources include wastewater discharges and atmospheric deposition from regional, national, and international sources.[190] Both mercury and PCBs bioaccumulate so larger older fish have higher concentrations.[191] Mercury concentrations tend to be lower in fish from

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180. *Id.* at 522, 529.

181. Monika Winder & Daniel E. Schindler, *Climate Change Uncouples Trophic Interactions in an Aquatic Ecosystem*, 85 ECOLOGY 2,100, 2,105 (2004).

182. J. CURT STAGER & MARY THILL, CLIMATE CHANGE IN THE CHAMPLAIN BASIN 17 (2010), http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/vermont/what-we-do/champlain-climate-report-5-2010-2.pdf.

183. *Id.* at 2.

184. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 31.

185. Ned W. Pankhurst & Philip L. Munday, *Effects of Climate Change on Fish Reproduction and Early Life History Stages*, 62 MARINE & FRESHWATER RES. 1,015, 1,020 (2011).

186. STAGER & THILL, *supra* note 182, at 15.

187. *Id.* at 19.

188. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 23, at 14.

189. Press Release, Envtl. Prot. Agency, Envtl. Prot. Agency Bans PCB Manufacture; Phases Out Uses (Apr. 19, 1979), https://www.epa.gov/aboutepa/epa-bans-pcb-manufacture-phases-out-uses [https://perma.cc/7E94-Z2B7].

190. CONN. DEP'T ENVTL. PROT. ET AL., NORTHEAST REGIONAL MERCURY TOTAL MAXIMUM DAILY LOAD vi–vii (2007).

191. *Toxics Release Inventory (TRI) Program: Persistent Bioaccumulative Toxic (PBT) Chemicals Covered by the TRI Program*, ENVTL. PROT. AGENCY (2015), https://www.epa.gov/toxics-release-inventory-tri-program/persistent-bioaccumulative-toxic-pbt-chemicals-covered-tri [https://perma.cc/T5FS-68QR].

eutrophic waters where the high concentration of phytoplankton dilutes the amount of mercury ingested by any one fish.[192] As a result, fish from the Main Lake would be expected to have higher concentrations than those from Missisquoi Bay.

There are many human-made substances with unknown toxicity have been detected in the lake. These include pharmaceuticals, fragrances, pesticides, and a wide variety of other byproducts of modern life.[193] Little is known about the individual effects of all these potential contaminants and even less is known about potential synergistic effects. Many of these substances can mimic natural hormones, causing unexpected changes in aquatic biota. For example, in one survey of smallmouth bass from the Missisquoi River, sixty to seventy percent of the males had eggs in their testes, which may be related to exposure to endocrine disrupting chemicals.[194] This rate was lower than other waterbodies near National Wildlife Refuges in the Northeast, but higher than reported from other surveys.[195]

CONCLUSION

Lake Champlain has undergone tremendous changes since the glaciers left the landscape. It has transitioned from a much larger freshwater lake to a saltwater sea and back to a smaller freshwater lake. The forests were cleared for timber and agriculture following the arrival of Europeans. Agriculture transitioned from homesteads to sheep grown for outside markets to dairy cows. Clearing land led to erosion and eutrophication of the waterbody. Eutrophication, coupled with climate change, has promoted growth of cyanobacteria in shallower portions of the lake, specifically Missisquoi and St. Albans Bays. Attempts to reverse eutrophication have thus far not been successful and there is little evidence, particularly in Missisquoi Bay, that reversal is possible. Other management challenges for the lake also loom. Intense focus on reversing decades of excess nutrient loading risks blinding us to management options that more effectively

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192. Piet Vieburg et al., *Mercury Biomagnification in Three Geothermally-Influenced Lakes Differing in Chemistry and Algal Biomass*, SCI. TOTAL ENV'T. 342, 351 (2014).

193. P. Phillips & A. Chalmers, *Wastewater Effluent, Combined Sewer Overflows, and Other Sources of Organic Compounds to Lake Champlain*, 45 J. AM. WATER RESOURCES ASS'N 45, 51 (2009).

194. *Sex Switching Bass Found in Lake Champlain's Waters*, LAKE CHAMPLAIN COMM. (Dec. 30, 2015), https://www.lakechamplaincommittee.org/learn/news/item/sex-switching-bass-found-in-lake-champlain-waters/ [https://perma.cc/WCK2-D434].

195. L.R. Iwanowicz et al., *Evidence of Estrogenic Endocrine Disruption in Smallmouth and Largemouth Bass Inhabiting Northeast U.S. National Wildlife Refuge Waters: A Reconnaissance Study*, 124 ECOTOXICOLOGY & ENVTL. SAFETY 50, 55 (2016).

prevent future problems. Priority conservation efforts to address future issues should include protecting the forested landscape, restoring and protecting river corridors, shutting off vectors for invasive species like the Champlain Canal, and minimizing impacts of new developments.

BACKGROUND FACTS: ROLE OF PHOSPHORUS IN LAKE CHAMPLAIN POLLUTION

William B. Bowden*

Introduction

INTRODUCTION

Phosphorus is an important element that is necessary to sustain life. It is a critical component of deoxyribonucleic acid and ribonucleic acid—better known as DNA and RNA—biomolecules that control the form and nature of all living organisms.[1] It is the essential atom in adenosine tri- and di-phosphate (ATP and ADP), the molecules that store and transport energy in all living organisms, making it possible to breath, move, think, reproduce, and survive.[2] Phosphorus is also a major element in phospholipids, one of the critical components of the cell walls in plants and animals and in hormones that regulate physiological functions.[3] One form of phosphorus

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1. ROBERT W. STERNER & JAMES J. ELSER, ECOLOGICAL STOICHIOMETRY: THE BIOLOGY OF ELEMENTS FROM MOLECULES TO THE BIOSPHERE 50 (2002).
2. *Id.*
3. Gabriel M. Filippelli, *The Global Phosphorus Cycle: Past, Present, and Future*, 4 ELEMENTS 89, 89 (2008).

when added to the flexible protein called collagen, makes it possible to create hard, stiff bones for skeletons, which were essential for the evolution of large organisms, like humans.[4] In a very real sense, life as we know it would not be possible without phosphorus.

But like many materials that we think of as essential for one reason or another, too much of a good thing can be bad. Phosphorus is regularly, but not always, implicated as a pollutant that is responsible for ugly, smelly, and potentially dangerous algal blooms.[5] Indeed, the entire Lake Champlain TMDL focuses on phosphorus and nothing else.[6] Why this one element? What are the special characteristics of phosphorus that explain why it behaves the way it does in the environment? And why is it that an element so essential to life could be so undesirable in some settings? Answers to these questions are crucial to understanding the central role of phosphorus in waterbodies like Lake Champlain and help inform what we can expect to happen as we begin to control the amount of phosphorus that is delivered to the lake each year.

I. A PRIMER ON PHOSPHORUS IN THE ENVIRONMENT

To begin with, phosphorus is an element; number fifteen in the periodic chart of elements.[7] Pure forms of phosphorus can be manufactured and are identified by their colors (white, red, violet, and black).[8] But these forms of phosphorus are either very unstable (even explosive) or non-existent in nature. Thus, we never find phosphorus as a free element in nature; it is always combined with other elements, notably oxygen, to form phosphate molecules.[9] Each phosphate molecule is composed of a single P atom surrounded by four oxygen atoms arranged in a tetrahedral pattern with phosphorus in the middle.[10] Arranged in this way the phosphate molecule carries an excess negative charge of -3.[11] To a chemist this means that the

4. Vaclav Smil, *Phosphorus in the Environment: Natural Flows and Human Interferences*, 25 ANN. REV. ENERGY ENV'T 53, 54 (2000).

5. J. Heisler et al., *Eutrophication and Harmful Algal Blooms: A Scientific Consensus*, 8 HARMFUL ALGAE 3, 4–5 (2008).

6. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN (2015).

7. *See generally* C.R. Hammond, *The Elements*, *in* CRC HANDBOOK OF CHEMISTRY AND PHYSICS 4 (David R. Lide ed., 86th ed. 2005).

8. *Id.*

9. *Id.*

10. *Phosphate*, PUBCHEM, https://pubchem.ncbi.nlm.nih.gov/compound/phosphate#section=Top [https://perma.cc/WZR9-5QH9] (last visited Apr. 15, 2016).

11. *Id.*

phosphate is a trivalent anion (PO_4^{3-}).[12] The practical implications of this characteristic is that the negatively charged phosphate molecule is naturally attracted to positively charged atoms and molecules (cations) and has the capacity to make three connections to these cations. For example, one of the most common and commercially important forms of phosphate is phosphoric acid (H_3PO_4).[13]

The ultimate source of phosphorus in the environment is from phosphate bound with a variety of other atoms in common minerals and rocks. Over time, the slow action of water and wind erodes even solid rocks in a process that geologists refer to as "weathering." Over geologic time periods, weathering erodes rocks and releases the phosphate that they contain.[14] Once released in this way, the phosphate is available for use by biota in ecological systems.[15]

The slow release of phosphate from rock naturally limits the rate at which phosphorus is released to the environment.[16] There are episodes in the pre-human past in which phosphorus delivery to the oceans was greater than normal.[17] However, it also appears to be the case that humans have accelerated the delivery of phosphorus to the ocean, perhaps by a factor of two.[18]

Long ago, humankind realized that by adding a little phosphorus (along with a few other key elements), one could grow a lot more biomass (i.e., food and fiber).[19] We now know why that is the case. Given that phosphorus is essential to so many critical parts of living organisms and is needed in only small amounts to serve these needs, it is clear that, given no other constraints, the addition of phosphorus in the form of phosphate will stimulate plant growth. This explains why phosphorus is such an important fertilizer. And so, the rush was on to find new and concentrated sources of phosphate that could be used to support a burgeoning, global, agricultural industry.[20] The first easy source of phosphate was from deposits of guano created by bird colonies, largely on small islands off the coast of Peru.

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12. *Id.*
13. STEPHEN M. JASINSKI, U.S. GEOLOGICAL SURVEY, MINERAL COMMODITY SUMMARIES, PHOSPHATE ROCK (2015).
14. Holm Tiessen, *Phosphorus in the Global Environment*, *in* THE ENCYCLOPEDIA OF PLANT-PHOSPHORUS INTERACTIONS 1, 5 (P.J. White & J.P. Hammond eds., 2008).
15. *Id.*
16. W.H. SCHLESINGER & E.S. BERNHARDT, BIOGEOCHEMISTRY: AN ANALYSIS OF GLOBAL CHANGE (Academic Press 3d ed. 2013).
17. Filippelli, *supra* note 3, at 89.
18. *Id.*
19. Dana Cordell, *The Story of Phosphorus: Global Food Security and Food for Thought*, 19 GLOBAL ENVTL. CHANGE 292, 292–94 (2009).
20. Smil, *supra* note 4, at 55.

Evidence suggests that the Andean peoples of Peru had collected guano as an agricultural soil amendment for perhaps thousands of years and guano remained an important source of phosphorus well into the 20th century.[21] Currently, the primary source of phosphate is the mineral form apatite, which is mined from operations in Florida and North Carolina, with smaller amounts mined in Idaho and Utah.[22] Large amounts of phosphate rock are also mined in China, Russia, and Morocco with smaller amounts in other countries.[23] The annual report on the phosphate mining industry produced by USGS notes tersely that there are "no substitutes for phosphorus in agriculture."[24] To meet our agricultural demand for phosphorus in the U.S. in 2014, we imported about 2.6 million metric tons of phosphate rock, largely from Morocco and Peru, representing about 15% of our total usage (28.1 million metric tons). This phosphate rock is wet-processed to create the basic feedstocks needed to support U.S. agriculture and industry.[25]

II. THE CHEMICAL BALANCE OF LIFE: THE LIMITS OF PHOSPHORUS BENEFITS

Of course, phosphorus is not the only element needed to create a healthy crop or to sustain a healthy animal. Most of the other elements in the periodic chart help to support healthy organisms in one way or another.[26] Notably, two other elements acting with phosphorus play particularly important roles. The other two elements are carbon and nitrogen.[27] Interestingly, these three elements are all close neighbors on the periodic chart of elements. But they serve very different purposes and have very different characteristics. Nitrogen is a central element in all amino acids, which are the essential building blocks of all proteins.[28] Proteins form a substantial portion of the total mass of plants and animals and serve critical functions as enzymes in living systems. Therefore, large amounts of nitrogen are also required for a healthy organism. Carbon is the essential backbone element of all living matter.[29] It is essentially the chemical

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21. GREGORY T. CUSHMAN, GUANO AND THE OPENING OF THE PACIFIC WORLD: A GLOBAL ECOLOGICAL HISTORY 25–26 (2013).
22. JASINSKI, *supra* note 13, at 118.
23. *Id.* at 119.
24. *Id.*
25. *Id.*
26. *See generally* K.O. Soetan et al., *The Importance of Mineral Elements for Humans, Domestic Animals and Plants: A Review*, 4 AFR. J. FOOD SCI. 200, 203–04 (2010) (reviewing the biochemical functions and importance of mineral elements in human and plant health).
27. SCHLESINGER & BERNHARDT, *supra* note 16.
28. STERNER & ELSER, *supra* note 1, at 59.
29. SCHLESINGER & BERNHARDT, *supra* note 16.

framework to which all of the other elements, including phosphorus and nitrogen, are attached. Thus, living organisms need a lot of carbon.

A logical deduction from this discussion is that there is some form of priority or "recipe" for these three fundamentally important elements. Specifically, living organisms need a lot of carbon to create the necessary organic framework, a moderate amount of nitrogen to fill in the protein matrix around the carbon framework, and a pinch of phosphorus to run the genetic engine of DNA and RNA fueled by energy from ATP and ADP.[30] The realization that carbon, nitrogen, and phosphorus are ordered in this way has profoundly important implications.

The first inkling that this ordering might be important arose from the work of Carl Sprengel, an agricultural chemist working in Europe in the early 1800s.[31] Even at this early time it was realized that nutrients played a key role in crop production. Sprengel was the first to note that it was not just the total amount of nutrient that was important. Rather, the factor that would most limit plant production was the nutrient that was least available to the plant: the so-called "minimum" or "limiting" nutrient.[32] This idea did not gain much attention until it was adopted by Justus von Liebig, an agricultural chemist working at about the same time who is now recognized as the father of organic chemistry.[33] Sprengel's hypothesis eventually became known as Liebig's Law of the Minimum and was widely illustrated by a figure in Whitson and Walster's 1912 book entitled *Soils and Soil Fertility*.[34] The figure shows a barrel composed of staves of different lengths. If one tried to fill the barrel with water, it could only be filled to the level of shortest stave. The only way to keep more water in the barrel would be to lengthen the stave. This illustrated Sprengel and Liebig's point that a crop (the barrel) is composed of many elements (staves) and the element that is most limiting (the shortest stave) will limit the crop production (the water in the barrel).[35] Liebig's Law subsequently became one of the most important tenants in the newly evolving field of ecology.

The next major evolution in thinking about the interplay of elements in crop production and ecological systems came from the work of an oceanographer, Alfred C. Redfield, working at the Woods Hole

30. STERNER & ELSER, *supra* note 1, at 49–50.

31. R. R. van der Ploeg et al., *History of Soil Science: On the Origin of the Theory of Mineral Nutrition of Plants and the Law of the Minimum*, 63 SOIL SCI. SOC'Y AM. J. 1055, 1057–58 (1999).

32. *Id.*

33. *Id*. at 1061 (accounting Sprengel and Liebig's dispute over which of them originated the concept of the Law of the Minimum, a classic story in the history of science).

34. A.R. WHITSON & H.L. WALSTER, SOILS AND SOIL FERTILITY 72 (1912).

35. *Id.*

Oceanographic Institute ("WHOI").[36] Redfield was trying to understand the controls on algal production in the Sargasso Sea—an area in the middle of the Atlantic Ocean—in which nutrient concentrations are particularly low.[37] Redfield would have been well aware of Liebig's Law. But at the time, the implications of Liebig's Law were simply that if you lacked a particular element, adding it would help stimulate production. What Redfield observed was that everywhere he looked, he found that the algae were composed of more or less the same ratio of carbon atoms to nitrogen atoms to phosphorus atoms.[38] The ratio was about 106:16:1 and it was remarkably invariant.[39] Redfield's work showed that this ratio of elements was an inherent, structural characteristic of the algae and furthermore, this inherent ratio provided an important refinement and quantitative context for Liebig's Law of the minimum.

The fundamental importance of Redfield's observations can be illustrated with a simple analogy. Imagine you run a bakery that makes cakes. You need several ingredients for each cake, but the key ingredients are flour, sugar, and eggs. You do not need these ingredients in equal proportions, but if you do not have the correct proportions the cake recipe will fail. Let us say you need two cups of flour, one cup of sugar, and a single egg for each cake. Thus, there is a relatively fixed ratio of the materials you need to bake a cake. Now imagine that you have an abundance of flour and sugar, but you have run short on eggs. In this case, the number of cakes you can bake is limited, specifically by the availability of the limiting resource: eggs. In our cake example, the flour is carbon, the sugar is nitrogen, and the egg is phosphorus. You do not need that many eggs to make a cake, but if you do not have enough, it will not matter if you have an abundance of sugar or flour; you cannot use them. But, if you have lots of eggs and a limitless supply of sugar and flour, you could bake as many cakes as you wish. The same is true for algae (biomass) in lakes. If you provide plenty of carbon, nitrogen, and phosphorus—in the correct ratios—you can grow a lot of biomass.

Redfield's Ratio spawned a generation of research that was fundamentally important to the water quality management principles we now use on a daily basis. One of the most important uses of Redfield's Ratio and Liebig's Law was a recommendation that arose from research on

36. ROGER REVELLE, ALFRED C. REDFIELD: 1890-1983 317 (1995).

37. A.C. Redfield, *On the Proportions of Organic Derivatives in Sea Water and Their Relation to the Composition of Plankton*, *in* JAMES JOHNSTONE MEMORIAL VOLUME (R.J. Daniel ed., 1934).

38. *Id.*

39. A.C. Redfield, *The Biological Control of Chemical Factors in the Environment*, 46 AM. SCIENTIST 205, 206 (1958).

the best way to manage algal production in lakes. Over many years, researchers had begun to notice a strong correlation between algal growth and phosphorus concentrations in lakes.[40] High phosphorus concentrations were correlated with more algal biomass.[41] Redfield's Ratio provided an explanation. As one of the three "essential" elements and the one that was needed in the lowest amount, controlling phosphorus was viewed as the most effective way to control algal growth.[42] This is still the primary objective of lake and reservoir management around the world. It is worth noting, however, that most of the research upon which this management recommendation was based was done on lakes in Europe, the United States, and Canada. These are all areas that have a common geologic history and climate. In other areas—for example, areas where the soils have very high phosphorus concentrations derived from volcanic parent materials—it might be more effective to control nitrogen than phosphorus. Hawaii and New Zealand are good examples where this is the case.[43] But under these circumstances, the principles behind Redfield's Ratio still hold with nitrogen rather than phosphorus as the focal element.

The next major advance in our understanding of nutrient interactions in environmental systems built on Redfield's ratio and the well-known concept in general chemistry called "stoichiometry," which is used to describe the strict ratio of atoms in a molecule.[44] For example, we all know that the water molecule is H_2O: two hydrogen atoms paired with one oxygen atom. That is the stoichiometry of water. If the ratio was something different—say, H_2O_2—the molecule could not be water—the stoichiometry would be wrong. In fact, this would be hydrogen peroxide, which you would want to be careful *not* to drink! Sterner and Elser reasoned that Liebig's Law and Redfield's Ratio suggested that there was a sort of *weak* stoichiometry in living organisms: an ecological stoichiometry.[45] They

40. Steven C. Chapra & Stephen J. Tarapchak, *A Chlorophyll a Model and Its Relationship to Phosphorus Loading Plots for Lakes*, 12 WATER RESOURCES RES. 1260 (1976); G.F. Lee et al., *Eutrophication of Water Bodies: Insights for an Age-Old Problem*, 12 ENVTL SCI. & TECH. 900 (1978); R.A. VOLLENWEIDER & P.J. DILLON, THE APPLICATION OF THE PHOSPHORUS LOADING CONCEPT TO EUTROPHICATION RESEARCH 21–37 (1974).

41. Lee et al., *supra* note 40, at 900.

42. David W. Schindler, *The Dilemma of Controlling Cultural Eutrophication of Lakes*, 279 PROC. ROYAL SOC'Y B. 4,322, 4,322 (2012).

43. E. White, *Lake Eutrophication in New Zealand—A Comparison with Other Countries of the Organisation for Economic Co- Operation And Development*, 17 N.Z. J. MARINE & FRESHWATER RES. 437, 437 (1983).

44. *Stoichiometry*, OXFORD ENGLISH DICTIONARY (2016) (stating that the word stoichiometry came into use in the early 1800s and is derived directly from the Greek word "*stoikheion" which means "element").*

45. STERNER & ELSER, Ecological stoichiometry: The biology of elements from molecules to the biosphere. 2002. 45. Sterner & Elser, *supra* note 1.

noted that this ecological stoichiometry is not as strict as chemical stoichiometry, but it exists nonetheless.[46] Furthermore, they were able to demonstrate that the essential framework of ecological stoichiometry could be derived from first principles of biology and chemistry and had unexpected consequences for biological systems at scales ranging from cells to individuals to communities and ecosystems.[47] They even suggested that there are implications for ecological stoichiometry at regional and global scales.[48] Our modern approach to large ecosystem management, including the Great Lakes and our oceans, recognizes that the principles of ecological stoichiometry are at work.[49]

III. LIEBIG, REDFIELD, AND LAKE CHAMPLAIN

With the foregoing principles in mind, we can now understand why phosphorus management is often effective in controlling algal production in lakes like Lake Champlain. Perhaps more importantly, phosphorus management is also thought to be an essential defense against the development of harmful algal blooms or "HABs."[50]

To understand why this is the case, it helps to return to the example of baking cakes. Let us say that your limiting resource is eggs (phosphorus). You have plenty of sugar (nitrogen) and flour (carbon). So your cake production (algal production) is limited by the supply rate of eggs. Let us say that you run across a new source of eggs and can now bake and sell cakes at a much faster rate. That works for a while. But then you find that your cake production is limited by a new factor: your supply rate of sugar.

This analogy can be applied to nutrient dynamics in lakes. Prior to extensive development in areas like the Lake Champlain Basin, the primary limitation on algal growth is thought to have been the rate at which phosphorus could be delivered. Carbon is widely available in the form of carbon dioxide (CO_2) in the atmosphere and this carbon can easily be converted into biomass through the simple process of photosynthesis.[51] All green plants, including algae, can engage in photosynthesis, so acquiring

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46. *Id.*
47. *Id.*
48. *Id.*
49. Robert Ptacnik et al., *Applications of Ecological Stoichiometry for Sustainable Acquisition of Ecosystem Services*, 109 OIKOS 52, 59 (2005); Philip G. Taylor & Alan R. Townsend, *Stoichiometric Control of Organic Carbon-Nitrate Relationships from Soils to the Sea*, 464 NATURE 1178, 1178 (2010); Jofre Carnicer et al., *Global Biodiversity, Stoichiometry and Ecosystem Function Responses to Human-Induced C-N-P Imbalances*, 172 J. PLANT PHYSIOLOGY 82 (2015).
50. David W. Schindler, *Evolution of Phosphorus Limitation in Lakes*, 195 SCI. 260, 260 (1977); Schindler, *supra* note 42, at 4,322.
51. EUGENE RABINOWITCH & GOVINDJEE, PHOTOSYNTHESIS 16 (1969).

carbon is not a great problem. Nitrogen arises naturally through a variety of processes, including natural fires, volcanic emissions, and lightning.[52] For example, lightning converts di-nitrogen gas (N_2), which is about seventy-eight percent of what we breathe in the air, into nitrogen oxides (NO_x) that can be turned into useful forms of nitrogen (e.g., nitrate) in water.[53] However, phosphorus is relatively harder to acquire. Before the industrial era, the primary source of new phosphorus was the weathering of rocks by the action of wind, water, and plant root growth.[54] Weathering is an extremely slow process that plays out over decades to millennia. The amount of new phosphorus released to the environment by this means is quite low. As a consequence, under pre-industrial conditions, phosphorus was likely to be the element that most limited production of algae in lakes like Lake Champlain.

But in the post-industrial world, phosphorus began to be mined and concentrated into forms that could be used on farms, in industry, and at home.[55] Eventually, this "new" phosphorus introduced into the ecosystem found its way to downstream receiving waters. To return to our cake analogy, there is now a new source of eggs that could accelerate production. According to the principles of ecological stoichiometry discussed above, we would expect the delivery rate of nitrogen to now limit new production by algae, enabled by the higher rate of phosphorus delivery. To be sure, algal growth might increase a little bit due to the new phosphorus, but eventually nitrogen limitation would prevail.

However, there is an additional piece to this story. It turns out that some microbial organisms have evolved an enzyme—nitrogenase—that can break apart N_2 molecules that are abundantly available in the air and easily soluble in water.[56] These organisms can convert N_2 to "reduced" forms of nitrogen in a process called nitrogen fixation and this reduced nitrogen can be used by algae for growth.[57] It is worth pausing to consider what a remarkable feat this is. Karl Haber, working with Carl Bosch in Germany in the early 1900s, discovered a way to create industrial quantities of ammonium (NH_4^+) from atmospheric N_2 by creating an environment pressurized to a level about 200 times higher than standard atmospheric

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52. David Fowler et al., *The Global Nitrogen Cycle in the Twenty-First Century*, 368 PHIL. TRANSACTIONS ROYAL SOC'Y B. 1, 3–9 (2013).

53. *Id.* at 3.

54. *See* Filippelli, *supra* note 3, at 90–94 (explaining the natural pre-human phosphorus cycle).

55. *Id.* at 94; SCHLESINGER & BERNHARDT, *supra* note 16.

56. Brian M. Hoffman et al., *Mechanism of Nitrogen Fixation by Nitrogenase: The Next Stage*, 114 CHEMICAL REV. 4,041, 4,042 (2014).

57. *Id.* at 4,041.

pressure, with a temperature elevated to between 400-500°C (752-932°F), and including one of several forms of an iron, aluminum, or silicate catalyst.[58] This is an extraordinarily harsh environment in which no living organism could survive. Yet the algae that have the nitrogenase enzyme (a type of biological catalyst) can do the same thing at typical atmospheric pressure and comfortable—even cool—temperatures![59] This is an amazing biological adaptation.

Not all algal species have the nitrogenase enzyme, but those that do have a competitive advantage over algal species that do not have this enzyme. All algae have a virtually unlimited supply of carbon as CO_2 in the air, which they access through the process of photosynthesis. Algal species that have the nitrogenase enzyme have access to an unlimited supply of nitrogen as N_2 in the air, which they can reduce by the process of nitrogen fixation. Thus, the growth of these species is limited only by the supply rate of phosphorus.[60] If the phosphorus supply rate goes up, these algae produce more biomass and may rapidly grow to bloom conditions.[61] These are the pea-soup thick, bright green, and often smelly scums of plant matter that we see in quiet bays of Lake Champlain on some August days.

Unfortunately, a large portion of these blooms are composed of a special group of organisms called cyanobacteria or "blue-green algae."[62] These organisms are classified as true bacteria but have characteristics of algae (chlorophyll and photosynthesis) and also characteristics of bacteria (no nucleus or internal cell membranes).[63] Nitrogen fixation is common among cyanobacterial species.[64] Furthermore, these organisms are capable of producing species-specific toxins that can have serious human health impacts, including skin rashes, nervous system disruption, and liver damage.[65] A variety of toxins are produced by different cyanobacterial

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58. VACLAV SMIL, ENRICHING THE EARTH: FRITZ HABER, CARL BOSCH, AND THE TRANSFORMATION OF WORLD FOOD PRODUCTION (MIT Press 2004).

59. Hoffman et al., *supra* note 56, at 4,042.

60. *Evolution of Phosphorus Limitation in Lakes*, *supra* note 50, at 262.

61. Factors that control harmful algal blooms are more complicated than indicated by this simple summary. However, this is the rationale most often presented for controlling phosphorus loading to lakes to control algal blooms. *See* Heisler et al., *supra* note 5, at 5 ("Physical, biological, and other chemical factors may modulate harmful algal species' responses to nutrient loadings.").

62. *Cyanobacteria: Blue-Green Algae*, VT. DEP'T OF HEALTH http://www.healthvermont.gov/enviro/bg_algae/bgalgae.aspx [https://perma.cc/4G95-ZFAE] (last visited Apr. 18, 2016).

63. Antonia Herrero et al., *Minireview: Nitrogen Control in Cyanobacteria*, 183 J. BACTERIOLOGY 411, 411 (2001).

64. *Id.* at 412.

65. JAMIE BARTRAM ET AL., TOXIC CYANOBACTERIA IN WATER: A GUIDE TO THEIR PUBLIC HEALTH CONSEQUENCES, MONITORING AND MANAGEMENT 7, 133, 146 (Ingrid Chorus & Jamie Bartram eds., 1999).

species, including microtoxin, cylindrospermopsin, anatoxins, and saxitoxins.[66] One of the perplexing riddles yet to be solved is to understand "why do these organisms produce these toxins" and, more importantly, "under what circumstances"? In some cases, large and very dense blooms of cyanobacteria have proven to be entirely non-toxic and in other cases, small and seemingly feeble blooms have proven to be very toxic.[67] The bottom line is that potentially-toxic cyanobacteria are particularly well adapted to thrive in the warm, relatively phosphorus-enriched conditions that prevail in some parts of Lake Champlain in the late summer.

IV. SOURCES AND CONTROLS OF PHOSPHORUS TO LAKE CHAMPLAIN

How did all of this new phosphorus end up in Lake Champlain? To start with, it is important to remember that phosphorus is a natural element in the environment and that it is required for life. In this sense, it is an essential nutrient and a common element in soils and the rocks from which soils are derived. The concentration of phosphorus in undeveloped soils in Vermont are not particularly unusual in this respect.[68] However, human activities have intensified the use of phosphorus and created local "hotspots" of high phosphorus concentrations that have led to regular and persistent water quality problems in lakes like Lake Champlain.[69]

It has clearly become necessary to significantly reduce the amount or "load" of phosphorus that reaches sensitive lakes like Lake Champlain. As a consequence, the State of Vermont, working with Region 1 of the U.S. Environmental Protection Agency ("EPA") has developed a recommendation for the total maximum daily load ("TMDL") that is allowable for the health of Lake Champlain.[70] The history, rationale, development, and implementation of the Lake Champlain Phosphorus TMDL is the subject of other articles in this issue. But in the context of this article, it is relevant to review briefly where this excess phosphorus is coming from and what happens to it.

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66. *Id.* at 19.

67. *Lake Conditions and Blue-Green Algae Bloom Updates*, VT. DEP'T OF HEALTH http://healthvermont.gov/enviro/bg_algae/weekly_status.aspx [https://perma.cc/845H-ZY73] (last visited Apr. 1, 2015).

68. Eulaila R. Ishee et al., *Phosphorus Characterization and Contribution from Eroding Streambank Soils of Vermont's Lake Champlain Basin*, 44 J. ENVTL. QUALITY 1,745, 1,746 (2015).

69. *See* Laura Arenschield, *Toledo Bearing Full Brunt of Lake Erie Algae Bloom*, COLUMBUS DISPATCH (Aug. 4, 2014), http://www.dispatch.com/content/stories/local/2014/08/04/this-bloom-is-in-bad-location.html [https://perma.cc/KY9N-SU9X] (explaining that in the summer of 2014 the City of Toledo had to shut down the water supply for a population of nearly 500,000 due to a large and toxic algal bloom that developed in Lake Erie).

70. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 1–2.

EPA has estimated that more than three-quarters of the total phosphorus load to Lake Champlain (631 of 922 metric tons/year) comes from sources in the State of Vermont with the balance coming from sources in New York and the Province of Quebec.[71] This is not surprising because compared to New York and Quebec, Vermont has more shoreline, a larger population, and more intensive land use.[72]

The largest portion—about forty-one percent—of the total phosphorus loading to Lake Champlain comes from agricultural lands in Vermont, which represent about nineteen percent of the total land area in the basin.[73] In the particular case of agriculture, farmers import large quantities of phosphorus in the form of grains for feed and fertilizers for crops.[74] The total quantity of phosphorus that leaves the basin in the form of intermediate or finished farm products is far less. The difference has to accumulate somewhere. It has proven to be impossible to retain this excess phosphorus on the farms and so it eventually makes its way to the lake.[75] On-farm retention is doomed to fail until imports to farms can be reduced to match exports from farms or the ability to permanently retain or recycle phosphorus on farm.

Developed (urban, suburban, and "barren") areas make up a relatively small portion of the overall land use in the Lake Champlain Basin approximately six percent) but account for eighteen percent of the total phosphorus load to Lake Champlain.[76] On a per-acre basis, urban areas deliver two to three times more phosphorus than agricultural lands.[77] It is still not clear why this is case. Leaking sewer pipes and excessive lawn

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71. *Id*. at 17.

72. Nathalie Fortin et al., *Toxic Cyanobacterial Bloom Triggers in Missisquoi Bay, Lake Champlain, as Determined by Next-Generation Sequencing and Quantitative PCR*, 5 LIFE 1,368, 1,369 (2015).

73. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 47; *see* AUSTIN TROY ET AL., LAKE CHAMPLAIN BASIN PROGRAM, UPDATING THE LAKE CHAMPLAIN BASIN LAND USE DATA TO IMPROVE PREDICTION OF PHOSPHORUS LOADING 87 (2007) (calculated using data from Appendix I).

74. *Where Does the Phosphorus in Lake Champlain Come From?*, LAKE CHAMPLAIN BASIN PROGRAM, http://sol.lcbp.org/Phosphorus_where-does-p-come-from.html [https://perma.cc/HQV9-WVAV] (last visited Apr. 19, 2016).

75. Erica Joy Brown Gaddis, *Landscape Modeling and Spatial Optimization of Watershed Interventions To Reduce Phosphorus Load to Surface Waters Using a Process-Oriented and Participatory Research Approach: A Case Study in the St. Albans Bay Watershed, Vermont*, RESEARCHGATE (2007), https://www.researchgate.net/publication/33692301_Landscape_modeling_and_spatial_optimization_of_watershed_interventions_to_reduce_phosphorus_load_to_surface_waters_using_a_process-oriented_and_participatory_research_approach_a_case_study_in_the_St_A [https://perma.cc/H69R-KVEZ].

76. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 47; TROY ET AL., *supra* note 73, at 87.

77. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 47 (indicating the amount of phosphors delivered from urban and agricultural areas); *see also* TROY ET AL., *supra* note 73, at 87 (indicating land use trends in the Vermont portion of the basin).

fertilization are potential sources of excess nutrients in ground and surface waters.[78]

Sewage treatment plants or wastewater treatment plants ("WWTWs") are a part of the developed landscape. However, largely because they are easy to measure and easy to regulate, we have separate estimates of their total contribution to the phosphorus load to Lake Champlain. The Vermont contribution from WWTWs is about four percent of the total.[79] This is a small percentage, but some have argued that the form of the phosphorus released from WWTWs is more readily available to microorganisms and algae for growth.[80]

Forest lands make up the majority of the land cover in Vermont (approximately sixty-six percent).[81] Although the amount of phosphorus delivered from each acre of forestland tends to be low compared to agricultural and developed lands, the comparatively large number of forestland acres means that the cumulative contribution is substantial, about sixteen percent of the total.[82]

One of the more surprising findings in the most recent research supporting the new TMDL is that streambank erosion provides approximately twenty-one percent of the total phosphorus load to the lake.[83] It should be noted that this phosphorus load comes from some combination of eroding agricultural and developed land streams and erosion from backroads in forested areas.[84]

Before leaving this topic it is important to recognize that it is an oversimplification to say that agriculture is the largest source of phosphorus and so phosphorus reduction by farmers is the most important priority. Nor is it entirely accurate to say that developed lands have the largest per-acre loading rate of phosphorus and so developers need to reduce their phosphorus loads first. Both statements are true to a point. But we all use the products from farms, many of us live in homes or rely on businesses that operate in developed lands and most of us recreate in the forestlands of Vermont. Thus, the solution to reducing phosphorus loading to Lake

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78. Neely Law et al., *Nitrogen Input from Residential Lawn Care Practices in Suburban Watersheds in Baltimore County, MD*, 47 J. ENVTL. PLAN. & MGMT. 737, 738 (2004); Duy Khiem Ly & Ting Fong May Chui, *Modeling Sewage Leakage to Surrounding Groundwater and Stormwater Drains*, 66 WATER SCI. & TECH. 2659, 2661 (2012).

79. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 47.

80. *Id.* at 19.

81. TROY ET AL., supra note 73, at 87.

82. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 47.

83. *Id.*

84. *Id.* at 19.

Champlain is not just one group's responsibility. It will require substantial efforts by everyone.

V. PHOSPHORUS AND FUTURE FOR LAKE CHAMPLAIN

As detailed elsewhere in this issue, Vermont will have to substantially reduce the total loading of phosphorus to Lake Champlain if we hope to control the unsightly and potentially dangerous algal blooms that now occur during most summers.[85] But "Vermont" is not a single entity that can be neatly managed. Vermont is composed of economic sectors, municipalities, neighborhoods, and individual property owners, each of whom is responsible—directly or indirectly—for some portion of the phosphorus that enters Lake Champlain. It is understandable that many people assume that their actions cannot possibly be important because the portion of the total phosphorus load for which they are responsible is infinitesimally small. It is interesting to note that there are about 600,000 people who live in the Lake Champlain basin.[86] If each person contributes about three-quarters of a pound of phosphorus each year, the sum is about 231 metric tons/year, the amount by which EPA has concluded that we need to reduce phosphorus loading.[87] Thus, if everyone committed to using just twelve ounces less phosphorus per year, we could reduce phosphorus loading to the target amount.

But, assuming we could do this, it is important to realize that we will not see an immediate improvement in lake water quality. Phosphorus is different from carbon and nitrogen in several respects. One important difference is that carbon and nitrogen can be converted naturally by microbes into forms that are volatile gases, which dissipate into the atmosphere.[88] Indeed, this process of volatilization renews these gas stocks in the atmosphere and allows the carbon and nitrogen cycles to persist.[89]

Phosphorus is different in that it has no volatile phase.[90] As a consequence, any new phosphorus that we bring into the Lake Champlain Basin will stay in the basin unless it is exported. It is true that a small amount of phosphorus leaks out each year via the Richelieu River and

85. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 7.

86. *Lake and Basin Facts*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-the-basin/facts/ [https://perma.cc/5VRY-VFL8] (last visited Mar. 30, 2015).

87. U.S. ENVTL. PROT. AGENCY, *supra* note 6.

88. Fowler et al., *supra* note 52, at 5–6.

89. *Id.* It is worth noting that we have created imbalances in these cycles to, which is leading to global warming.

90. Smil, *supra* note 4, at 56, 61.

discharges to the St. Lawrence River.[91] But the majority of the phosphorus stays in the basin.[92] If that phosphorus stayed where it was used, we would have fewer problems with Lake Champlain. However, Lake Champlain is the lowest point of the basin. It is the receptacle that is the final resting place of sediment and phosphorus that drains from our entire landscape and travels down our rivers. It may take decades, centuries, or millennia, but much of the phosphorus that we use on fields, lawns, parks, gardens, and in the food we eat will eventually end up in the lake. If the sources of that phosphorus were originally from outside the basin, the total burden of phosphorus to the Lake Champlain Basin and, eventually, Lake Champlain will increase.

Fortunately, most of the phosphorus that settles into the sediments of Lake Champlain is buried.[93] In fact, the majority of the annual phosphorus load to the lake is simply buried and never has a chance to affect algal production.[94] This sediment phosphorus eventually becomes a part of the geological cycle of rock formation and weathering.[95] However, there is a store of phosphorus in the near-surface—active sediments of Lake Champlain that could continue to fuel algal production for decades, even without additional phosphorus inputs from rivers.[96] This is certainly discouraging news, but it should also reinforce our commitment to clean up the lake. Specifically, armed with this knowledge, it is clear that we have to commit to this clean up over the long haul. It is a certainty that we will expend great effort and considerable resources to reduce the phosphorus loading to Lake Champlain. We should not be discouraged if we see little immediate benefit in terms of reduced algal blooms. In time, we should begin to see positive results. However, this lag may be longer than the current planning horizon for Vermont Act 64,[97] or for the EPA TMDL.[98] Understanding why phosphorus behaves the way it does will hopefully reinforce our commitment to implement the hard changes needed to return Lake Champlain to a condition that supports all of our economic, recreational, and spiritual needs.

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91. Eric Smeltzer & Scott Quinn, *A Phosphorus Budget, Model, and Load Reduction Strategy for Lake Champlain*, 12 LAKE & RESERVOIR MGMT. 381, 383–84 (1996).

92. *Id.* at 384.

93. *Id*. at 389.

94. Eric Smeltzer et al., *Environmental Change in Lake Champlain Revealed by Long-Term Monitoring*, 38 J. GREAT LAKES RES. 6, 14–16 (2012).

95. Smil, *supra* note 4, at 80.

96. Donald W. Meals et al., *Lag Time in Water Quality Response to Best Management Practices: A Review*, 39 J. ENVTL. QUALITY 85, 89 (2010).

97. 2015 Vt. Acts & Resolves 309,710.

98. U.S. ENVTL. PROT. AGENCY, *supra* note 6, at 55–56.

CYANOBACTERIA AND HUMAN HEALTH CONCERNS ON LAKE CHAMPLAIN

Angela Shambaugh[1]

INTRODUCTION

Cyanobacteria, common photosynthetic organisms found around the world, pose a human health risk because of the possibility that they may produce toxins. The proliferation of cyanobacteria directly impacts drinking water usage and recreational activities in surface waters. Over the last decade, a strong relationship among academia, state agencies, a local environmental organization, and the regional Champlain management organization has increased local knowledge and capacity to respond to the presence of these organisms in the lake. Reducing the number, extent and intensity of cyanobacteria blooms is a priority of state water quality management activities, outlined in detail by the Champlain Total Maximum Daily Load ("TMDL"), the Phase I Implementation Plan, and the Vermont Clean Water Act.

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1. Angela Shambaugh has worked as an aquatic biologist for the Watershed Management Division at the Vermont Department of Environmental Conservation since 2004. She coordinates the cyanobacteria monitoring program on Lake Champlain and has more than twenty-five years of experience in the fields of phytoplankton ecology and water quality. Views expressed in this paper reflect the views of the author only and do not necessarily represent the policies of the State of Vermont.

Cyanobacteria are important components of ecosystems. Previously called blue-green algae, these highly adaptable bacteria are found in all environments, aquatic and terrestrial, from the equator to the poles.[2] One of the oldest organisms on Earth, geologic and genetic evidence has shown that cyanobacteria were the first organisms to evolve the ability to photosynthesize, a process which dramatically reshaped life on Earth and eventually resulted in the oxygen-dominated atmosphere now present.[3] Cyanobacteria also have an important role in nitrogen cycling, particularly in extreme environments such as deserts and polar regions where this nutrient is in short supply.[4] There is increasing interest in using cyanobacteria to naturally enhance agricultural productivity.[5]

In aquatic environments, cyanobacteria can grow profusely, producing masses of floating scum and discoloring the water.[6] These masses, commonly known as blooms, deter recreational activities, disrupt water supplies, and impact other aquatic organisms when oxygen levels drop in response to the large quantity of biomass.[7] Fish kills are a common occurrence during intense cyanobacteria blooms when oxygen levels can drop significantly.[8] Some species of cyanobacteria can also produce potent toxins and it is this aspect of cyanobacteria ecology which has raised awareness of these organisms in recent years. Blooms have moved beyond being an unsightly nuisance to become potential health risks. There are no federal regulations outlining response to cyanobacteria blooms and jurisdictions across the country have developed individual approaches, ranging from no response to closing entire lakes to public recreation and drinking water use.

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2. Hans W. Paerl et al., *Cyanobacterial—Bacterial Mat Consortia: Examining the Functional Unit of Microbial Survival and Growth in Extreme Environments*, 2 ENVTL. MICROBIOLOGY 11, 11–12 (2000).

3. Armen Y. Mulkidjanian et al., *The Cyanobacterial Genome Core and the Origin of Photosynthesis*, 103 PROC. NAT'L ACAD. SCI. 13,126, 13,129 (2006).

4. *See generally* Thulani P. Makhalanyane et al., *Ecology and Biogeochemistry of Cyanobacteria in Soils, Permafrost, Aquatic and Cryptic Polar Habitats*, 24 BIODIVERSITY & CONSERVATION 819 (2015) (describing the role cyanobacteria play in extreme environments).

5. *See generally* Jay Shankar Singh, *Efficient Soil Microorganisms: A New Dimension for Sustainable Agriculture and Environmental Development*, 140 ARGIC., ECOSYSTEMS & ENV'T 339 (2011) (describing how sustainable agriculture can keep up with agricultural needs while remaining environmentally friendly and safe).

6. Hans W. Paerl et al., *Harmful Freshwater Algal Blooms, with an Emphasis on Cyanobacteria*, 1 SCI. WORLD 76, 78 (2001).

7. *Id.* at 76.

8. *Id.* at 102.

On Lake Champlain, cyanobacteria have been observed in the plankton community since the 1930s.[9] Pigment markers in sediment cores from St. Albans and Missisquoi Bay document their presence in pre-colonial times and earlier.[10] These organisms are natural and native components of the Lake Champlain ecosystem. Blooms have been documented in some locations on Lake Champlain for many years. Saint Albans Bay, in particular, has experienced blooms since at least the late 1960s.[11] Cyanobacteria have been abundant in Missisquoi Bay since the early 1990s.[12] The Main Lake has also experienced blooms periodically since that time.[13]

Cyanobacteria proliferate in nutrient-rich waters and it is in these areas of Lake Champlain—Missisquoi and St. Albans Bays—where extensive intense blooms regularly occur and persist.[14] Here, waters become increasingly discolored and turbid as the cyanobacteria population grows over the summer. Under low wind conditions, or in protected areas, thick layers of cyanobacteria form at the water surface. The result is a carpet of green, blue, and occasionally, white scum at the water's surface, which may extend for miles on a calm sunny day.[15] Though they vary in magnitude each year, blooms on Champlain's nutrient-rich bays are present during much of August and into September.[16] While other areas of the lake may occasionally experience dense scums, it is the northern bays where cyanotoxins periodically exceed recreational guidelines.[17]

I. CYANOBACTERIA TOXINS

Cyanobacteria are known to produce a variety of potent toxins. There is currently no clear understanding of the role these have in the life cycle of

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9. *See* Suzanne N. Levine et. al., *The Eutrophication of Lake Champlain's Northeastern Arm: Insights From Paleolimnological Analyses*, J. GREAT LAKES RES. 35, 42 (2012) (explaining algal abundance from 1600 in Missisquoi Bay).

10. *Id.*

11. *Id.* at 36.

12. *See* Angela Shambaugh, *Historical Phytoplankton Densities At Missisquoi Bay, Station 50* 1 (Vt. Dep't Envtl. Conservation, Draft, 2008) (stating that long-term monitoring of Missisquoi Bay began in 1992).

13. *Id.*

14. ANGELA SHAMBAUGH ET AL., CYANOBACTERIA MONITORING ON LAKE CHAMPLAIN SUMMER 2014 5 (2015), http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/lp_Cyanobacteria2014.pdf.

15. *Cyanobacteria: Blue-Green Algae*, VT. DEP'T OF HEALTH, http://www.healthvermont.gov/enviro/bg_algae/bgalgae.aspx (last visited Apr. 7, 2016).

16. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATORS REPORT 13 (2015).

17. *Id.*

cyanobacteria.[18] Not all are capable of toxin production and the ability is not shared by all taxa within a genus. Toxin production can also be turned on and off by the cells.[19] There is no visible indication that toxins are present and blooms may contain a mixture of toxic and non-toxic cells.[20] As a result, all blooms must be considered potentially toxic.[21]

Cyanotoxins affect vital organs throughout the body.[22] The hepatotoxins (microcystin, cylindrospermopsin, and nodularin) may damage the liver.[23] The neurotoxins (anatoxin, neosaxitoxin, saxitoxin) affect the nervous system.[24] Beta-Methylamino-L-alanine ("BMAA") has been linked to neurological disease such as Lou Gehrig's Disease (also know as "ALS") and Parkinson's disease.[25] Dermatoxins (lyngbyatoxin, aplysiatoxins, and lipopolysaccharides) may cause severe skin rashes and gastrointestinal distress.[26] Several cyanotoxins are likely tumor-promoters and possible carcinogens.[27] Exposure to these compounds can cause illness, sometimes severe, in mammals. Dogs are especially susceptible, with numerous deaths attributed to cyanotoxins each year in the U.S.[28] Livestock and wildlife deaths are reported periodically.[29]

People are also susceptible to cyanobacterial toxins, though attributing illness to cyanobacteria exposure can be difficult. Symptoms experienced

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18. Timothy G. Otten & Hans W. Paerl, *Health Effects of Toxic Cyanobacteria in U.S. Drinking and Recreational Waters: Our Current Understanding and Proposed Direction*, WATER AND HEALTH 75, 75 (2015).

19. *Id.* at 76.

20. *Id.* at 80–81.

21. *Id.* (explaining that it is difficult to consider an organism safe for consumption "when we know so little about it"); TOXIC CYANOBACTERIA IN WATER: A GUIDE TO THEIR PUBLIC HEALTH CONSEQUENCES, MONITORING AND MANAGEMENT ¶ 3.1 (Ingrid Chorus & Jamie Bartram eds., 1999).

22. TOXIC CYANOBACTERIA IN WATER, *supra* note 22, ¶ 3.1.1; *see generally* LESLEY D'ANGLADA ET AL., ENVTL. PROT. AGENCY, HEALTH EFFECTS SUPPORT DOCUMENT FOR CYANOBACTERIAL TOXIN MICROCYSTINS (2015) [hereinafter EPA MICROCYSTINS EFFECTS]; LESLEY D'ANGLADA ET AL., ENVTL. PROT. AGENCY, HEALTH EFFECTS SUPPORT DOCUMENT FOR CYANOBACTERIAL TOXIN CYLINDROSPERMOPSIN (2015) [hereinafter EPA CYLINDROSPERMOPSIN EFFECTS]; LESLEY D'ANGLADA ET AL., ENVTL. PROT. AGENCY, HEALTH EFFECTS SUPPORT DOCUMENT FOR CYANOBACTERIAL TOXIN ANATOXIN-A (2015) [hereinafter EPA ANATOXIN-A EFFECTS] (each report provides an analysis of the effects of the specific cyanotoxin on human health); U.S. GEOLOGICAL SURVEY, GUIDELINES FOR DESIGN AND SAMPLING FOR CYANOBACTERIAL TOXIN AND TASTE-AND-ORDER STUDIES IN LAKES AND RESERVOIRS 8 (2008), http://pubs.usgs.gov/sir/2008/5038/pdf/SIR2008-5038.pdf [hereinafter USGS GUIDELINES].

23. USGS GUIDELINES *supra,* note 22, at 8.

24. *Id.*

25. *Id.*

26. *Id.*

27. *Id.*

28. Lorraine C. Backer et al., *Canine Cyanotoxin Poisonings in the United States (1920s-2012): Review of Suspected and Confirmed Cases from Three Data Sources*, 5 TOXINS 1,597, 1,597–98 (2013).

29. *Id.* at 1,598.

may not be reported to a physician or may be misdiagnosed.[30] Human illness associated with cyanobacteria has been reported from around the world since the 1930s.[31] Though human deaths have occurred after exposure,[32] such cases are rare. More commonly, exposure results in skin, gastrointestinal, or respiratory symptoms. On Lake Champlain, a study conducted on Missisquoi Bay found residents experienced minor gastrointestinal and respiratory illnesses after exposure to cyanobacteria through drinking water and recreational activities.[33] No severe human illness associated with cyanobacteria exposure on Lake Champlain has been reported to date.

Analytical methods to detect cyanotoxins range in sensitivity and length of time required to complete the analysis. Liquid chromatography/mass spectrometry ("LC/MS") methods provide the most sensitive options.[34] Understanding of the complexity and variety of toxins—microcystin currently has more than 100 known variants[35]—is gained primarily through these methods. However, equipment is costly, requires highly trained staff, and typically needs at least 24 hours before results become available.[36] Methods are specific to individual toxins, requiring multiple tests to determine which toxins may be present in a bloom.

Rapid enzyme-linked immunosorbent assay ("ELISA") techniques have become the most common test used to inform recreational and drinking water response to the presence of cyanotoxins.[37] The method is comparatively inexpensive and results can be available in minutes (the dip-stick approach) or hours (the multi-well plate approach). ELISA currently are available for microcystin, cylindrospermopsin, nodularins, anatoxin, and BMAA.[38]

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30. Lorraine C. Backer et al., *Cyanobacteria and Algae Blooms: Review of Health and Environmental Data from the Harmful Algal Bloom-Related Illness Surveillance System (HABISS) 2007-2011*, 7 TOXINS 1,048, 1,055 (2015).

31. TOXIC CYANOBACTERIA IN WATER, supra note 22, ¶ 4.1.1.

32. *Id.*; San M.F.O. Azevedo et al., *Human Intoxication By Microcystins During Renal Dialysis Treatment in Caruaru – Brazil*, 181 TOXICOLOGY 441, 442 (2002).

33. Benoît Lévesque et al., *Prospective Study of Acute Health Effects in Relation to Exposure to Cyanobacteria*, 466–67 SCI. TOTAL ENV'T 397, 398, 401–02 (2014).

34. EPA MICROCYSTINS EFFECTS, *supra* note 22, at 26.

35. *Id.* at xii.

36. USGS GUIDELINES, *supra* note 22, at 9.

37. *Id.* at 8–9.

38. *Id.* at 8.

II. FACTORS ENCOURAGING THE GROWTH OF CYANOBACTERIA

Cyanobacteria are highly successful organisms, as their presence on Earth for millennia and in some of the most extreme environments can attest. In particular, they have several ecological strategies that allow them to proliferate and dominate in aquatic ecosystems, particularly those that are highly nutrient-enriched. These include buoyancy regulation, tolerance of elevated temperature, nitrogen fixation, and protection from oxidative stress.

Many cyanobacteria can form gas vacuoles within their cells and control their position in the water column in response to environmental conditions, particularly in stable, calm waters.[39] This allows cyanobacteria to remain at the water surface or at depths that are suitable for maximum photosynthesis.[40] Buoyancy can also change in response to cell nutrient status, with some taxa such as *Microcystis* descending to the sediment surface in shallow waters to obtain nutrients that may be lacking in the surface waters,[41] then rising again for optimal photosynthesis. Dense accumulations at the surface shade out competitors, both other algae and rooted aquatic plants.[42]

Cyanobacteria grow under a wide range of temperatures. Though some taxa are capable of strong growth in winter conditions, highest densities typically occur in mid- to late summer on Lake Champlain.[43] On Missisquoi Bay, blooms are most likely to occur once water temperatures reach 68° F.[44]

Reactive compounds, such as hydrogen peroxide, form when dissolved organic carbons are broken down under the high light intensities found at the water's surface and can be readily absorbed into cells.[45] Recent studies suggest that microcystin may have a role in protecting cyanobacteria cells

39. Aharon Oren, *Cyanobacteria: Biology, Ecology and Evolution*, *in* CYANOBACTERIA: AN ECONOMIC PERSPECTIVE 10 (Naveen Sharma, Ashwani Rai & Lucas Stahl eds. 2014); Hans W. Paerl & Timothy G. Otten, *Harmful Cyanobacterial Blooms: Causes, Consequences, and Controls*, 65 ENVTL. MICROBIOLOGY 995, 999 (2013).

40. Oren, *supra* note 39, at 10; *Harmful Cyanobacterial Blooms*, *supra* note 39, at 999.

41. *See generally* Justin D. Brookes & George G. Ganf, *Variations in the Buoyancy Response of Microcystis Aeruginosa To Nitrogen, Phosphorus and Light*, 23 J. PLANKTON RES. 1399, 1407–09 (2001) (explaining responses in buoyancy of microcystis to limitations in resources).

42. *Id.*

43. *See* SHAMBAUGH, *supra* note 14, at 2 (documenting the highest concentration of mircosystin in August).

44. Nathalie Fortin, *Toxic Cyanobacterial Bloom Triggers in Missisquoi Bay, Lake Champlain, as Determined by Next-Generation Sequencing and Quantitative PCR*, 5 LIFE 1,346, 1,366 (2015).

45. *Harmful Cyanobacterial Blooms*, *supra* note 39, at 1,002.

from these stressors, enabling them to survive the harsh conditions present in prolonged surface blooms[46] and providing a competitive advantage.[47]

Nutrients play a pivotal role in determining community composition and abundance of phytoplankton.[48] Phytoplankton can only grow to the extent that vital nutrients are available, either dissolved in the water or released from organic matter as it decomposes.[49] In the aquatic environment, the concentration of phosphorus—the essential nutrient in shortest supply—and differences among phytoplankton taxa in their ability to use available forms, regulates the density and composition of the phytoplankton community.[50] As phosphorus concentrations increase, more biomass is supported and growth continues until another limitation—often of nitrogen—occurs. Many cyanobacteria, e.g. *Anabaena,* are capable of nitrogen fixation, which enables them to utilize gaseous nitrogen present in the water.[51] Others have evolved cellular processes that enable them to use different forms of nitrogen in the water more efficiently, influencing community structure.[52] Current research suggests the dominance of cyanobacteria in eutrophic systems is an outcome of the co-limitation of phosphorus and nitrogen.[53]

Finally, cyanobacteria are resistant to grazing pressure from zooplankton, mussels, and fish.[54] It may be physically difficult for zooplankton to capture and consume large gelatinous colonies and long filamentous forms.[55] Cyanobacteria may be less palatable and therefore actively avoided by zebra mussels.[56] They may also be resistant to digestion

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46. Yvonne Zilliges et al., *The Cyanobacterial Hepatotoxin Microcystin Binds to Proteins and Increased the Fitness of Microcystis Under Oxidative Stress Conditions*, 6 PUB. LIBR. SCI. ONE 1, 8 (2011).

47. Hans W. Paerl & Timothy G. Otten, *Blooms Bite the Hand that Feeds Them*, 342 ENVTL. SCI. 433, 434 (2013).

48. C.S. REYNOLDS, THE ECOLOGY OF PHYTOPLANKTON 362–363 (2006).

49. William B. Bowden, *Background Facts: Role of Phosphorus in Lake Champlain Pollution*, *supra* p. 506.

50. *Id.* at 365.

51. M.B. Allen & Daniel Arnon, *Studies on Nitrogen-Fixing Blue-Green Algae. I. Growth and Nitrogen Fixation by Anabaena Cylindrica Lemm*, 30 PLANT PHYSIOLOGY 366, 366 (1955).

52. *See generally* Marie-Eve Monchamp et al., *Nitrogen Forms Influence Microcystin Concentration and Composition via Changes in Cyanobacterial Community Structure*, 9 PUB. LIBR. SCI. ONE 1 (2014) (indicating that some cyanobacteria cells have evolved to use nitrogen from waters).

53. *Harmful Cyanobacterial Blooms*, *supra* note 39, at 1,004.

54. Orlando Sarnelle, *Initial Conditions Mediate the Interaction Between Daphinia and Bloo-Forming Cyanobacteria*, 52 AM. SOC'Y LIMNOLOGY & OCEANOGRAPHY 2,120, 2,120 (2007).

55. Alan E. Wilson et al., *Effects of Cyanobacterial Toxicity and Morphology on the Population Growth of Freshwater Zooplankton: Meta-Analyses of Laboratory Experiments*, 51 AM. SOC'Y LIMNOLOGY & OCEANOGRAPHY 1,915, 1,916 (2006).

56. Henry A. Vanderploeg et al., *Zebra Mussel (Dreissena Polymorpha) Selective Filtration Promoted Toxic Microcystic Blooms in Saginaw Bay (Lake Huron) and Lake Erie*, 58 CAN. J. FISHERIES & AQUATIC SCI. 1,208, 1,218 (2001).

and may absorb nutrients as they pass through the gut.[57] Their ability to grow rapidly may also overwhelm the available consumers and limit the ability of the zooplankton to control cyanobacteria density.[58] Cyanotoxins may inhibit zooplankton growth.[59]

III. ECOSYSTEM AND HUMAN IMPACTS

Under low nutrient conditions, cyanobacteria often pass unnoticed. The annual transition from diatom-dominated communities in early spring to cyanobacteria dominance during the warmer stratified period and back to diatom domination after fall turnover[60] typically causes little change in visual appearance. As nutrient concentrations increase, blooms of cyanobacteria may become more common. Blooms of other phytoplankton, e.g., diatoms or green algae, also may occur but do not form the surface scums characteristic of many cyanobacteria.[61] Water clarity can be greatly reduced, which decreases swimming activity. Beaches may be closed. Boating activities can also be curtailed by blooms due to odors and the risk of inhaling water droplets containing cyanobacteria.[62] Fishing activity is generally not restricted during cyanobacteria blooms, but public health officials often recommend removing the skin, discarding the entrails, and washing fillets before consumption as a precaution.[63] The frequency and intensity of cyanobacteria blooms increases with rising nutrient concentrations.[64]

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57. *Phosphorus Uptake by Microcystis During Passage Through Fish Guts*, 48 AM. SOC'Y LIMNOLOGY & OCEANOGRAPHY 2,392, 2,394 (2003).

58. Francis Chan, *Bloom Formation in Heterocystic Nitrogen-Fixing Cyanobacteria: The Dependence on Colony Size and Zooplankton Grazing*, 49 AM. SOC'Y LIMNOLOGY & OCEANOGRAPHY 2,171, 2,176 (2004).

59. Lars-Anders Hansson et al., *Cyanobacterial Chemical Warfare Affects Zooplankton Community Composition*, 52 FRESHWATER BIOLOGY 1,290, 1,291 (2007).

60. Water density changes with water temperature. As water is warmed by sunlight, density changes and results in the formation of distinct layers of water which do not readily mix, a phenomenon known as stratification. As sunlight decreases in the fall, water temperatures become more similar in density and increasing winds can break down stratification. At these times, lake water from top to bottom mixes readily, even in lakes as large and deep as Champlain. The period is known as fall turnover. For further discussion of stratification and turnover, see ROBERT G. WETZEL, LIMINOLOGY: LAKE AND RIVER ECOSYSTEMS (3d ed. 2001).

61. *Id.* at 334–35.

62. *See* Lorraine C. Backer et al., *Recreational Exposure to Microcystins During Algal Blooms in Two California Lakes*, TOXICON 1 (2009) (concluding that recreational activities on water bodies with blooms can generate "aerosolized cyanotoxins, making inhalation a possible route of exposure").

63. *Health and Ecological Effects*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/nutrient-policy-data/health-and-ecological-effects (last updated Mar. 4, 2016).

64. *Harmful Cyanobacterial Blooms*, *supra* note 39, at 1,004.

Drinking water facilities may also be impacted by the presence of cyanobacteria. Approximately 145,000 people consume water from Lake Champlain for drinking.[65] In Vermont alone, twenty-three private and public supplies draw water from Lake Champlain.[66] Intake structures and treatment train and purification activities directly influence the extent to which a facility may be impacted by the presence of cyanobacteria and cyanotoxins.[67] The Vermont Drinking Water and Groundwater Protection Division works closely with operators around Lake Champlain who proactively monitor surface conditions, change treatment processes in response to the density of cyanobacteria and algae, and test for the presence of cyanobacteria toxins when conditions warrant.[68]

Beach closures due to cyanobacteria occur each summer in parts of Lake Champlain.[69] Fish kills due to low oxygen conditions have occurred on Missisquoi Bay, as have mussel die-offs.[70] There have been no recent detections of cyanobacteria toxins in finished drinking water provided by facilities in Vermont.[71] In Quebec, drinking water facilities on the northern shores of Missisquoi Bay have altered their treatment train in response to the annual presence of intense scums and detectable toxin concentrations.[72]

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65. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATORS REPORT 16 (2015).

66. *Id.*

67. ENVTL. PROT. AGENCY, RECOMMENDATIONS FOR PUBLIC WATER SYSTEMS TO MANAGE CYANOTOXINS IN DRINKING WATER 5–6 (2015); GAYLE NEWCOMBE ET AL., MANAGEMENT STRATEGIES FOR CYANOBACTERIA (BLUE-GREEN ALGAE): A GUIDE FOR WATER UTILITIES iv (2010), http://www.waterra.com.au/publications/document-search/?download=106.

68. *Cyanobacteria: Blue-Green Algae*, VT. DEP'T OF HEALTH, http://www.healthvermont.gov/enviro/bg_algae/bgalgae.aspx#monitor (last visited June 16, 2016).

69. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 65, at 12.

70. Elissa Schuett, *Blue-Green Algae Kills Thousands of Fish in Missisquoi Bay*, VT. WATER RESOURCES & LAKE STUDIES CTR. (Aug. 27, 2012), https://www.uvm.edu/rsenr/vtwater/?Page=news&storyID=14222&category=vwrlsc.

71. Kathryn Flagg, *Public Water Systems Watch for Toxic Algae in Lake Champlain*, SEVEN DAYS (Aug. 13, 2014), http://www.sevendaysvt.com/vermont/public-water-systems-watch-for-toxic-algae-in-lake-champlain/Content?oid=2416816; *see* VT. DEP'T OF ENVTL. CONSERVATION, PROCESS FOR MANAGING ANATOXIN, CYLINDROSPERMOPSIN, AND MICROCYSTIN IN RAW AND FINISHED WATER SAMPLES FOR PUBLIC WATER SYSTEMS 2 (2015), http://drinkingwater.vt.gov/wqmonitoring/pdf/FINAL_CYANOPRACTICE2015.pdf (outlining the recommended cyanotoxin testing procedures for Lake Champlain) [hereinafter PROCESS FOR MANAGING ANATOXIN] *Cyanobacteria: Blue-Green Algae*, *supra* note 68 (providing links to the results of the weekly testing done of drinking water intakes in Lake Champlain over the 2015 summer for cyanotoxins).

72. *See generally* Arash Zamyadi et al., *Application of in Vivo Measurements for the Management of Cyanobacteria Breakthrough into Drinking Water Treatment Plants*, 16 ENVTL. SCI: PROCESSES & IMPACTS 313 (2014) (describing the recommended interventions developed by the Canadian Ministry of Environment to manage the increased presence of cyanobacteria in drinking water sources).

IV. REGULATORY RESPONSIBILITY

Prior to 2015, there were no federal or state regulations outlining response to cyanobacteria blooms or cyanotoxins. Before the early 2000s, most public health officials in the Northeast were not aware of the health risks associated with blooms, though blooms did occur. With the development of ELISA in the late 1990s, testing of recreational and drinking water sources increased, documenting the frequent occurrence of some cyanotoxins, particularly microcystin, in surface waters around the country.[73] Without a common standard response, jurisdictions developed their own approach to the protection of public health during cyanobacteria blooms, often in crisis mode when they realized that the bloom on their shoreline might be highly toxic. Guidance from the Centers for Disease Control ("CDC") and the World Health Organization[74] provided valuable information, but was used inconsistently in developing response protocols around the country. The general public, who could not recognize cyanobacteria blooms, were confused and highly concerned when cyanobacteria were confirmed in surface waters close to home.

At the time of the 1999 bloom in the Burlington area, there were no cyanobacteria response plans for Lake Champlain. State officials in Vermont and New York provided guidance, but responsibility to put closures and drinking water bans in place belonged to the towns. Early on, many towns in Vermont and New York did not to respond to cyanobacteria blooms in their recreational waters. In Quebec, however, closures occurred more frequently.[75] The result was a piecemeal approach to cyanobacteria response where closures occurred on the Canadian side of the border but guidance was infrequently publicized on the U.S. side.

With the development of the Lake Champlain Cyanobacteria Monitoring Program (discussed below), a uniform and regular source of data supported state and provincial officials as they developed response protocols for public beach managers. Communication between the states

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73. Jennifer L. Graham, *Environmental Factors Influencing Microcystin Distribution and Concentration in the Midwestern United States*, 38 WATER RES. 4,395, 4,397 (2004); *see generally* John R. Beaver et al., *Land Use Patterns, Ecoregion, and Microcystin Relationships in U.S. Lakes and Reservoirs: A Preliminary Evaluation*, 36 HARMFUL ALGAE 57 (2014) (showing the patterns of microcystins now after testing has increased).

74. *See generally* WORLD HEALTH ORG., GUIDELINES FOR SAFE RECREATIONAL WATER ENVIRONMENTS, VOLUME 1: COASTAL AND FRESH WATERS ix, xix (2003), http://apps.who.int/iris/bitstream/10665/42591/1/9241545801.pdf (providing guidelines "intended to be used as the basis for the development of international and national approaches" to deal with health risks from cyanobacteria and other dangerous aquatic organisms).

75. *See Cyanobacteria (Blue-Green Algae)*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/human-health/cyanobacteria/ (last visited Apr. 20, 2016).

and Quebec improved as a result of the monitoring program. Though guidance protocols have commonalities, the three major jurisdictions each maintain their own thresholds triggering public health response.[76] While authority to close beaches still remains with towns in most cases, when blooms are suspected, state and provincial officials contact town health officials and local beach managers directly with information and materials to guide a consistent response.[77]

Drinking water response also varies among the jurisdictions. In Vermont, the Department of Health ("VDH") and the Department of Environmental Conservation ("DEC") worked with Champlain drinking water operators to establish a voluntary cyanobacteria response practice in 2007, one of the first in the country.[78] Operators receive weekly email updates and guidance about using this information in daily operations. In 2015, VDH and DEC facilitated the weekly testing of both raw and finish water at all twenty-three Vermont facilities on Champlain.[79] They also assisted smaller facilities with development of cyanobacteria response plans.

In June 2015, the EPA released guidelines outlining monitoring, analysis, and response to cyanobacteria in drinking water sources[80] for two cyanobacterial toxins: microcystin and cylindrospermopsin. Mandatory testing was not required; but in December, EPA issued proposed revisions to the Unregulated Contaminant Monitoring Rule ("UCMR 4") for Public Water Systems, which includes a monitoring design to gather more information on ten cyanobacteria toxins.[81] All water systems serving more than 10,000 people will be required to participate in short-term monitoring

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76. *Blue-Green Algae and Health*, N.Y. DEP'T OF HEALTH, http://www.health.ny.gov/environmental/water/drinking/bluegreenalgae/ (last updated Feb. 2016); *see* QUEBEC DÉVELOPPEMENT DURABLE, LA GESTION DES ÉPISODES: DE FLEURS D'EAU D'ALGUES BLEU-VERT 1 (2014), http://www.mddelcc.gouv.qc.ca/eau/algues-bv/outil-gestion/gestion-episodes.pdf (indicating when Canadian province's public health response thresholds are triggered); VT. DEP'T OF ENVTL. CONSERVATION, CYANOBACTERIA (BLUE-GREEN ALGAE) GUIDANCE FOR VERMONT COMMUNITIES 13 (2015), http://www.healthvermont.gov/enviro/bg_algae/documents/BGA_guide.pdf.

77. CYANOBACTERIA (BLUE-GREEN ALGAE) GUIDANCE FOR VERMONT COMMUNITIES 13-14, *supra* note 75.

78. PROCESS FOR MANAGING ANATOXIN, *supra* note 71, at 1.

79. *Cyanobacteria: Blue-Green Algae*, *supra* note 68; *see generally What's New*, VT. RURAL WATER ASS'N, http://www.vtruralwater.org (last updated Apr. 3, 2016) (explaining how the Vermont Rural Water Association combats and prevents more water pollution of drinking water in Vermont).

80. *Guidelines and Recommendations*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations#what2 (last updated Mar. 15, 2016).

81. *Monitoring Unregulated Drinking Water Contaminant: Fourth Unregulated Contaminant Monitoring Rule*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/dwucmr/fourth-unregulated-contaminant-monitoring-rule (last updated Dec. 16, 2015).

beginning in 2018.[82] Eight hundred smaller systems will be randomly selected for participation.[83]

V. THE RECENT HISTORY OF CYANOBACTERIA AND MONITORING ON LAKE CHAMPLAIN

During a bloom on the Main Lake in 1999 and again in 2000, several dog deaths were attributed to cyanobacteria toxins on Lake Champlain.[84] The occurrence of toxins in lake water was shocking to the general public and generated apprehension about recreation on the lake. Vermont public health officials turned to scientists at the University of Vermont's School of Natural Resources ("UVM," now the Rubenstein School of Environment and Natural Resources) and the SUNY College of Environmental Science and Forestry ("SUNY-CESF") for assistance developing a response to that first bloom.

Little was known about cyanobacteria populations on Lake Champlain at that time and even less about their toxins. Resources in the Champlain Basin were, however, uniquely poised to respond. The Lake Champlain Basin Program ("LCBP") had funded a water quality monitoring program at more than a dozen sites around the lake since 1992 to support development and implementation of the Champlain TMDL.[85] UVM had the technical expertise in phytoplankton identification. With financial backing from the LCBP and support from DEC field staff, UVM developed and implemented a monitoring program within two years.[86] In 2003, a local NGO, the Lake Champlain Committee ("LCC"), joined the partnership, recruiting the first citizen volunteers to assist with monitoring.[87] UVM, LCC volunteers, and DEC field staff collected weekly samples and assessed bloom severity. Data from the program were shared with state and local health officials through weekly email summaries, individual alerts, and annual reports.

The earlier years of the program focused on developing protocols using cell counts and toxin analyses. Selected stations were monitored at weekly intervals and response actions were triggered when cell counts and/or

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82. *Id.*

83. *Id.*

84. Gregory L. Boyer et al., *The Occurrence of Cyanobacterial Toxins in Lake Champlain*, *in* LAKE CHAMPLAIN: PARTNERSHIP AND RESEARCH IN THE NEW MILLENNIUM 241, 255 (T. Manley et al. eds., 2004).

85. *Monitoring Programs*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/data-monitoring/monitoring-programs/ (last visited Apr. 10, 2016).

86. Author's personal knowledge.

87. *Monitoring Programs*, *supra* note 85.

microcystin concentrations exceeded threshold levels.[88] Budget and time constraints limited the number of stations monitored, but the data distributed through the email list and alert notifications provided valuable information for other locations around the lake.[89] UVM also offered training and guidance materials about cyanobacteria to drinking water operators and public beach managers.

As the monitoring program matured and awareness of the health concerns associated with cyanobacteria increased around the basin, a visual protocol[90] was developed in 2012 to complement the quantitative protocols and provide a mechanism for the general public to evaluate conditions whenever they were on the water.[91] With assistance from volunteers recruited and trained by LCC, the Champlain cyanobacteria monitoring program now monitors more than eighty sites around the lake annually, using both qualitative and quantitative protocols.[92]

The monitoring data show that cyanobacteria are present throughout the lake each summer, typically appearing in mid- to late June and persisting through October in some locations. Several potentially toxic taxa are present during much of the summer, most commonly *Anabaena*, *Microcystis*, and *Aphanizomenon*. In much of the lake, these taxa rarely reach levels of concern and blooms are also rare. In the northern shallow bays and shoreline locations, however, blooms are frequent and often contain microcystin. On occasion, concentrations exceed guidelines established by the jurisdictional authority.

Monitoring also documents the rapid appearance and disappearance of blooms. Many cyanobacteria have the ability to regulate their buoyancy in response to environmental conditions, primarily light to support photosynthesis. On calm, sunny days, or in protected locations, cyanobacteria can rise to the surface and accumulate there in a matter of hours. These are small organisms, however, and no match for water currents. With a change in wind direction or wave strength, they can be mixed back into the water column in a matter of minutes. As a result,

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88. Mary C. Watzin et al., *Application of the WHO Alert Level Framework to Cyanobacterial Monitoring of Lake Champlain, Vermont*, 21 ENVTL. TOXICOLOGY 278, 279 (2006).

89. *Id.* at 280.

90. The Lake Champlain Committee's current volunteer materials can be viewed at *Blue-Green Algae Monitor*, LAKE CHAMPLAIN COMM., http://www.lakechamplaincommittee.org/get-involved/volunteers/bgamonitors/ (last visited Mar. 30, 2016).

91. ANGELA SHAMBAUGH ET AL., CYANOBACTERIA MONITORING ON LAKE CHAMPLAIN, SUMMER 2012: FINAL REPORT FOR THE LAKE CHAMPLAIN BASIN PROGRAM (2013), https://anrweb.vt.gov/PubDocs/DEC/WSMD/lakes/docs/lp_Cyanobacteria2012.pdf.

92. SHAMBAUGH, *supra* note 14, at 2.

conditions at monitored locations frequently change, making communication about the location and extent of blooms difficult.

The intensity, composition, and location of blooms vary annually.[93] Cyanobacteria proliferate each summer in nutrient-rich St. Albans and Missisquoi Bays, but annual median cell density range widely at long-term monitoring sites.[94] The worst conditions are typically observed in late summer and blooms in these bays can persist for weeks.[95] Cyanobacteria are also common in the nutrient-rich South Lake, but blooms are rarely reported from that area.[96] Blooms do occur periodically on the Main Lake and can affect large areas under the right environmental conditions.[97] In contrast to the northern bays, blooms on the Main Lake occur primarily in early summer and typically disappear within a few days.[98] Consistently around the lake, the most intense blooms and highest cell densities occur along shorelines and in protected downwind bays.[99]

Toxin analyses detect the presence of microcystin at multiple locations in Missisquoi Bay each summer.[100] Microcystin is documented less frequently on St. Albans Bay and rarely in the Main Lake.[101] Concentrations vary greatly between locations and among years. Highest concentrations of microcystin are typically on Missisquoi Bay.[102] Anatoxin is detected infrequently.[103] Periodic testing has not detected the presence of any other cyanotoxins to date.

Data from stations that have been monitored consistently since 2003, when the program began, indicate that overall cyanobacteria conditions were worse prior to 2007 on Missisquoi and St. Albans Bays.[104] Median cell densities since 2007 have decreased and some locations have also experienced a decrease in the number of blooms observed during the summer.[105] Changes in the monitoring program and the influence of local

93. *See id.* at 39–40 (depicting the mean density of cyanobacteria in Missisquoi and St. Albans Bay from 2003 to 2014).

94. *Id.* at 41.

95. *Cyanobacteria in Vermont: What Causes Blooms and Scums?*, VT. DEP'T OF ENVTL. CONSERVATION, http://www.watershedmanagement.vt.gov/lakes/htm/lp_cyano_what_causes_blooms.htm (last visited Apr. 8, 2016).

96. *Id.* at 19.

97. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 65, at 2.

98. *Cyanobacteria in Vermont: What Causes Blooms and Scums?*, *supra* note 95.

99. LAKE CHAMPLAIN BASIN PROGRAM, *supra* note 65, at 13.

100. SHAMBAUGH, *supra* note 14, at 18–19.

101. *Id.* at 14.

102. *Id.* at 13.

103. *Id.* at 2.

104. *Id.* at 41.

105. *Id.*

environmental conditions on bloom formation make it difficult to identify trends in more recent years.

Since 2012, when the visual protocol was developed, more than ninety percent of the reports submitted each summer document good conditions on Lake Champlain (Figure 1). Blooms continue to be reported each year from locations around the lake, however, and public outreach remains a key component of the monitoring effort. In addition to the weekly updates to public health officials and drinking water suppliers, a tracking map has been developed by the Vermont Department of Health which provides updates to the general public in near real-time.[106] Though water conditions can change rapidly at a given location, the qualitative observations and quantitative data collected by the monitoring program provide a common and consistent source of information to support public health officials and inform the general public about lake conditions.

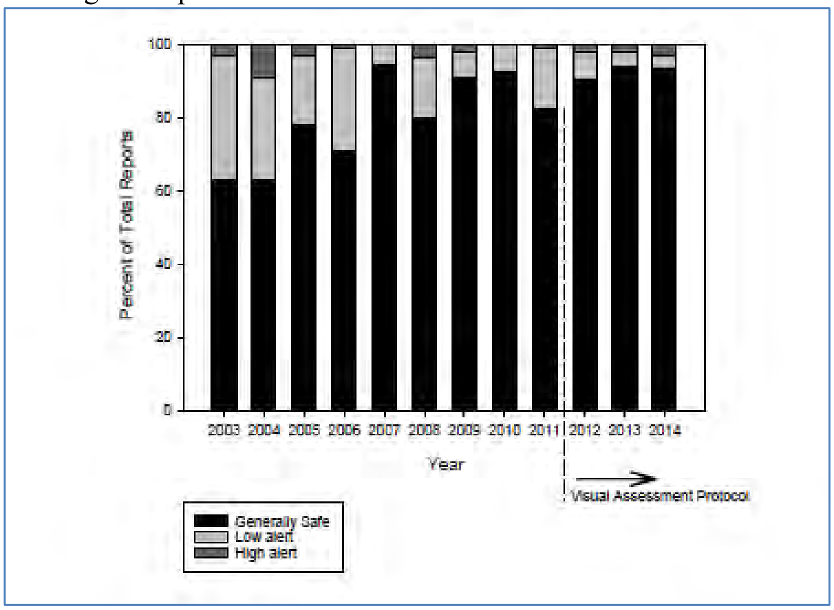

Figure 1. Cyanobacteria status reports Lake Champlain by category, percent of total reports received. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included. From Shambaugh et al. *supra* note 14.

106. *Vermont Blue Green Algae Tracker*, VT. OF DEP'T HEALTH, https://apps.health.vermont.gov/gis/vttracking/bluegreenalgae/d/ (last visited Apr. 6, 2016).

The use of a qualitative visual system in conjunction with a traditional quantitative monitoring program has enabled the Lake Champlain cyanobacteria monitoring program to cover a much larger geographic area than was possible for the qualitative program alone. In 2015, the program received more than one hundred reports each week during July.[107] With support from the VDH, volunteer monitoring expanded to two additional Vermont lakes and more than ninety percent of the reports during the summer were provided by LCC volunteers.[108] This very successful partnership between state agencies, local NGOs, and citizen volunteers has increased awareness of the potential health concerns associated with cyanobacteria and understanding of the environmental conditions that support their growth.

VI. REDUCING THE OCCURRENCE OF BLOOMS ON LAKE CHAMPLAIN AND OTHER VERMONT WATERS

Phytoplankton are integral to aquatic ecosystems from Lake Champlain to small ponds. Human activities on the land have increased the rate at which nutrients are deposited in lakes, thereby increasing the growth potential of phytoplankton. Blooms—rapid and dense growth by a single class of phytoplankton—are a natural response to abundant nutrients and a specific set of environmental conditions. Lake Champlain and other Vermont waters experience annual blooms of diatoms, green algae, and cyanobacteria. Blooms of cyanobacteria, however, pose a human health risk and may have direct impacts on drinking water production and recreational activities.

Reduction of blooms is accomplished by eliminating the environmental conditions allowing a particular group of phytoplankton to outcompete other groups for common resources. Cyanobacteria gain competitive advantage through their ability to regulate buoyancy, tolerate the high light intensity and conditions present at the water surface, and circumvent nitrogen limitation in phosphorus-rich environments. Management options to eliminate the competitive advantage conferred by buoyancy and adaptation to life at the water surface are limited for a waterbody the size of Lake Champlain. Such options also do not address the underlying causes of cyanobacteria dominance—the essentially unlimited availability of the key

107. *See Vermont Blue-Green Algae (Cyanobacteria) Tracker*, VT. DEP'T OF HEALTH (June-Oct. 2015), https://apps.health.vermont.gov/gis/vttracking/BlueGreenAlgae/2015Summary/ (download the 2015 summary data to see each individual report).

108. *Id.*

growth-limiting nutrient phosphorus and the increasing availability of nitrogen.

Decreasing the amount of phosphorus reaching Lake Champlain and other surface waters in the basin will limit the amount of overall biomass that can be produced by cyanobacteria and other phytoplankton. Increasing recognition of the role of nitrogen in promoting cyanobacteria growth and toxicity suggests that adoption of a dual-nutrient strategy may be necessary.[109] Elimination of cyanobacteria from Vermont's water is not possible, nor is it prudent given the important ecological roles these organisms have in the environment. Reducing the flow of nutrients into surface waters through the management approaches outlined in the Lake Champlain TMDL and the Vermont Clean Water Act will reduce the competitive edge cyanobacteria have, increase the diversity of phytoplankton communities, and reduce the risk of exposure to cyanobacterial toxins.

Future lake management will need to consider the impacts of climate change on cyanobacteria growth.[110] Under current climate change scenarios, increased water temperatures and longer growing seasons are expected, conditions which are likely to enhance cyanobacteria growth in Lake Champlain.[111] Stormwater inputs to surface water, with their high nutrient load, are expected to increase with more intensive rainfall events. Longer dry periods may lead to increased evaporation, resulting in concentration of nutrients within waterbodies. Reduction of nutrients is a key strategy to increase resiliency and protect Vermont's surface waters for changes, which may lie ahead.

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109. EPA ANATOXIN-A EFFECTS, *supra* note 22, at 6–7.

110. C. Gombault, *Impacts of Climate Change on Nutrient Losses from the Pike River Watershed of Southern Quebec*, 95 CAN. J. SOIL SCI. 337, 339 (2015); *see generally* Hans W. Paerl & Valerie J. Paul, *Climate Change: Links To Global Expansion of Harmful Cyanobacteria*, 47 WATER RES. 1,349 (explaining how the global expansion of harmful bacteria is linked to climate change).

111. *See* J. CURT STAGER & MARY THILL, CLIMATE CHANGE IN THE CHAMPLAIN BASIN: WHAT NATURAL RESOURCE MANAGERS CAN EXPECT AND DO 17, 19 (2010), http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/vermont/what-we-do/champlain-climate-report-5-2010-2.pdf.

THE LAKE CHAMPLAIN BASIN AS A COMPLEX ADAPTIVE SYSTEM: INSIGHTS FROM THE RESEARCH ON ADAPTATION TO CLIMATE CHANGE ("RACC") PROJECT

Christopher Koliba, Asim Zia, Andrew Schroth, Arne Bomblies, Judy Van Houten, and Donna Rizzo[1]

INTRODUCTION

Like all large, freshwater lake systems situated within a populated region, the Lake Champlain Basin ("LCB") is a decidedly "social ecological system," meaning that human activity has altered the ecosystem through human land use decisions, development patterns, infrastructure, and water management practices to the extent that we may no longer consider ecosystems as divorced from human influence and impact.

Likewise, as paleoclimatological studies have shown, the Earth's climate (heating and cooling cycles, precipitation patterns, and extreme

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weather events) has directly shaped landscapes and ecosystems and often dictated societies' land use and land management decisions.[2] As the climate changes, it has been the case that landscapes, ecosystems, and human actions are intertwined and adapt in response to one another.

By viewing the LCB as a social ecological system that is adapting in response to climate change, watershed planners can better anticipate the region's water quality challenges. Without managing this adaptation, acceleration in the decline of water quality in the LCB is likely. This article draws on the transdisciplinary research project undertaken by a team of Vermont scientists and students to study and model aspects of the LCB as a complex adaptive system comprising climatological, terrestrial, aquatic, and human components (including public and private social behaviors, land use decisions, and policy and governance responses to water quality needs). We will highlight the activities and some of the preliminary results to emerge from the early stages of the National Science Foundation funded Research on Adaptation to Climate Change ("RACC") project. With a goal to inform the "adaptive management" of the LCB's watersheds, we will also discuss implications of the RACC project for addressing critical policy challenges facing the region.

I. WHY THINK OF THE LAKE CHAMPLAIN BASIN AS A COMPLEX SOCIAL ECOLOGICAL SYSTEM?

Lake Champlain is the largest lake in the northeastern United States after the Great Lakes. It lies between the states of Vermont and New York and the province of Quebec, Canada to the north. It is 170 km long and at its broadest point it is 20 km wide. It has a maximum depth of 122 m, a mean depth of 23 m, and considerable variation in trophic status and morphology across its extent. The LCB, shared by Vermont, New York, and Quebec, has a land to water ratio of almost 19:1, making water quality in the lake intimately tied to activities on the land.

Some shallow embayments of Lake Champlain, like many freshwater ecosystems around the world, have experienced rapid eutrophication; phosphorus control is a major focus of management with concentrations ranging from 10 µg/L (micrograms per liter or parts per billion) in Burlington Bay to 100 µg/L in Missiquoi Bay. Because municipal point-source treatment has been upgraded throughout the basin, almost 90% of the current phosphorus load is nonpoint source. In Section 303(d) of the

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2. *See generally* BRIAN FAGAN, THE LONG SUMMER: HOW CLIMATE CHANGED CIVILIZATION (2004) (arguing that changes in climate have shaped societies throughout history).

Clean Water Act, the United States Environmental Protection Agency ("EPA") requires all states to identify waters that are "impaired"—that is, which do not meet the state water quality standards.[3] Once identified, states must analyze and set Total Maximum Daily Load ("TMDL") targets for each pollutant to the water body.

As noted elsewhere in this volume, the State of Vermont has worked to develop a comprehensive TMDL plan for the LCB. Over the last fifteen years, multi-million dollar investments have been made to improve water quality in Lake Champlain and eliminate the algal blooms that impact human and animal health and deter tourists. However, despite the best efforts of many agencies and individuals, these water quality goals have not been achieved in most segments of Lake Champlain, as phosphorus concentrations are either increasing or remaining relatively constant, even with significant implementation of and resource allocation toward phosphorus loading reduction schemes across portions of the LCB.[4]

The LCB is a social-ecological system, composed of both biophysical and social components in which human-derived institutional infrastructure (mixed public and private sector governance arrangements), built infrastructure (road, bridges, treatment of storm, drinking, and wastewater), and economic systems (markets) have inserted themselves into the dynamic structures of biophysical systems to "the extent that the latter have, in the true sense of the word, become socio-ecological."[5] Humans have "homogenized parts of their environment in order to bring [biophysical] dynamics under control," as in the cultivation of land for food production, river corridor management practices, timber harvesting, development of impervious surface, and more. According to Oren Young et al., the survival of social ecological-systems becomes increasingly "dependent on the resilience of their social dynamics in contrast to their purely biophysical dynamics."[6] In other words, the future of social ecological systems is deeply impacted by the decisions that humans make. Human actors living on Vermont's landscape have, for many generations, indelibly altered the landscape and, therefore, Lake Champlain itself. The accumulation of centuries of land use has contributed to the current water quality challenges faced within the LCB.

From the 1700s to the early 1800s, almost eighty percent of the land in

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3. 33 U.S.C. §1313(a) (2012).

4. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATORS REPORT 6, 11 (2015), http://sol.lcbp.org/images/State-of-the-Lake_2015.pdf [https://perma.cc/R7WD-WA9G] [hereinafter STATE OF THE LAKE].

5. Oran R. Young et al., *The Globalization of Socio-Ecological Systems: An Agenda for Scientific Research*. 16 GLOBAL ENVTL. CHANGE 304, 306.

6. *Id.*

what is now the State of Vermont was cleared for agriculture and pasture, leading to a huge increase in sediment inputs to streams and rivers. These trends have resulted in a legacy of increased sediment that resides today in terraces and deltas throughout Vermont watersheds and associated receiving lake and pond sedimentary deposits. During and after the Great Depression, some Vermonters abandoned their farmland to head west and much of the landscape reverted to early successional forest. Today, the land in the LCB is about sixty-five percent forested, with the remaining land primarily in dairy-related agriculture (cow herds and corn and hay rotation) and growing residential and commercial development.[7]

One of the major consequences of human action upon the landscape is the production of nonpoint source pollution and transport of excessive nutrient (e.g., phosphorus and nitrogen) loadings to receiving waters. As has been discussed extensively in this volume, the consequences of excessive nutrient loading include the potential for eutrophication of freshwater lakes like Lake Champlain. The sources of nutrient loading have been well documented in studies of the region[8] and include stormwater runoff from developed land where impervious surfaces and spread of fertilizers on lawns, institutional and commercial property, and recreational green spaces contribute to phosphorus and nitrogen loading into local receiving water bodies. Streambank erosion, logging activities, roadway runoff, and wastewater treamtment accounts for other sources of nutrient loading. Agricultural land use practices combined with poor nutrient management practices, such as excessive fertilizer application, often contribute to a substantial portion of the nutrient loading in certain regions. The sheer number and variation of nonpoint sources pose serious challenges to those concerned about water quality.

In the parlance of planning and complexity science, nonpoint source water pollution is a "wicked problem" because of the complex interactions of social, ecological, and climatological factors that contribute to the problem. With such a wide range of sources and complicated consequences, the framing of nonpoint source pollution as a problem involving many different social actors contributes to competing views around the definition of the problem (e.g., the sources) and mitigation strategies, giving rise to a range of policy preferences and strategies considered.[9] Competing views on

7. AUSTIN TROY ET AL., UPDATING THE LAKE CHAMPLAIN BASIN LAND USE DATA TO IMPROVE PREDICTION OF PHOSPHORUS LOADING 18 (2007), https://www.uvm.edu/giee/pubpdfs/Troy_2007_Lake_Champlain_Basin_Program.pdf [https://perma.cc/U7M4-2AKP].

8. *See* STATE OF THE LAKE, *supra* note 4, at 8–10 (describing the various sources of nutrient loading into Lake Champlain).

9. JOHN W. KINGDON, AGENDAS, ALTERNATIVES, AND PUBLIC POLICIES (1984).

both the nature of problems and intended solutions often lead to "trade-off" or zero-sum considerations. These trade-offs are often framed as being between environmental and economic considerations, pitting costs of managing nonpoint pollution by government institutions, private land owners, businesses, and taxpayers against the anticipated environmental and social benefits of alleviating the problem through specific investments of political and financial capital.

The critical question driving the wickedness of nonpoint pollution is "Who is responsible for causing it?" By definition, nonpoint pollution sources are "nonpoint" because the pollution does not flow from a pipe or other similarly specific, non-distributed source. Monitoring and modeling at the appropriate watershed- and basin-wide scales can, in fact, generate fairly effective estimates of the general sources of nonpoint pollution. But attempting to pin-point specific sources leads to high levels of uncertainty that constrain planning horizons, assignment of accountability, and the political willingness to regulate land use decisions. The use of water sensors and advanced isotopic tracing may possibly play a role in narrowing down the exact sources of nonpoint pollution, but this capacity is still likely a ways off.

To add complication, the impacts of nonpoint pollution are likely driven by significant time lags and legacies of sediment that persist across the system.[10] It may take years and even decades for the cumulative impacts of nonpoint pollution to take effect and manifest as algal blooms in the region's bays.

Adding to the challenge of managing nonpoint pollution is anticipating the impact that climate change may have on adding to the intractability of the problems. RACC research is suggesting that increased temperatures and persistent storm events in northeastern U.S.[11] caused by climate change will likely contribute to the exacerbation of algal blooms.[12] The climate of the Lake Champlain Basin has warmed by 2.1°F since 1976; precipitation has increased by 3 inches over 8 decades; ice rarely covers the main lake anymore and the "freeze up" is delayed 2 weeks compared to the late

10. *See* Peter D.F. Isles et al., *Dynamic Internal Drivers of a Historically Severe Cyanobacteria Bloom in Lake Champlain Revealed Through Comprehensive Monitoring*, 41 J. OF GREAT LAKES RES. 818, 828 (2015) (concluding that historical loading is a key factor responsible for eutrophic conditions).

11. Justin Guilbert et al., *Impacts of Projected Climate Change over the Lake Champlain Basin in Vermont*, 53 J. APPLIED METEOROLOGY & CLIMATOLOGY 1861 (2014).

12. Asim Zia et al., Climate and Land Use Change Induced Transformations Across a River-Lake Continuum: Insights from an Integrated Assessment Model of Lake Champlain's Missisquoi Bay, 2000-2040, 3 (2015) (unpublished manuscript) (submitted to Environmental Research Letters and on file with Vermont Journal of Environmental Law).

1800s; and precipitation is increasingly in the form of rain delivered through extreme weather events.[13] The snow pack in the watershed and ice cover on rivers and lakes has similarly changed.[14] The results of RACC statistical climate downscaling modeling[15] anticipates further warming, rising surface water temperatures, more rain, and severe weather through the rest of the century, even in the event that greenhouse gas emissions are reduced.

A recent Intergovernmental Panel on Climate Change ("IPCC") report highlights the necessity of an integrated adaptive management approach to risk and resilience.[16] The recent National Climate Assessment echoed the grand challenge of resilience to extreme events induced by climate change: "Climate change, combined with other stressors, is overwhelming the capacity of ecosystems to buffer the impacts from extreme events."[17] "Increasing resilience and enhancing adaptive capacity provide opportunities to strengthen water resources management and plan for climate change impacts."[18]

The impacts of climate change on water quality and the resultant tangible environmental consequences for nonpoint pollution likely hinges on the choices land users and owners make regarding land use management and land cover decisions (e.g., cutting forests to develop crops, implementation of soil management approaches, utilization of cropping techniques, investments in stormwater infrastructure, etc.). Given the large role that human agency brings to land use decision making, perhaps the most critical questions for water planners concern the persistent jurisdictional knots that compound the problem. Persistent questions are asked but rarely resolved, at least to the satisfaction of key stakeholders. These questions include: "Who is responsible for addressing the causes of nonpoint pollution?"; "How do we balance individual and collective property rights?"; "What are the appropriate intergovernmental programmatic and governance designs that can facilitate a transition from a culture of nutrient waste management to sustainability and resilience?"; and

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13. Guilbert et al., *supra* note 11.

14. *Id.*

15. *Id.*

16. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY (Martin Parry et al. eds.,2007)

17. PETER M. G. CHAPTER 8: ECOSYSTEMS, BIODIVERSITY, AND ECOSYSTEM SERVICES 196, 217 (2014), http://nca2014.globalchange.gov/report/sectors/ecosystems [https://perma.cc/9YGJ-N3E2] (click "Download" in the top corner of the page to download a static PDF of the report chapter).

18. ARIS GEORGAKAKOS ET AL., CLIMATE CHANGE IMPACTS IN THE UNITED STATES: CHAPTER 3: WATER RESOURCES 70 (2014), http://nca2014.globalchange.gov/report/sectors/water [https://perma.cc/MDE6-BJKQ] (click "Download" in the top corner of the page to download a static PDF of the report chapter).

"What are the ideal strategies to incentivize and shape sound water quality-friendly land use, development, infrastructure, and related decisions?"

The conclusion to draw from this description of the causes and consequences of nonpoint pollution within social-ecological systems like the LCB is that we are dealing with a complex and adaptive system. Wicked problems like those stemming from nonpoint pollution require systems-level views of the relationship between the terrestrial, aquatic, climatological, and social aspects of the system.

A recent National Science Foundation ("NSF") solicitation describes a complex system as one in which individual organisms (or agents) can respond and adapt to changes in their environment, self-organize, and spontaneously reorganize in response to changing conditions. Despite the diverse nature of complexity in physical, biological, social, and engineered systems, there are universal principles, process abstractions, and systems-thinking methodologies that unify the study of complex systems.[19] The essential properties of complex systems (e.g., emergence, scaling phenomena and mechanisms, robustness, adaptability, collective dynamics, complex network characteristics, tipping points and phase transitions, alternate stable states, and selection to the edge-of-chaos) may be studied, modeled, and understood using complex adaptive systems approaches.

The rise of computational power allows us to capture and advance our theories and methods for studying and understanding the relationships between surface water flow and land use, societal governance arrangements and the public policies they create and implement. This understanding can then be extended to policy makers and planners through an "adaptive management" approach.

Adaptive management is a systematic process for improving management policies and practices by learning from the outcomes of management strategies implemented using a systems-level focus.[20] The ideal of adaptive management is to use the tools and findings from the natural and social sciences to inform long-term strategic planning and decision making.

RACC was designed to inform the adaptive management of the LCB. In the next section we provide a basic conceptual architecture used by RACC to describe the LCB as a complex adaptive system and consider

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19. *See generally* JOHN H. MILLER & SCOTT E. PAGE, COMPLEX ADAPTIVE SYSTEMS: AN INTRODUCTION TO COMPUTATIONAL MODELS OF SOCIAL LIFE (2007) (exploring various methods of modeling complex systems).

20. Claudia Pahl-Wostl, *The Importance of Social Learning in Restoring the Multifunctionality of Rivers and Floodplains*, 11 ECOLOGY & SOC'Y (2006), http://www.ecologyandsociety.org/vol11/iss1/art10/ [https://perma.cc/X6FH-QSL8].

some ways that systems-level perspectives can be generated for policy makers and other stakeholders.

II. HOW CLIMATE CHANGE, HYDROLOGICAL SYSTEMS, TERRESTRIAL SYSTEMS HUMAN BEHAVIOR, LAND USE PATTERNS, AND POLICY DECISIONS AND TOOLS ARE CONCEIVED IN RACC

In 2012, the Vermont Experimental Program to Stimulate Competitive Research ("VT EPSCoR") applied for and obtained a multi-million dollar grant from NSF to undertake a transdisciplinary research project designed to study, model, and help inform solutions to nonpoint source pollution in the Vermont portion of the LCB, with a deeper focus on the Missisquoi and Winooski watersheds. Through RACC, VT EPSCoR has built critical laboratory facilities[21] and environmental observatory networks for the Lake and its watersheds, created transdisciplinary research teams that integrate complex systems modeling across all research spheres, and drawn investigators together from many Vermont institutions and the private sector. Through RACC, transdisciplinary teams of social and natural scientists from the University of Vermont, Middlebury College, St. Michael's College, and Johnson State College collaborated to address fundamental, hypothesis-driven research questions: How will the interactions of climate change and land use alter hydrological processes and nutrient transport from the landscape, internal processing, and eutrophic state within the lake, and what are the implications for adaptive management strategies?

To provide an overview of the major sub-questions guiding the RACC project, we provide some detail of the major themes and areas of work undertaken to address them. The Question 1 or "Q1" team is organized around studying the *in-lake* processes impacting lake eutrophication. The Question 2 or "Q2" team is organized around studying the *to-lake* process unfolding at the interface between the terrestrial and aquatic systems. The Question 3 or "Q3" team is focused on the *social, policy, and governance* processes in place that impact land use and land management decisions and practices. The models developed by the three question teams are linked together through an integrated assessment model ("IAM"). Members of all three teams participate in the planning, design, and use of the IAM to generate basic and applied science findings. Recognizing that climate change has already impacted the LCB social-ecological system, another

21. For example, one such lab is Social Ecological Gaming and Simulation Lab. *SEGS Mission*, SEGS LAB, http://www.uvm.edu/~segs/segs_mission [https://perma.cc/NU39-V4RG] (last visited July 23, 2016).

team of researchers has downscaled climate model output for the LCB. A brief overview of the RACC scope of work and major sub-questions is provided.

A. Monitoring and Modeling the Interaction Between In-Lake Processes

RACC Question 1: What is the relative importance of endogenous in-lake processes (e.g. internal loading, ice cover, hydrodynamics) versus exogenous to-lake processes (e.g. land use change, snow/rain timing, storm frequency and intensity, land management) to lake eutrophication and algal blooms?

The *in-lake*, Q1 team focuses on advanced biogeochemical and hydrodynamic monitoring and modeling of Missisquoi Bay and its watershed to address Question 1 and contribute to addressing the overarching RACC research question. The basic premise driving the *in-lake* research is that the historical loading of nutrients (primarily phosphorus from the Missisquoi River) has ultimately driven the Bay to a eutrophic state, allowing harmful algal blooms occur on a regular basis in the summer; yet, it is unclear to what extent the severity of the blooms is driven by watershed or internal lake processes. Furthermore, it is unknown how both internal and external drivers of nutrient loading and associated harmful algal blooms will evolve under changing climate and land use-management scenarios projected/envisioned for the LCB and how this will be manifest in lake water quality and algal bloom dynamics. To accomplish our research aims, we developed a process-based biogeochemical and hydrodynamic model that can be embedded in the larger integrated assessment model that in turn will simulate watershed, land use, and governance dynamics across the basin, allowing us to project the impact of both climate change and adaptive management over time on Missisquoi Bay water quality and algal dynamics.[22] To achieve this aim, the Q1 team developed an advanced

22. To be able to answer Question 1 and develop a model that accurately simulates the drivers of water quality and algal blooms, it is essential to have enough data over time and space that spans critical variables or parameters that drive the system. To accomplish this, Q1 researchers deployed sensors and automated water sample collection units in both Missisquoi Bay and its watershed that were coupled with manual sampling campaigns. In the bay, sensors were deployed to study its physics, chemistry, and ecology at relatively high frequency—a measurement is taken every half hour or hour depending on the sensor. Physical sensors measured water movement (velocity and direction), sediment transport, water temperature and level, and wave height and period. These sensors were distributed across the bay so that we could understand how water and sediment move within the bay. Additionally, sensors were used to monitor the weather affecting the bay with measurements such as wind speed, orientation, air temperature, and relative humidity. At one location in the bay, selected by the team because it was representative of the average depth of the bay and was in a region where algal blooms

monitoring observatory to collect high frequency environmental monitoring data in both the watershed and the bay. These data are then used to develop an advanced physical-ecological-biogeochemical process-based model of Missisquoi Bay to quantify, analyze, and understand the drivers of nutrient and bloom dynamics in the current system, which can be embedded in the larger IAM. This model can then be used in conjunction with other model components outlined in additional sections of this article to address our hypotheses related to existing lake drivers of blooms and water quality and also likely impacts of climate change and opportunities for adaptive management that may suppress nutrient loading and bloom activity in the face of climate change.

Missisquoi Bay is an ideal site to study the relationship between internal and external drivers of nutrient loading and algal blooms. The large (1000 km^2) watershed is heavily impacted by nonpoint source pollution of phosphorus and nitrate, the excessive loading of which have caused eutrophication in this system. Indeed, analysis of sediment cores collected in this bay confirm that the onset of eutrophication in the bay coincides

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were frequently observed, the team deployed a biogeochemical monitoring platform. Once an hour, a sensor moved vertically through the water column profile on a winch collecting data every half meter. This sensor unit measures pH, dissolved oxygen, chlorophyll, phycocyanin (a pigment associated with cyanobacteria), temperature, conductivity, and turbidity. These sensors are very useful for studying how the system behaves over various timescales (daily to seasonal cycles) and in response to important disturbances such as storms when manually sampling at the required frequency would be difficult due to their sporadic nature and potentially dangerous conditions. In addition to the sensors, three systems that automatically collected water samples from the platform at different depths every eight hours were deployed. Those samples were collected to measure nutrient concentrations in the bay at much higher frequency than we could manually conduct within our financial and personnel resources constraints, but likely critical to understanding and modeling nutrient dynamics in the bay. Once a week, researchers would visit the biogeochemical monitoring station and collect additional samples that were more sensitive with respect to time of collection and subsequent analyses (e.g., soluble reactive phosphorus, dissolved metals, and nitrogen species). Additionally, sediment cores would be collected each week so that we could monitor the chemical composition of the sediment and how it changed over time in response to varying conditions in the water column. In the winter, the hydrodynamic sensors remained under the ice whereas the biogeochemical platform needed to be removed, but sporadic under-ice grab sampling of water and sediment was conducted. This effort was critical because remarkably little is known about under-ice hydrodynamics and biogeochemistry, yet one of the most obvious harbingers of recent global climate change has been a decrease in the occurrence and duration of ice cover across high latitude lakes. Q1's watershed sampling focused on four sites within the Missisquoi River watershed where automated water sampling systems were deployed to quantify nutrient and sediment loading during storm events. Those efforts were supplemented with additional grab sampling to characterize baseflow and spring melt when the automatic systems were not functioning. The deployment of these monitoring networks allowed us to capture variability in internal and external processes across inter-annual, seasonal, episodic, and even sub-daily timescales. These robust and holistic time series data has enabled the research team to make both significant advances in our understanding of the basic processes in the watershed and lake that impact water quality and algal bloom development and also provide the requisite database to develop a robust model to simulate the Missisquoi Bay system and embed in the RACC IAM. The Q1 team has deployed an array of water sensors (provide details) and analyzed the life cycle of the alga; blooms in Missisquoi Bay.

with excessive nutrient loading in the Missisquoi Basin during the second half of twentieth century. Furthermore, the drivers of these nutrient loadings from the river network to the bay have already been detected generally in a trajectory that promotes more severe and continued nutrient loading.[23] For example, more severe storms (such as Tropical Storm Irene in 2011) promote erosion of the landscape and streambanks, which make them disproportionately impactful on suspended sediment and associated phosphorus loading to the lake. If storm frequency and severity continue to increase in the northeast with climate change as projected,[24] so will the concentration of phosphorous in the lake and potentially the occurrence of harmful algal blooms. Climate change and the landscape management decisions to come will likely amplify the intensity of nutrient delivery to the lake.[25]

The internal morphology and biogeochemistry of Missisquoi Bay are also thought to strongly influence the nutrient loading and bloom dynamics. Because the entire bay is relatively shallow and largely isolated from mixing with the main lake, the chemical processes occurring at the interface between the bay's sediments and water interface (the lake bottom) heavily impact water quality. In this case, the sediments of Missisquoi Bay serve as a long-term repository for phosphorus-rich sediment ("legacy P") derived from many years of erosion in the Missisquoi Basin (nonpoint source external loading of phosphorous). A large fraction of that legacy P is bound to the surface of a particular suite of minerals— iron oxyhydroxides—that are particularly sensitive to oxygen conditions in the water column. Because Missisquoi Bay is so shallow (maximum depth five meters), if conditions in the bottom of the Bay become conducive (low in oxygen) to dissolving those iron minerals that bear much of the legacy phosphorus, that phosphorus can be released and become accessible to algae populations that also need to live near the surface of the lake to convert energy via photosynthesis.[26] This is an example of internal loading of phosphorous,

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23. GUND INST. FOR ECOLOGICAL ECON. & UNIV. OF VT., VERMONT CLIMATE ASSESSMENT: CONSIDERING VERMONT'S FUTURE IN A CHANGING CLIMATE 185 (Gillian L. Galford et al. eds., 2014), http://dev.vtclimate.org/wp-content/uploads/2014/04/VCA2014_FullReport.pdf [https://perma.cc/3ABR-HBYK]; Guilbert et al., *supra* note 11.

24. Guilbert et al., *supra* note 11.; JOHN WALSH ET AL., CLIMATE CHANGE IMPACTS IN THE UNITED STATES: CHAPTER 2: OUR CHANGING CLIMATE 20 (2014), http://nca2014.globalchange.gov/report/our-changing-climate/introduction [https://perma.cc/M2KS-JVNB] (click "Download" in the top corner of the page to download a static PDF of the report chapter).

25. Sujay S. Kaushal et al., *Land Use and Climate Variability Amplify Carbon, Nutrient, and Contaminant Pulses: A Review with Management Implications*, 50 J. AM. WATER RESOURCES ASS'N 585, 588 (2014).

26. Isles et al., *supra* note 10, at 819, 825; Courtney D. Giles et al., *The Mobility of Phosphorus, Iron, and Manganese Through the Sediment–Water Continuum of a Shallow Eutrophic Freshwater Lake Under Stratified and Mixed Water-Column Conditions*, BIOGEOCHEMISTRY, 2015, at

and for this to occur, environmental conditions need to be present that would consume oxygen in the bottom water of Missisquoi Bay. These conditions include a minimal water column (prolonged thermal stratification), microorganisms that consume oxygen living in the sediment and water, and the temperature of the water and sediment.

Of course all of these drivers of internal phosphorous loading may be differentially impacted by climate change. For example, warmer temperatures could promote more stratification of the water column, which would increase internal loading of phosphorous, yet increased stormy conditions could suppress internal phosphorous loading by mixing the water column and keeping the bottom of the bay relatively well-oxygenated and iron minerals from dissolving. As a result, it becomes apparent that both extensive monitoring of internal and external processes and drivers and sophisticated holistic modeling are necessary to understand and quantify the relative importance of environmental dynamics that control water quality and algal blooms in this system and, in turn, project how climate change and management decisions will impact this complex system.

A number of other Q1-specific accomplishments have been derived from both interpretations of our Missisquoi Bay/Basin monitoring effort, and statistical modeling from the Vermont Department of Environmental Conservation ("DEC") long-term water quality monitoring dataset. For example, Isles et al. demonstrate that our first year of monitoring, 2012, was the strongest algal bloom on record for Missisquoi Bay, primarily due to the particularly hot and dry conditions of that summer that promote internal loading of phosphorous to feed the bloom.[27] Giles et al. established a conceptual model of the hydrodynamic, biogeochemical, and ecological drivers of internal phosphorous loading through analysis of both hydrodynamic and biogeochemical data from Missisquoi Bay, demonstrating how hydrodynamic conditions exert strong internal control on water quality and algal bloom development in the bay.[28] Schroth et al. established a framework for understanding the biogeochemical behavior of phosphorus and metals underneath the ice and how this might impact summer water quality and bloom dynamics, again relying on our hydrodynamic and biogeochemical monitoring data.[29] Currently, Q1 researchers are focused on interpretation of the drivers of the dramatic

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16, http://link.springer.com/content/pdf/10.1007/s10533-015-0144-x [https://perma.cc/XYN5-UT4G].

27. Isles et al., *supra* note 10, at 821–22.

28. Giles et al., *supra* note 26.

29. Andrew W. Schroth et al., *Dynamic Coupling of Iron, Manganese, and Phosphorus Behavior in Water and Sediment of Shallow Ice-Covered Eutrophic Lakes*, 49 Envtl. Sci. & Tech.. 9,758 (2015), http://pubs.acs.org/doi/pdf/10.1021/acs.est.5b02057.

inter-annual variability observed in water quality and bloom dynamics over the 2012–2015 monitoring period, as understanding the drivers of inter-annual variability is an essential, yet often overlooked, precursor to projecting impacts of climate change on many systems.

Concurrently, Q1 researchers have also been mining the historical DEC water quality dataset to learn more about the drivers of water quality across the entire lake, essentially scaling up our focus through use of existing big data. Xu et al. used those data to modify an existing EPA protocol for assessing water quality—the trophic state index—so that it relied on more powerful statistical analyses and took into account ecosystem specific variability.[30] Xu et al. used the same dataset and a similar statistical approach for development of ecosystem specific targets for nutrients in different lake segments.[31] Both of these approaches will be particularly useful to Vermont water quality managers and policy makers and elsewhere when monitoring water quality and trying to predict responses to climate/policy/land use change. Isles et al., using the same dataset, detected climate change impacts on nutrient ratios throughout Lake Champlain, and used those data to develop a conceptual model on what is driving long-term changes in nitrogen and phosphorus in the lake, and how different components of climate change impact water quality in deep and shallow segments of Lake Champlain.[32]

Some major findings from the Q1 team include fresh insights into the role that water column stability has on blue-green algae blooms and particularly the roles that winds and turbidity caused by storm mixing play in the process.[33] Additionally, the role that legacy P plays as a driver of shallow bay blue-green algae blooms is being understood.[34]

B. Modeling Terrestrial-Aquatic Systems as "To-Lake" Processes

RACC Question 2: Which alternative stable states can emerge in the watershed and lake resulting from non-linear dynamics of climate drivers, lake basin processes, social behavior, and policy decisions?

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30. Yaoyang Xu et al., *Quantile Regression Improves Models of Lake Eutrophication with Implications for Ecosystem-Specific Management*, 60 FRESHWATER BIOLOGY 1841 (2015).

31. *See* Yaoyang Xu, Andrew W. Schroth & Donna M. Rizzo, *Developing a 21st Century Framework for Lake-Specific Eutrophication Assessment Using Quantile Regression*, 13 LIMNOLOGY & OCEANOGRAPHY: METHODS 237 (2015) (using long-term water quality data to revise classic equations of tropic state indices).

32. Isles et al., *supra* note 10.

33. *See id.* at 827 (describing the effects of storms on algal blooms in Missisquoi Bay).

34. *See* Courtney D. Giles et al., *Characterization of Organic Phosphorus Form and Bioavailability in Lake Sediments*, 44 J. ENVTL. QUALITY 882 (2015) (studying the effects of nutrients from sediment on eutrophic conditions in Missisquoi Bay).

The Q2 *to-lake* team seeks to understand how changes in precipitation form (rain versus snow), persistence, and intensity as well as other climate variables interact with changing land use in the LCB watersheds to transport sediment-bound phosphorus to the lake. In addition, the Q2 team seeks to understand other physical impacts of climate change such as changes to stream geomorphic condition and other factors driving stream systems to disequilibrium. For the last two decades, there has been increased water flow and nutrient and sediment loading to Lake Champlain.[35] The human behavioral and policy-driven alterations to the watershed in the form of agricultural practice, biofuels production (including timber harvesting), and urbanization can amplify watershed runoff response to precipitation events. Denuded and cultivated landscapes will yield higher runoff, more landslides and, combined with increases in extreme precipitation events from climate change, these changes will impact stream flow regimes and associated sediment and nutrient transport. Better understanding of the relationship between streambank characteristics and sediment transport is being pursued by members of the Q2 team.[36] Tracer signature and isotopic tracing could support more "precise" policy applications.[37] With this research, it becomes possible to consider how "regime shifts" occur when one type of stream morphology and flow regime may radically switch, impacting infrastructure and ecological services. Moreover, increased sediment loading into the lake could shade the littoral zone, altering lake ecology by inhibiting sunlight. Also, vegetation patchiness can change in the watershed based on human behavioral, policy, and climate drivers, with several internal feedbacks. A regime shift from non-patchy to patchy vegetation, or vice versa, can affect productivity and erosion, with grazing, land clearing, fires, and droughts as possible drivers.[38]

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35. STATE OF THE LAKE, *supra* note 4, at 6, 10.

36. L. Borg et al., Streambank Stability Assessment Using in Situ Monitoring and Computer Modeling (under review with Earth Surface Processes and Landforms) (on file with author); S.D. Hamshaw et al., Quantifying Streambank Erosion: A Comparative Study Using an Unmanned Aerial System (UAS) and a Terrestrial Laser Scanner (2016) (in progress) (on file with author).

37. *See* Kristen Underwood, Spatial Variation in Stream Power: Application of Neural Kriging to Classify Erosional and Depositional Stream Reaches in a Globally-Conditioned Vermont Headwater Catchment (forthcoming 2016) (using tracer signature and isotopic tracing) (visit http://www.uvm.edu/~epscor/pdfFiles/2016_racc_retreat/15_Underwood%20RACC%20retreat%20Feb6.pdf [https://perma.cc/3HKT-A8RG] for a PowerPoint presentation on the forthcoming paper).

38. *See* Ibrahim N. Mohammed et al., Univ. of Vt., Coupled Dynamic Modeling to Assess Human Impact on Watershed Hydrology, Presentation at 2014 AGU Fall Meeting (Dec.15–19, 2014) (discussing various models used to simulate the impacts of land use decisions and climate change on Lake Champlain).

Much of the Q2 research has been centered on characterizing the nature of climatic changes in Vermont and the impacts on watershed hydrology. This has involved climate model downscaling to a spatial resolution that is consistent with the watershed models and as analysis of historical climate data. Climate data are used to drive watershed models that simulate the physical processes of water flowing over land, into the subsurface, and through the channel network. The models are parameterized by numerous soil, vegetation, and hydraulic field instruments.

The RACC project has performed necessary climate downscaling work to link coarse-resolution climate model output to local-level impacts, such as topographically-influenced precipitation and temperature changes. The resulting dataset is a high-resolution time series of temperature and precipitation that can be used to drive hydrology models. The RACC project has also developed watershed models to simulate the impacts of climate change on the Missisquoi and Winooski River basins, using the downscaled climate time series as inputs. Land usage, which affects land surface hydrology, changes in the model with changing management practice, and the resulting output is stream discharge and sediment and nutrient loading to the lake under various management and climate change scenarios.

The major findings of the climate downscaling elements of RACC include an increased likelihood of higher temperatures, particularly during the winter months, and increases in the duration of precipitation events during the spring melt-off season and shorter, but stronger precipitation events toward the latter summer months.[39] As a result of these changes, last and first frosts dates are likely to continue to occur earlier and later in the season, respectively. Ice cover on Lake Champlain and snow cover over the entire region are also likely to be significantly less as the century proceeds. The implications of these shifts for the nutrient loading challenges will be addressed as the RACC project proceeds.

C. Human Decisions and Behavior on Land Use, Land Cover and Land Management

RACC Question 3: In the face of uncertainties about alternate climate change scenarios, how can science-based, adaptive management interventions (e.g. regulation, incentives, treaties) be designed, valued and implemented in the multi-jurisdictional LCB?

39. Justin Guilbert et al., *Characterization of Increased Persistence and Intensity of Precipitation in the Northeastern United States*, 42 GEOPHYSICAL RES. LETTERS 1888 (2015).

The Q3 *social, policy, and governance* team is interested in understanding and modeling how human decision making and behaviors impact nonpoint pollution and the roles that public policy and institutional actors play in managing water quality for the LCB. The Q3 team views the LCB through the lens of land use, policy-making, and resource allocation. Human agents are studied and modeled at two levels: at the "ground" level as landowners and land users,[40] and at the institutional level as policy makers, resource allocators, and regulators in intergovernmental relations and governance networks.[41] To model the behaviors and decision making of land owners and users, an interactive land use transition agent based model ("ILUTABM") has been developed.[42]

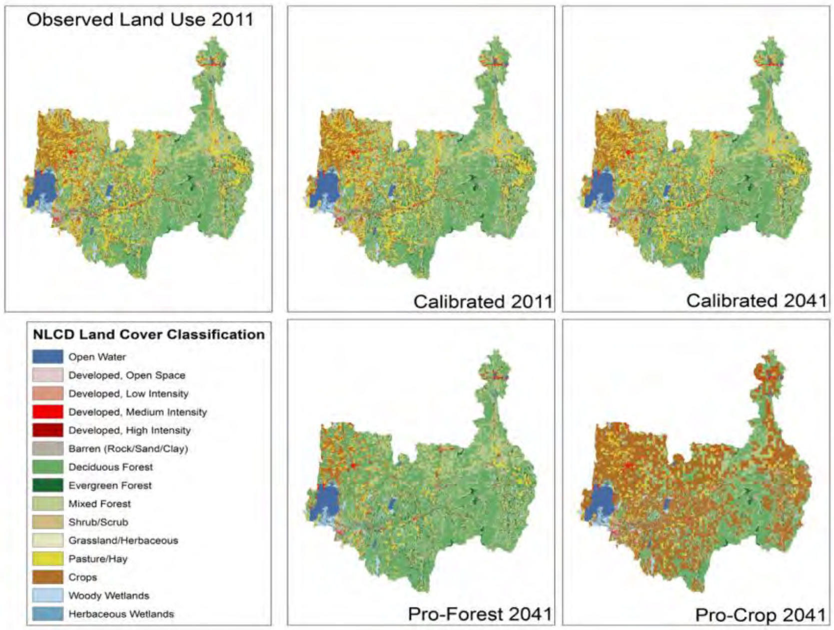
Figure yy. below depicts current (2011) land cover using NLCD Land Cover Classification categories, and several land cover scenarios (for instance: pro-forest and pro-crop scenarios) extending into 2041 as produced through the ILUTABM.

40. *See generally* Yushiou Tsai et al., *An Interactive Land Use Transition Agent-Based Model (ILUTABM): Endogenizing Human-Environment Interactions in the Western Missisquoi Watershed*, 49 LAND USE POL'Y 161 (2015) (studying human agents at the landowner level).

41. CHRIS KOLIBA ET AL., RESEARCH ON ADAPTATION TO CLIMATE CHANGE: 2013 WATER QUALITY SURVEY 2–3 (2014), http://www.uvm.edu/~epscor/pdfFiles/documents/Vermont_Water_Quality_Survey_2013_final.pdf [https://perma.cc/3SKA-DDGY]; Asim Zia & Chris Koliba, *The Emergence of Attractors Under Multi-Level Institutional Designs: Agent-Based Modeling of Intergovernmental Decision Making for Funding Transportation Projects*, 30 AI & SOC'Y 315, 315 (2013); Steve Scheinert et al., *The Shape of Watershed Governance: Locating the Boundaries of Multiplex Networks*, 2 COMPLEXITY, GOVERNANCE & NETWORKS 65 (2015).

42. Tsai et al., *supra* note 40, at 162; Asim Zia et al., Simulating Land-Use Land Cover Change (LULCC) at Watershed Scales Under Heterogeneous Policy Designs: An Agent Based Model of Missisquoi Watershed in the Lake Champlain Basin, 2000-2040, SwarmFest 2015 (July 2015) (unpublished conference paper and presentation) (on file with author) [hereinafter SwarmFest]; *see* Asim Zia et al., Experimental Simulations of Land-Use Land Cover Change (LULCC) Under Heterogeneous Policy Regimes: An Agent-Based Model of Rural-Urban Forest Interface in the Missisquoi Watershed of Lake Champlain Basin, 2000-2050, Conference on Complex Systems (2015) (abstract available at http://www.ccs2015.org/tracks/complexity-in-infrastructure-planning-environment/experimental-simulations-of-land-use-land-cover-change-lulcc-under-heterogeneous-policy-regimes-an-agent-based-model-of-rural-urban-forest-interface-in-the-missisquoi-watershed-of-lake-champlain-ba/) (on file with author) (using Agent-Based Model to simulate rural-urban-forest interface).

Figure yy. ILUTABM Simulated Land Use Scenarios (Figure adopted from Zia et al.[43]



The ILUTABM includes the decision heuristics of simulated land owners (for instance, the decision of whether to expand a farm into adjacent forests). The model developed by Tsai et al. considers how the economic conditions of farm operations impact land use patterns.[44] It also considers how the enforcement of new and existing land use laws at multiple levels of governance, such as Act 250 at the state level and zoning regulations at the local town, level impact land use patterns.[45] We have found that both the economic conditions of farms and the response of the farms to changing ecosystem service gradients (e.g., changing soil productivity conditions) are significant drivers of farmers' decisions to expand or contract the size of their farm operations.[46] Conjoint analysis studies[47] found that the minimum subsidy threshold that farmers are willing to accept for best management practice ("BMP") adoption is higher than currently being offered by Nature

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43. SwarmFest, *supra* note 42; Zia et al., *supra* note 42.
44. Tsai et al., *supra* note 40, at 166.
45. SwarmFest, *supra* note 42; Zia et al., *supra* note 42.
46. *See* Tsai et al., *supra* note 40, at 167 (using financial status to predict the likelihood that a farmer will expand operations); SwarmFest, *supra* note 42; Zia et al., *supra* note 42.
47. Jennifer Miller, Farmer Adoption of Best Management Practices Using Incentivized Conservation Programs 102 (June 6, 2014) (unpublished M.S. thesis, The University of Vermont) (on file with author).

Resource Conservation Service ("NRCS"). It is likely that increased subsidies to farmers are needed to improve the adoption of farm BMPs. We conclude that the economic conditions of famers will likely continue to play a major role in expanding or contracting the distribution patterns of land use within the LCB; however, the economic conditions of farmers are intrinsically tied to the evolution of ecosystem services across the landscape, in particular, soil health and stream protection. A novel contribution of the ILUTABM is the ability to simulate the evolution of fifteen classes of land use and land cover at watershed scales, which requires modeling the competitive land-use dynamics that occur at the cusp of rural-urban-forest interfaces.[48]

Another feature of the ILUTABM concerns the implementation of specific land use management practices. At this juncture, RACC has focused on the use of three specific agricultural BMPs: cover cropping, conservation tillage, and riparian buffer strips. To calibrate our models to historical BMP adoption rates, we have collected survey data, conducted experimental games, and undertaken comprehensive literature reviews. This analysis has led us to render the following additional conclusions about BMP adoption in the agricultural sector: (1) farmers' adoption of BMPs is most likely influenced by their perceived abilities to manage, own, and control the implementation of the BMP themselves; (2) survey data and preliminary results from experimental games suggest that prior knowledge and familiarity with BMPs are major drivers of adoption rates;[49] and (3) the influence of social pressures from peers and family members may also influence adoption rates.[50]

Data are being collected to better understand and simulate how specific incentives (in the forms of cash payments, grants, technical assistance, and tax credits) contribute to specific adoption rates of BMPs. The Q3 team has studied various farmer incentive programs and concluded that the current payment levels of programs such as NRCS's Environmental Quality Incentives Program ("EQIP") are not sufficient to ensure maximum levels of adoption. It is also likely, that there will be a decrease in the rate of adoption, suggesting an optimal return on investment after which return on income ("ROI") declines. In other words, the adoption rates of BMPs will eventually plateau or even decline as the incentive (money) is increased, in part because other factors, such as locus of control and social pressures, are also in play. The goal of these and other Q3 studies is to better understand

48. SwarmFest, *supra* note 42; Zia et al., *supra* note 42.

49. *See* Miller, *supra* note 47, at 21 (stating that knowledge about the impacts of agricultural practices affect a farmer's likelihood to adopt BMPs).

50. *Id.*

how behavioral triggers (e.g., economic, social, and psychological) contribute to land user/owner decisions. The implications for balancing financial subsidies with technical assistance programs can be derived from fine-tuning the ILUTABM to specific watersheds and sub-watersheds.

A second Q3 focus area concerns the institutional arrangements and resource investments made to mitigate nonpoint pollution. These arrangements are understood as "governance networks." [51] Governance comprises the processes and structures responsible for making critical decisions. Governance of common pool resources processes involve the resolution of trade-offs and to carrying out the implementation and evaluation phases of the policy cycle. Governance networks are the social systems that encompass multi-scale interactions, emergent behavior, pattern formation, and self-organization, and they are often inherently stochastic (operate in unpredictable ways).[52] They possess nonlinear couplings, lags, inertia and feedbacks across multiple processes and scales. They often emerge through a series of incremental policy actions that are undertaken simultaneously at the local, regional, state, provincial, national, and international levels.[53]

Figure zz (below) provides a visual representation of the water quality governance network in place for the LBC. The different planes represent levels of jurisdictional reach: national level entities like the United Stated EPA, and NRCS, and Environment Canada; Basin-wide entities established to provide coordination and focused attention on Lake Champlain, such as the Lake Champlain Basin Program ("LCBP"); state-level agencies such as the Vermont Agency of Natural Resources ("VT ANR"), Agency of Agriculture, Food and Markets ("VT AAFM"), and Vermont Agency of Transportation ("VTrans"); regional entities such as regional planning commissions and regional conservation districts; local governments and municipalities; and individual land owners and land users. These institutional and individual actors interact and impact the landscape (the base layer). The pentagon shapes represent those critical decision-making spaces where regulatory and resource allocation decisions are made. The figure does not include the wider array of advocacy groups, private firms and other stakeholders who all play a role in the region. These actors have been identified and captured in extensive institutional network analysis and intergovernmental programmatic data collected by the Q3 team.

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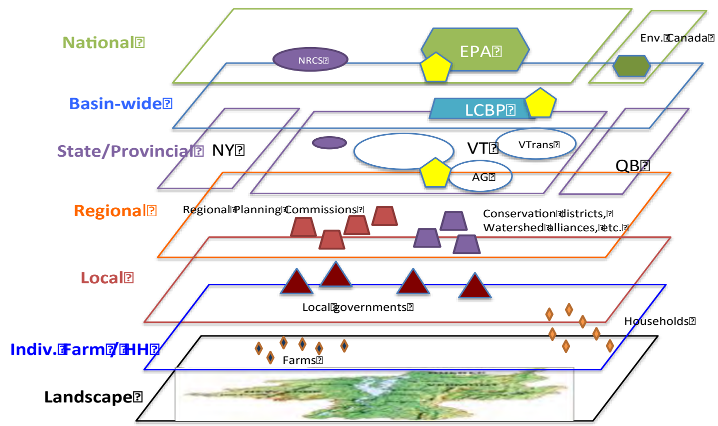
51. CHRISTOPHER KOLIBA, JACK W. MEEK & ASIM ZIA, GOVERNANCE NETWORKS IN PUBLIC ADMINISTRATION AND PUBLIC POLICY. (2010).

52. *Id.*

53. Jouni Paavola, *Institutions and Environmental Governance: A Reconceptualization*, 63 ECOLOGICAL ECON. 93, 94 (2007).

Figure zz. Water Quality Governance Configuration for the LCB



The effectiveness of particular regional watershed governance networks to enhance the health, resiliency, and adaptive capacity of regional social ecological systems varies greatly.[54] The variability in the network design, the existence of political dynamics, and the calibration of hydrological models to the prevailing economic and political realities have all been cited as challenges to drawing definitive conclusions regarding the effectiveness of these regional responses.[55] In RACC we hypothesized that ineffective watershed governance networks may drive watersheds to relatively lower-valued stable states, just as effective watershed governance networks may induce watersheds to stable states that are valued relatively higher by society and policy makers. The kind of "governance informatics" being introduced as part of this project is used to facilitate adaptive policy responses, generate social learning, foresight and situational awareness among different decision makers in the system, improve understanding of lags and inertia, and, above all, move beyond the notion of one-size-fit-all governance panaceas and policy interventions.[56]

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54. *See id.* at 100 (describing factors that influence the effectiveness of governance networks).

55. Carl Folke et al., *Adaptive Governance of Social-Ecological Systems*, 30 ANN. REV. ENVTL. RESOURCES 441 (2005); *see generally* PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS (Lance H. Gunderson & C.S. Holling eds., 2002) (seeking to develop a theory of changing systems where economic, ecological, and institutional systems all interact).

56 Christopher Koliba, Asim Zia& Brian H. Y. Lee. *Governance Informatics: Utilizing Computer Simulation Models to Manage Complex Governance Networks*, 16 INNOVATION J. ., 2011.

To date, our analysis of the LCB governance network concludes that the region possesses a large number institutional actors involved in the management of water quality for the region.[57] Planning and coordination in response to the TMDL and the LCBP "Opportunities for Action" strategic planning process draw on similar sets of institutional actors and recommendations of policy tools,[58] suggesting a relatively well-coordinated set of actors and common activities. However, as the extent of the nonpoint pollution problem is better understood and some of the intractable challenges associated with this wicked problem are more clearly defined, it is highly likely that new institutional design considerations are warranted. In the realm of transportation-land-use planning, for example, Zia and Koliba found that shifting decision making authority from state to regional planning levels *vís-a-vís* planning and prioritization of road-way projects that implicated water quality (and also related environmental impacts) may induce more equitable resource allocation across regions.[59] The work of the Q3 team to map, simulate, and posit alternative governance scenarios can provide stakeholders with opportunities to consider new watershed or bioregional arrangements, foster new "networks of innovation," and other novel-but-useful institutional arrangements. An instance of such institutional redesign has recently taken place between VT ANR and VT AAFM, in which shared staffing and tighter coordination between regulatory and technical assistance programs is found.

D. Tying It All Together: Integrated Assessment Model

The major focus of the RACC project is on the wicked problem of nutrient loading into Lake Champlain and the implications of these patterns for water quality. One unique contribution to the basic science of fresh lake nutrient loading problems accomplished by RACC is pioneering methods to wrap land use, hydrological, lake, and governance models into the IAM.[60] Although space precludes a detailed overview of the technical components of the RACC IAM here, we will discuss how the IAM is being configured within the context of the social, ecological, and climatological features

57. Scheinert et al., *supra* note 41, at 78–79.

58. KOLIBA ET AL., *supra* note 41, at 2.

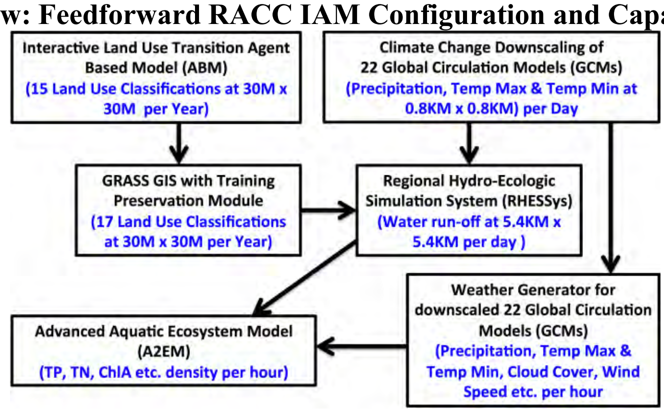
59. Zia & Koliba, *supra* note 41.

60. Asim Zia et al., Adaptive Co-Management of "Tipping Points" in Social Ecological Systems: Governing Alternate Stable States in Lake Champlain Basin at the 2014 Norwich Conference on Earth System Governance: Access and Allocation in the Anthropocene, (July 1–3, 2014) [hereinafter Tipping Points]; Asim Zia et al., Quantifying Uncertainty in Modeling the Impacts of Climate Change on Water Quality in Freshwater Lakes: A Bayesian Network Model of Missisquoi Bay (2014) (unpublished manuscript) (abstract on file with Vermont Journal of Environmental Law and manuscript being submitted to Environmental Research Letters) [hereinafter Quantifying Uncertainty].

being addressed within and across the RACC teams. In this sense, the IAM team, comprised of representatives from all of the RACC teams, provides an integrative platform to model the LCB as a complex adaptive system.

At the time of writing this article, a model of Missisiquoi Bay has been fully calibrated, validated, and integrated in the larger RACC IAM, which was a significant accomplishment and the larger team is well-poised to now use the IAM to examine the impacts of climate change and adaptive management scenarios on water quality and algal bloom dynamics over time. Figure ww below shows the configuration of the feedforward version of the RACC IAM: twenty-two ensembles of global climate models ("GCMs") are used to drive three climate scenarios (RCP 4.5, 6.0 and 8.5), and four land use scenarios (BAU, Pro-forest, Pro-Ag and Pro-urban development) through the hydrological and lake models. High resolution spatial and temporal forecasts of hydrological and lake biogeochemical conditions are predicted under alternate climate change and land use change scenarios.[61] Each scenario of RACC IAM requires generation of approximately two terrabytes of data, hence the need to run the model on supercomputing clusters. Delphi panel surveys and mediated modeling workshops have been organized to configure specific governance and policy design scenarios for identifying adaptation to climate change scenarios that best mitigate nutrient reduction in the watersheds and lake systems.

Figure ww: Feedforward RACC IAM Configuration and Capability

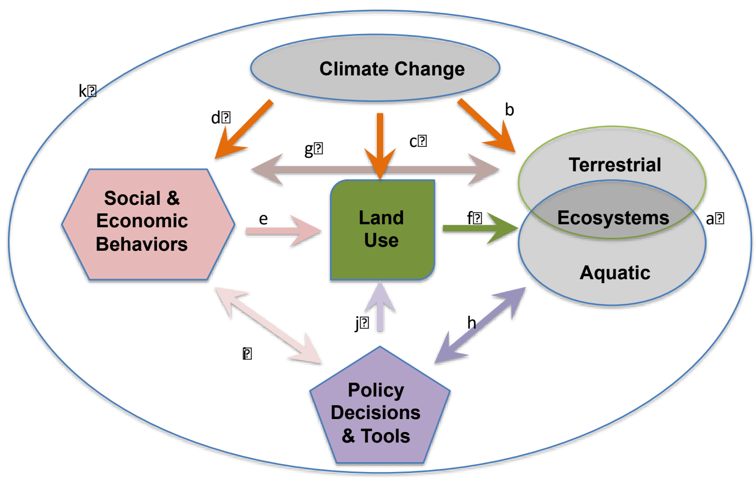


61. Tipping Points, *supra* note 60; Quantifying Uncertainty, *supra* note 60.

III. WHAT HAS BEEN LEARNED ABOUT THIS COMPLEX SOCIAL ECOLOGICAL SYSTEM?

The framework for representing the LCB as a complex adaptive system is represented in figure XX. The reader will recognize the major facets of the RACC project found within the coupled terrestrial-aquatic ecosystems, climate change, land use, social and economic behavior, and policy decisions, and tools features. Questions 1 and 2 of RACC encompass the terrestrial and aquatic ecosystems, climate change, and land use features, while question 3 of RACC encompasses the land use, social and economic behavior, and policy decisions and tools features of the project. The entire system modeled through the IAM(k.).

Figure XX. RACC Model: LCB as Complex Adaptive System



A key feature of the RACC approach to modeling the LCB as a complex system lies in the interconnections between the system's component parts. In the next section we briefly highlight the nature of each link, drawing reference back to specific conditions impacting the LCB. These links are described as either feedforward or feedback links in the model.

a. **Coupled aquatic & terrestrial links.** The relationship between an ecosystem's terrestrial and aquatic systems is widely appreciated and serves as a central feature of most models of natural ecosystems. Many of the basic research RACC findings mentioned earlier in this article lie at the interface between the LCB's aquatic and terrestrial ecosystems. Land cover, streambank erosion, and stream and river morphology have direct and critical implications for water quality. Much of the *to-lake* studies being undertaken in the Q2 team are designed to better understand the coupled aquatic-terrestrial links. Likewise, the Q1 team's focus on *in-lake* processes is also very much tied to the coupled dynamics of land and water. Phosphorus enters the hydrological system through sediment. The transportation of sediment facilitates the erosion and reconfiguration of terrestrial features. RACC researchers have built sophisticated models to understand this very dynamic.[62]

b. **Climate change and aquatic and terrestrial ecosystem links.** The role of climate and weather, and changes to the climate over time, upon aquatic and terrestrial ecosystems has long been understood as part of the paleoclimatological and geological history of the planet.[63] Temperature variation and precipitation patterns have always contributed to erosion, sediment transport, and more. As the climate of the LCB changes, as it is predicted to do,[64] better understandings of expected increases in extreme weather events and higher temperatures on algal blooms is critical. It is clearly apparent that as temperatures and precipitation intensity rises, conditions allowing for the advanced eutrophication of Lake Champlain are likely.[65] In the context of current conditions, climate change has led to rising temperatures and more extreme precipitation events, particularly during the spring melt-off and late summer seasons. RACC research has highlighted the role that large storm events play in triggering and, interestingly, shutting down algal blooms.[66]

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62. *See* Ibrahim Nourein Mohammed, Arne Bomblies & Beverley C. Wemple, *The Use of CMIP5 Data To Simulate Climate Change Impacts on Flow Regime Within the Lake Champlain Basin*, 3 J. HYDROLOGY: REGIONAL STUD. 160 (2015) (using Coupled Model Intercomparison Project phase 5 ("CMIP5") data to study alternative possibilities that might emerge in the Lake Champlain Basin for various climate change scenarios).

63. *See* FAGAN, *supra* note 2, at xi–xii (describing the author's introduction to ancient climate).

64. Guilbert et al., *supra* note 11; Guilbert et al., *supra* note 39, at 18.

65. Mohammed, Bomblies & Wemple, *supra* note 62, at 179; *See* Isles et al., *supra* note 10, at 823 (observing warm temperatures during a pre-bloom phase in Missisquoi Bay); Zia et al., *supra* note 12, at 17–18.

66. *See* Isles et al., *supra* note 10, at 827 (describing the effects of storms on algal blooms in Missisquoi Bay).

c. **Climate change and land use links**. As archeological studies of climate and environmental impacts on human civilizations have been promulgated,[67] it has been noted how changes in climatic conditions, be they glacial advances during ice ages, intense flooding and drought conditions, or more subtle temperature rises and falls, have helped to shape how human beings use and cultivate the land. Specifically for the present era in the LCB, increasing temperatures have extended growing seasons[68] and will likely continue to extend them in future decades.[69] More persistent flooding events have caused some farmers to abandon fields, relocate pasture lands, and even go out of business.[70] The resilience of the region is predicated on how land use evolves as a result of climate change.

d. **Social and economic behavior and climate change links**. The role of social and economic behavior as a driver of climate change has been clearly recognized by the IPCC and generally recognized by the scientific community. It is likely that as the impacts of climate change become more apparent, human adaptation to climate change will become increasingly evident.

e. **Social and economic behavior and land use links**. Land use is a byproduct of human agency and the tight interaction of human use and value of ecosystem services with human economics needs to be dynamically generated over time. The decisions of land users/owners to transition land from one type of cover and use to another, and to adopt BMPs, can "add up" to watershed scale land use and land cover patterns. By setting in place democratic governance mechanisms and policies in the form of incentives, sanctions, and regulations, policy makers can seek to shape human social and economic behavior that becomes apparent at the landscape scale. This provides a scientific basis to understand the relationship between human agency, ecosystem services, and land use.

f. **Terrestrial and aquatic ecosystems and land use links**. The evolution of human civilizations has depended on how early

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67. FAGAN, *supra* note 2, at xiii.

68. VERMONT CLIMATE ASSESSMENT, *supra* note 23, at 13.

69. Guilbert et al., *supra* note 11.

70. *See, e.g.*, VERMONT CLIMATE ASSESSMENT, *supra* note 23, at 13 ("Variations in seasonal precipitation combined with the increased frequency of high-energy storms could lead to extreme year-to-year weather variations with implications on farm business viability.").

human societies have, essentially, taken what ecosystems have given them.[71] Geological, aquatic, and other landscape characteristics have limited how and where lands can be cultivated and inhabited. Although extensive efforts have been made to bring ecosystems into some kind of order through the development of irrigation systems, transportation systems, and other forms of built infrastructure, it is clear that land use practices are confined to the capacities of ecosystems and surrounding waterways. RACC researchers are finding that land use clearly impacts stream metabolism—e.g., we see clear signals between urban, agriculture and forested land covers and stream metabolism.[72] The models devised by RACC are built to better understand this interplay, with a particular focus on how these dynamics impact the health of Lake Champlain.

g. **Terrestrial and aquatic ecosystems and social and economic behavior links.** The very nature of a social ecological system must take into account the indelible link between human agency and ecosystems. Ecological economists have advanced the notion of "ecosystem services" as a way to place value on ecosystems and to allow this valuation to intentionally shape social and economic behavior. For instance, the aesthetic and recreational value of Lake Champlain lies in the use of the lake as an ecosystem valued for its swimability and fishability. In this way, the true value of and costs to degrading ecosystems may be understood as consequences and drivers of human behavior. In the RACC project, this direct link between human behavior and ecosystems is understood as a matter of public perception of the value of water quality and other ecosystem services.[73]

h. **Policy decisions and tools and terrestrial and aquatic ecosystems links**. As the more recent history of modern environmental policy and management can attest, the growth of populations and the need for natural resources, such as clean water, fossil fuel, metals and minerals, and food, increases the

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71. *See generally* FAGAN, *supra* note 2 (describing how societies have adapted to variations in climate throughout history).

72. Ryan Sleeper et al., Presentation on Ecosystem Metabolism in Streams with Contrasting Land Use at the Society of Freshwater Sciences Annual Meeting in Sacramento, California (May 22-25, 2016).

73. *See* Tsai et al., *supra* note 40, at 162 (describing how the ILUTABM simulates the relationship between landowners' land use decisions and ecosystem services); Zia et al., *supra* note 12, at 2.

need to place protections on terrestrial and aquatic ecosystems that provide ecosystem services.[74] As the accumulation of air and water pollution impact the quality of human life and compromise biodiversity and wildlife habitat, the link between policy decisions and tools and ecosystem preservation is of critical importance. In the context of the RACC project and the problems of nonpoint pollution in Lake Champlain, the environmental laws in place to protect wetlands, wildlife habitat, and biodiversity play significant roles in ensuring water quality standards are met.[75] While the RACC public opinion polling has concluded that Vermonters, irrespective of their proximity to lake, ideological predisposition, and age, are very much concerned about the health of water quality in the lake and are willing to pay increased fees and taxes to support lake cleanup programs.

i. **Policy decisions and tools and social and economic behavior links**. Public policies are enacted to address particular policy goals and to serve in the public interest. In the context of ecosystem preservation and the intentional development of land use, policy tools such as implementation grants, subsidies and technical assistance contracts, loan and insurance programs, permits, regulations, tax exemptions, and zoning laws are created to, essentially, guide social behaviors.[76] In turn, policy decisions are (or at least should be) informed by how citizens perceive policies such as regulations, incentives, and technical assistance programs.[77] In the context of the LCB, as is likely the case anywhere in the United States, policy makers are sensitive to public perceptions and public and special interest support of and resistance to policy actions plays a role in determining how policy responses to wicked problems like nonpoint pollution are addressed.

j. **Policy decisions and tools and land use links.** Of particular interest to the RACC project and other invested stakeholders is the role that policy tools play in regulating and encouraging certain land use practices. In the Vermont portion of the LCB,

74. Folke et al., *supra* note 55; Oran Young et al., *The Globalization of Socio-Ecological Systems: An Agenda for Scientific Research*, 16 GLOBAL ENVTL. CHANGE 304.

75. KOLIBA ET AL., *supra* note 41, at 16–17.

76. *Id.* at 2.

77. STEVE SCHEINERT ET AL., VALUE OF WATER QUALITY AND PUBLIC WILLINGNESS TO PAY FOR WATER QUALITY POLICY AND PROJECT IMPLEMENTATION 1 (2014).

zoning rules are set by localities, devolving critical land use planning to the level of local governance. National and state land use laws, such as the United States Clean Water Act and Clean Air Act, subsequent interpretations of these acts, and state level land use law, also play key roles in shaping the policy environment. In Vermont, Act 250 and the more recent Act 64, posited as Vermont's "Clean Water Act," all play a role in regulating and incentivizing land uses. In addition, significant financial resources are provided through national and state governments to encourage stormwater infrastructure, waste and drinking water treatment, sustainable forestry, and clean water and nutrient management practices for agricultural operations.[78] In the context of the RACC project and the wicked problems of nonpoint pollution, the relationship between policy tool and resource allocation options, and possible land use patterns are being modeled and simulated.[79]

k. **System integration.** When considering the LCB as a complex adaptive system that is bound together as a couple human-natural or social-ecological system, it becomes important to consider how some combinations of feedback and feedforward processes ultimately impact nutrient flows and algal blooms. It should be evident by now that nutrient loading of phosphorus and nitrogen follow a direct pathway (from climate and resultant weather events) into the terrestrial and aquatic ecosystems that are shaped by land use decisions made by social, economic, and policy actors. In turn, we may understand how the terrestrial and aquatic ecosystems and, specifically in the context of the RACC project, the eutrophication of Lake Champlain responds to climatic events and alterations and to land use patterns brought about through policy decisions, tools, and laws. Developing the ability to simulate these kind of complex dynamics lies at the heart of the RACC IAM.

The complexity of interactions of ecosystems, social systems, and climatological systems outlined here bring into clearer focus some of the key drivers of system stability and change. Our focus here has been on the land use and geomorphological drivers of nutrient loading, the biogeochemical drivers of blue green algae blooms, and the social and

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78. Scheinert et al., *supra* note 41, at 78.

79. *See* Tsai et al., *supra* note 40 (using an interactive land use transition agent-based model to simulate land use changes); Zia et al., *supra* note 12.

economic behavioral drivers of land use, public policy, and governance arrangements. Although system integration is the larger goal of the RACC project, the effort to identify some of the "component parts" of the larger system can contribute to our understanding of the problem. To suggest that the kind of advanced models being developed by RACC researchers will come up with *the* solution to the water quality problems highlighted here would be an overstatement. Tremendous uncertainty revolves around most of the complex interactions highlighted here. However, by conceiving of and modeling the LCB as a complex adaptive, system we may be in a better position to discover critical leverage points[80] and overarching patterns[81] that, if addressed through creative public policy and market incentives, can effectively mitigate some of the more egregious impacts of nutrient loading on the social ecological system.

RACC research is contributing to what is known about the causes and consequences of nonpoint pollution. Advanced data collection technologies, such as water sensors, certain tracing methodologies, LiDAR, and drone surveillance, can contribute to the adaptive management of the region's water resources, as can advances in modeling human behavior and institutional responses. Advanced computer simulation models, calibrated and validated to historical data, have been devised and are being refined. The extensive monitoring of internal and external processes and drivers and sophisticated holistic modeling are necessary to understand and quantify the relative importance of environmental dynamics that control water quality and algal blooms in this system and project how climate change and management decisions will impact this complex system.

As a result of this research we know much more about the climatological and biogeochemical drivers of algal blooms.[82] As our results indicate, the conditions for the continued persistence of algal blooms are in place despite the well intentioned efforts of policy makers to address the root causes of nonpoint pollution. Substantial reductions in nutrient loading will likely take decades in order to lead to significant reductions in algal blooms and other manifestations of cyanobacteria contamination.[83] Climate

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80. *See* DONELLA H. MEADOWS, THINKING IN SYSTEMS: A PRIMER 145 (Diana Wright ed., 2009) (defining leverage points as "places in the system where a small change could lead to a large shift in behavior").

81. *See* Mica R. Endsley, *Toward a Theory of Situation Awareness in Dynamic Systems*, 37 HUM. FACTORS 32, 47 (1995) (emphasizing the importance of situational awareness in recognizing patterns in complex systems).

82. *See* Isles et al., *supra* note 10 (studying the factors contributing to a severe algal bloom in Missisquoi Bay); Zia et al., *supra* note 12.; *see* Mohammed, Bomblies & Wemple, *supra* note 62 (using models to study alternative effects of climate change on the Lake Champlain Basin).

83. Zia et al., *supra* note 12, at 17–18.

change is likely to exacerbate algal blooms in both shallow and deep bays. The potential "cancelling out" effects of climate change on policy interventions directed at nutrient management need to be better understood.

Overall, Vermonters are concerned about climate change and highly value water quality.[84] The issue posed is whether the political will and economic resources exist to address nonpoint pollution. Vermonters see it as the role of state government, then individuals, to insure water quality.[85] Our research has found that robust governance networks exist to support water quality management in the LCB and that these networks are dominated by state agencies.[86] Recent coordination between state agencies has resulted in new policy windows for the region (see the development of Vermont Clean Water Initiative).[87] After study of the *2011 Opportunities for Action* and the then-draft TMDL plan, we conclude that both plans recommend a similar balance of regulatory and incentives-based policy tools to advance water quality goals, suggesting a consensus forming around specific suites of policy options.[88] The devolution of power, in terms of allocation and use of programmatic funds from federal and state agencies to local towns and regional/watershed levels, may provide interesting avenues to re-design the intergovernmental relations in this complex adaptive system.

While there are limits, Vermonters appear to support water quality and that this support is not spatially constrained by proximity to Lake Champlain. Our public opinion polling suggests that there is willingness to pay for water quality to certain levels and through certain policy tools.[89] We have also learned more about what it takes for specific land owners and users to adopt water quality BMPs. RACC researchers have found that familiarity with and/or capacity to implement specific BMPs (such as riparian buffers, cover cropping, and conservation tillage) influences an actor's willingness to adopt certain practices.[90]

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84. KOLIBA ET AL., *supra* note 41, at 2.
85. *Id.* at 9–10.
86. Scheinert et al., *supra* note 41, at 78.
87. *E.g.*, Trey Martin, *The Vermont Clean Water Act: Water Quality Protection, Land Use, and the Legacy of Tropical Storm Irene*, *infra* p. 688.
88. KOLIBA ET AL., *supra* note 41, at 18–19.
89. Scheinert et al., *supra* note 77, at 1.
90. *See* Miller, *supra* note 47, at 22 (arguing that farmers are more likely to adopt BMPs that are low in complexity and highly compatible with the existing farm system); Scott C. Merrill et al., An Examination of the Effect of Information: Awareness of Buffer Strip Effects Increases Adoption Rates (2016) (unpublished manuscript) (a PowerPoint presentation on the findings in this paper is available at http://www.uvm.edu/~epscor/pdfFiles/2016_racc_retreat/21_merrill_RACC%20Retreat%20Feb%202016%20_%20Experimental%20gaming%20research_%20the%20next%20step%20in%20data%20gathering%20and%20complex%20systems%20analysis.pdf [https://perma.cc/67TK-V69M]).

New market mechanisms, such as nutrient cap and trade programs, phosphorous taxes, incentives for agroecological BMPs, incentives for stormwater management, and ecological design of urban towns, may provide viable options to adapt to climate change-induced risks to water quality. Technical assistance programs aimed at improving the perceived behavioral control of farmers to adopt BMPs need to be expanded, which might have large multiplier effects on keeping the nutrients from flowing into the waterways. New performance-based payment for ecosystem programs could be used to improve soil conservation, stormwater management, and use of "precision agriculture" in reducing phosphorous runoff. Decreasing price and increasing accuracy of water quality sensors implies that these sensor networks can be expanded upon throughout the watersheds for increased monitoring and decentralized control of nutrient fluxes. Bottom up town and watershed-scale land use planning, in particular conservation of riparian buffers, wetlands, and forests broadly defined, could go a long way toward protecting Lake Champlain from climate change-induced extreme events, such as floods. This planning process needs to be democratic, bottom-up iterative, and adaptive.

Despite reasons for optimism, there do appear to be real behavioral limits on land users' abilities to fully enact water quality BMPs through the use of incentives and voluntary compliance efforts. We will continue to look into the need for increased regulatory powers and enhanced efforts to stimulate innovation to overcome entrenched behaviors.

CONCLUSION

Our exploration of the problem of nonpoint pollution as a wicked problem that is resulting from a complex set of climatological, ecological, and social factors has been advanced with a sincere desire to inform the adaptive management of the LCB's nonpoint pollution problems. Viewing the LCB as a complex adaptive system is contributing to the region's capacity to effectively manage nonpoint pollution and its impacts on Lake Champlain and its watersheds. Recalling the nature of wicked environmental problems, we assert that the breadth and complexity of the problem will likely not lead to easy nor quick solutions. Algal blooms and other indicators of compromised water quality in Lake Champlain and in some of its embayments are likely to persist for decades to come. By deepening our understanding of the complex dynamics shaping the problem, we aspire to work with stakeholders to harness this complexity in order to ensure clean waters for future generations.

LESSONS FOR LAKE CHAMPLAIN FROM CHESAPEAKE BAY: RETURNING BOTH WATERS TO THE "LAND OF LIVING"[1]

David K. Mears and Rebecca A. Blackmon[2]

INTRODUCTION: LAKE CHAMPLAIN AND THE CHESAPEAKE BAY COMPARED

At first glance, Lake Champlain and the Chesapeake Bay might not seem to have much in common: one is a narrow freshwater lake and the other is a wide saltwater bay and estuary. It is true that Lake Champlain was once a saltwater, inland sea, connected to the Atlantic Ocean just as the

1. The Third Circuit concludes the decision which is the subject of this article with a quote from Robert Frost's poem, *The Gift Outright,* noting that "[t]he Chesapeake Bay TMDL will require sacrifice by many, but that is a consequence of the tremendous effort it will take to restore health to the Bay—to make it once again a part of our land of living. Am. Farm Bureau Fed'n v. U.S. Envtl. Prot. Agency, 792 F.3d 281, 310 (3d Cir. 2015).

2. David Mears is Vice Dean for Faculty and Professor of Law at Vermont Law School; Rebecca Blackmon is a student at Vermont Law School and the Editor in Chief for Vermont Journal of Environmental Law Volume 18.

Chesapeake is today.[3] For the past ten thousand years or so, however, the water in Lake Champlain has been fresh. The lake is mostly deep and long, with the exception of its most southern reach and northern bays.[4] The Chesapeake, by contrast, is saltwater and relatively shallow.[5]

These two great waters also differ greatly in the size and patterns of human development in their watersheds. While the area of the Lake Champlain watershed is large relative to the surface area of the lake, the predominant land use is rural and dominated by forests and farms. The lake can brag of bordering two states and the Canadian province of Quebec,[6] but its watershed is sparsely settled with a relatively small percentage of urban and suburban development.[7] The Chesapeake Bay is, in contrast, quite a bit larger with a watershed that includes significant parts of six states and the entire District of Columbia—approximately eight times larger than the Lake Champlain basin.[8] The Chesapeake Bay watershed also has a much greater population, with several major metropolitan areas and intense urban and suburban development.[9]

The two watersheds do, however, share a common set of environmental and legal challenges. First, the bodies of water and their watersheds are both large and complex ecological systems[10] substantially impacted by human activities.[11] Both the bay and the lake suffer from the effects of excessive amounts of nutrients and sediment pollution. The specific nutrients of concern are nitrogen and phosphorus. Nitrogen is the greater

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3. *Geologists Sees Sea Where Lake Now Flows*, LAKE CHAMPLAIN LIFE, ://lakechamplainlife.com/lake-champlain-geology/ (last visited Feb. 16, 2016).

4. *Id.*; *Lake and Basin Facts*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-the-basin/facts/ (last visited Feb. 11, 2016).

5. *Facts and Figures*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/discover/bay101/facts (last visited Feb. 16, 2016).

6. Vermont, New York, and the Canadian province of Quebec border Lake Champlain. *Nature of the Basin-Lake Champlain Basin Atlas*, LAKE CHAMPLAIN BASIN PROGRAM, http://atlas.lcbp.org/HTML/nat_aboutlcbp.htm (last visited Mar. 30 2016).

7. LAKE CHAMPLAIN BASIN, COMPREHENSIVE WILDLIFE CONSERVATION STRATEGY FOR N.Y. 174 (2015), http://www.dec.ny.gov/docs/wildlife_pdf/lkchamplaintxt.pdf.

8. *Facts and Figures*, *supra* note 5 (indicating that the "surface area of the Bay and its tidal tributaries is approximately 4,480 square miles."); *Lake and Basin Facts*, *supra* note 4 ("Lake Area: 435 sq[are] miles (1127 sq[are] kilometers) of surface water.").

9. *See Facts and Figures*, *supra* note 5 ("The Chesapeake Bay watershed is home to more than 17 million people. About 150,000 new people move into the Bay watershed each year.").

10. *See generally id.* (listing Chesapeake Bay facts indicating how large the bay is and its relation to human activity); LAKE CHAMPLAIN BASIN, *supra* note 7, at 173–74 (describing the size and complexity of the Lake Champlain Basin).

11. *Lake Champlain: The Issues and Threats*, LAKE CHAMPLAIN INT'L, https://www.mychamplain.net/threats-explained (last visited Feb. 11, 2016); *Learn the Issues*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/issues (last visited Mar. 5, 2016); *see also How Does a Healthy Ecosystem Protect Lake Champlain*, STATE OF THE LAKE, http://sol.lcbp.org/Biodiversity_healthy-ecosystems.html (last visited Feb. 11, 2016) (describing the various human impacts on Lake Champlain).

concern for the Chesapeake Bay, while phosphorus is the greater concern for Lake Champlain due to the differences between salt and fresh water ecosystems.[12]

Also, while the relative proportions among sources vary across the two separate watersheds, the categories of pollution that pose the most significant problems are the same: polluted runoff from agriculture and developed land, discharges from municipal and industrial wastewater treatment plants, and erosion from unstable streambanks and beds.[13] Finally, and significantly for the purposes of this article, both Lake Champlain and the Chesapeake Bay are subject to the protections of the federal Clean Water Act ("CWA") as implemented by the states. Because both the lake and the bay are impaired due to excessive levels of nutrients, the CWA requires implementation of a type of pollution reduction program referred to as a Total Maximum Daily Load ("TMDL").[14]

More specifically, because both water bodies are impaired and not meeting water quality standards established under the CWA, the United States Environmental Protection Agency ("EPA") and the affected states have an obligation to work together to establish pollution reduction targets and strategies for meeting those targets.[15] In the case of Chesapeake Bay, EPA has established a TMDL for this purpose.[16] This particular TMDL, as established by EPA, requires each of the six states in the basin and the District of Columbia to establish implementation plans.[17] These plans, which occur in phases, are designed to substantially reduce pollution loads as necessary to return Chesapeake Bay to full health.[18]

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12. Robert W. Howarth & Roxanne Morino, *Nitrogen as the Limiting Nutrient for Eutrophication in Cosatal Marine Ecosystems: Evolving Views Over Three Decades*, 51 LIMNOLOGY & OCEANOGRAPHY 364 (2006); VH Smith, GD Tilman, JC Nekola, *Eutrophication: Impacts of Excess Nutrient Inputs on Freshwater, Marine, and Terrestrial Ecosystems*, 100 ENVTL. POLLUTION 179, 179–96 (1999); U.S. ENVTL. PROT. AGENCY, PREVENTING EUTROPHICATION: SCIENTIFIC SUPPORT FOR DUAL NUTRIENT CRITERIA 2 (FEB. 2015), https://www.epa.gov/sites/production/files/documents/nandpfactsheet.pdf (discussing growing scientific understanding that there is a need to control both phosphorus and nitrogen regardless of whether in a freshwater or saltwater system).

13. *Compare Nitrogen & Phosphorus*, CHESAPEAKE BAY FOUND., http://www.cbf.org/about-the-bay/issues/dead-zones/nitrogen-phosphorus (last visited Feb. 17, 2016) (discussing the effects of nitrogen and phosphorus on the Chesapeake Bay estuary); *The Issues and Threats*, *supra* note 11 (listing the various human caused threats to the Lake Champlain estuary).

14. Clean Water Act of 1972, 33 U.S.C. § 1313(d)(1)(C) (1994) (effective Oct. 10, 2000).

15. *Am. Farm Bureau Fed'n*, 792 F.3d at 288 (indicating that under the CWA, EPA and states work together in "cooperative federalism").

16. *See generally* ENVTL. PROT. AGENCY, CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, U.S. ENVTL. PROT. AGENCY (2010), https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-document.

17. *Id.* at ES-8 to ES-9, http://www.epa.gov/sites/production/files/2014-12/documents/bay_tmdl_executive_summary_final_12.29.10_final_1.pdf.

18. *Id.* at ES-9.

In an effort to address a central inadequacy of past TMDLs, EPA has also established an accountability framework to accompany the Chesapeake Bay TMDL with consequences in the event that the states do not meet the commitments they have made in their implementation plans.[19] These plans include schedules and deliverables that are driving significant investments of resources by the states as well as those sectors that are contributing to the pollution including agriculture, industry, municipalities, and landowners.[20] EPA has recently approved a TMDL for Lake Champlain that includes a similar accountability framework.[21] It is in this way that the fate of these two critical water bodies are linked.

I. TMDLS AS A PATH TO A SOLUTION FOR BOTH THE LAKE AND THE BAY

For many decades, dating back at least to the passage of the CWA in 1972, states and EPA have been attempting to find ways to tackle the full array of pollutants impacting major aquatic ecosystems like Chesapeake Bay and Lake Champlain.[22] While significant progress was made with regard to the pollution coming out of municipal and industrial wastewater treatment plants, pollution associated with precipitation events grew worse.[23] The polluted stormwater runoff from the streets of cities, such as Burlington and Baltimore and their suburbs, increased as development expanded.[24] Farm runoff from states like Vermont and Virginia increased as more land was converted to grow corn and soybeans with more intensive use of fertilizers and as feedlot operations and dairies grew in size, contributing greater volumes of animal waste.[25] Finally, the combination of increased development and the loss of wetland and floodplain functions caused streambanks and beds to become increasingly unstable and erosive.[26]

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19. *Id.* at 7-2, https://www.epa.gov/sites/production/files/2014-12/documents/cbay_final_tmdl_section_7_final_0.pdf.

20. *Id.*

21. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 4959 (2016) https://www.epa.gov/sites/production/files/2016-06/documents/phosphorus-tmdls-vermont-segments-lake-champlain-jun-17-2016.pdf.

22. Dave Owen, *After the TMDLs*, *infra* p. 845.

23. *See Learn the Issues*, *supra* note 11 (explaining how stormwater runoff increased because of increased development across the watershed).

24. *See* STORMWATER, LAKE CHAMPLAIN BASIN PROGRAM (2016) (explaining that developed land sends more phosphorus into the lake than agricultural land).

25. Chuck Ross & Marli Rupe, *Agricultural Sources of Water Pollution: How Our History Informs Current Debate*, *infra* p. 825.

26. Dianna M. Hogan & J.V. Loperfido, *Science Summary—Water-Quality Improvement Resulting from Suburban Stormwater Management Practices in the Chesapeake Bay Watershed*, U.S. GEOLOGICAL SURVEY (2013), http://chesapeake.usgs.gov/sciencesummary-

The structure of the CWA has contributed to increasing the challenge of tackling these widespread and diffuse sources of pollution. The CWA differentiates between pollution that flows out of pipes and precipitation-driven pollution that flows in a more diffuse fashion across the landscape.[27] The former categories of pollution are referred to as "point sources" and are subject to strict permit controls relying first on technology-based controls and secondarily on water quality-based limits.[28] EPA plays a direct oversight role in the implementation of this point source permitting program, referred to as the "National Pollutant Discharge Elimination System" ("NPDES").[29]

Precipitation-driven sources of pollution are typically referred to as "nonpoint sources" and are not subject to the same type of permitting system.[30] Instead, these sources are subject to state programs that are largely voluntary and involve limited EPA oversight.[31] Due to the fact that many waterbodies are significantly impacted by nonpoint source pollution, this distinction poses an obstacle to achieving the CWA's objective to fully "restore and maintain the chemical, physical, and biological integrity of the nation's waters."[32]

Adding to the confusion, there is another intermediate category of pollution sources, such as stormwater from large municipalities, certain industrial facilities, and large farms, which have come under increasing levels of direct regulation under the CWA.[33] These latter sources are treated as point sources and are required to obtain NPDES permits. Due to the fact that this category of pollution is frequently driven by precipitation events, the pollution control requirements rely on "best management practices" instead of the more traditional steady-state pollution control technologies used to address point-source pollution.[34]

As a consequence of this fractured approach, EPA and the states have not effectively addressed the full suite of pollution sources affecting the

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stormwatermanagement.html; *see also* STORMWATER, *supra* note 24 (stating that "stormwater . . . can erode stream banks and increase water pollution"); Mike Kline, *Giving Our Rivers Room To Move: A New Strategy and Contribution to Protecting Vermont's Communities and Ensuring Clean Water*, *infra* p. 733 (discussing river erosion in Vermont).

27. 33 U.S.C. § 1342(l)(1)–(2) (2012) (explaining that states will not be required to secure a permit for agricultural return flows and stormwater runoff from plants and mines, etc.).

28. *Id.* § 1362(14).

29. *Id.* §§ 1342,1329(b).

30. *Id.* § 1342(l)(1)–(2). (indicating that nonpoint sources are managed by the states).

31. *Id.* § 1329(b); Dave Owen, *After the TMDLs*, *infra* p. 859.

32. 33 U.S.C. §1251(a).

33. *See generally* Kenneth M. Murchison, *Learning From More Than Five-and-a-Half Decades of Federal Water Pollution Control Legislation: Twenty Lessons for the Future*, 32 B.C. ENVTL. AFF. L. REV. 527 (2005).

34. *Id.*

nation's waters. This state of affairs has led many to look to a provision of the CWA Section 303(d), which is the portion of the Act that requires states to establish TMDLs when water quality is impaired, even after point-source pollution has been controlled through the NPDES permitting program.[35] TMDLs can be viewed as the vehicle in the CWA for ensuring that states tackle the challenge of reducing nonpoint source pollution when point-source controls are insufficient to achieve water quality standards, even if fully implemented and enforced.[36] To date, the effectiveness of TMDLs in achieving this goal has been mixed, largely due to the lack of an accountability mechanism to ensure that the implementation plans developed for those TMDLs were in fact implemented.[37]

In the Chesapeake Bay TMDL, EPA attempted to overcome the shortcomings of other large TMDLs through building an accountability mechanism not expressly found in the CWA.[38] In response, organizations representing farmers, developers, and businesses challenged EPA's decision and took their case to the United States Court of Appeals for the Third Circuit, where, as discussed below in more detail, they lost.[39]

The Lake Champlain TMDL includes an accountability mechanism similar in structure to the one used for Chesapeake Bay[40] and may face a similar legal challenge. For this reason, a discussion of the Chesapeake Bay TMDL, and the decision by the Third Circuit upholding it, are highly relevant to the efforts underway in Vermont to implement a similar TMDL for Lake Champlain.

II. THE DEVELOPMENT OF THE CHESAPEAKE BAY TMDL

EPA refers to the Chesapeake Bay TMDL—established by EPA on December 29, 2010 and currently being implemented—as "a historic and comprehensive 'pollution diet' to restore clean water in the Chesapeake Bay and the region's streams, creeks, and rivers."[41] The Chesapeake Bay

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35. 33 U.S.C. § 1313(d)(1)(C).

36. *See* CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at ES-2 (explaining how EPA is making states accountable even if they have been adequately regulating point-source pollution).

37. *See* Dave Owen, *After the TMDLs*, *infra* pp. 849–53.

38. *See* CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-4 to 7-12 (discussing the details of the accountability framework).

39. *Am. Farm Bureau Fed'n*, 792 F.3d at 281–82, *cert. denied*, 136 S. Ct. 1246 (2016).

40. Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *infra* pp. 683–84.

41. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHOROUS, AND SEDIMENT, *supra* note 16, at ES-1.

Foundation calls this TMDL the "Chesapeake Clean Water Blueprint."[42] The Chesapeake Bay TMDL has its roots in studies and work by state environmental agencies and EPA going back more than four decades.[43]

The need for water pollution control for Chesapeake Bay arose in the early 1900s when oyster populations began to significantly drop, prompting scientists to question the impacts that human behavior has on Chesapeake Bay.[44] Other signs of an ecological crisis were demonstrated in the collapse of other major fisheries including the bay's famed blue crab, menhaden, shad, and striped bass populations and outbreaks of a microorganism releasing chemicals toxic to fish called Pfiesteria piscicida, which is associated with eutrophication.[45]

Widespread public recognition of the precise nature of the water quality problems facing the bay grew substantially after Congress tasked EPA with conducting a study on the bay's health, which culminated in EPA's 1983 report, "Chesapeake Bay: A Framework for Action."[46] The studies identified nutrient pollution as a major culprit with the major sources being agricultural runoff, wastewater from municipal and industrial facilities, urban and suburban stormwater runoff, septic tanks, and atmospheric deposition of nitrogen.[47] This conclusion has been reinforced and refined in numerous subsequent studies with the most notable addition being the growing appreciation by scientists of the important need to address the causes of erosion from unstable streambanks and channels.[48] Based on this information, many Chesapeake Bay agreements have been signed over the

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42. *What is the Chesapeake Clean Water Blueprint?*, CHESAPEAKE BAY FOUND., http://www.cbf.org/how-we-save-the-bay/chesapeake-clean-water-blueprint/what-is-the-chesapeake-clean-water-blueprint (last visited Mar. 5, 2016).

43. *See Bay History*, Chesapeake Bay Program, http://www.chesapeakebay.net/history (last visited July 26, 2016) (showing the timeline of the Chesapeake Bay watershed development and history of water pollution); *see also* William G. Howland, *The Lake Champlain Basin Program: Its History and Role*, *infra* p. 588 (discussing a similarly protracted history of efforts to address nutrient pollution in Lake Champlain).

44. *Bay History*, *supra* note 43.

45. *Id.*

46. *See generally* U.S. ENVTL. PROT. AGENCY, CHESAPEAKE BAY: A FRAMEWORK FOR ACTION (1983), http://www.chesapeakebay.net/content/publications/cbp_13262.pdf (indicating EPA's findings about the water quality of Chesapeake Bay).

47. *Id.* at 39.

48. CHESAPEAKE BAY PROGRAM, BEST MANAGEMENT PRACTICES FOR SEDIMENT CONTROL AND WATER CLARITY ENHANCEMENT 37 (2006), http://www.chesapeakebay.net/content/publications/cbp_13369.pdf; CHESAPEAKE BAY PROGRAM, TECHNICAL MEMORANDUM: ANALYSIS OF STREAM SEDIMENT STUDIES IN SUPPORT OF OBJECTIVE 1 OF THE SEDIMENT REDUCTION AND STREAM CORRIDOR RESTORATION ANALYSIS, EVALUATION AND IMPLEMENTATION SUPPORT TO THE CHESAPEAKE BAY PROGRAM PARTNERSHIP 1 (2014), http://www.chesapeakebay.net/channel_files/21418/techmemo_%283-25-14%29_-_analysis_of_stream_sediment_studies.pdf (recognizing stream channel and bank erosion as a substantial source of sediment load).

years, all aimed at reducing nutrient and sediment loadings into the bay.[49] To date, however, all have fallen short of restoring the waters to the agreed-upon goals.[50]

The 1983 Chesapeake Bay Agreement was the first significant effort by at least some of the states in the watershed (Maryland, Virginia, Pennsylvania, and the District of Columbia) and EPA to establish a watershed-based effort. The agreement began the path toward the current Chesapeake Bay TMDL.[51] The 1983 agreement established the Chesapeake Executive Council ("CEC") to "assess and oversee the implementation of coordinate plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine systems."[52] This agreement was insufficient to drive meaningful progress, but the establishment of the CEC laid the foundation of a framework of cooperation between EPA and the states necessary for restoring and protecting the bay.[53] The 1987 Chesapeake Bay Agreement renewed the 1983 agreement by establishing the first numeric targets, including a goal of reducing phosphorus and nitrogen loads into the Bay by forty percent by the year 2000.[54]

When it became clear in the late 1990s that those targets would not be met, the states and EPA took another step on the protracted journey toward the current TMDL in the form of the 2000 Chesapeake Bay Agreement.[55] In this agreement, EPA and the bay states made commitments to reduce nutrient and sediment pollution in the bay sufficient to remove the bay from the list of impaired waters by 2010.[56] A component of the 2000 Agreement was the commitment to "develop and implement locally supported watershed management plans,"[57] a concept later broadened and made

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49. *Chesapeake Bay Watershed Agreement*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/chesapeakebaywatershedagreement/page (last visited Mar. 5, 2016) (Chesapeake Bay agreements were signed in 1983, 1987, 1992 (amendments), and 2000).

50. *Id.*

51. CHESAPEAKE BAY PROGRAM, 1983 CHESAPEAKE BAY AGREEMENT (1983), http://www.chesapeakebay.net/content/publications/cbp_12512.pdf.

52. *Id.*

53. *Chesapeake Executive Council*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/groups/group/Chesapeake_Executive_Council (last visited Feb. 12, 2016).

54. CHESAPEAKE BAY COMMISSION, 1987 CHESAPEAKE BAY AGREEMENT 3 (1987), http://www.chesapeakebay.net/content/publications/cbp_12510.pdf.

55. CHESAPEAKE BAY PROGRAM, CHESAPEAKE 2000 1 (2000), http://www.chesapeakebay.net/channel_files/19193/chesapeake_2000.pdf.

56. *Id.* at 6.

57. *Id.* at 4.

enforceable in the form of the watershed implementation plans ("WIPs") developed pursuant to the 2010 TMDL.[58]

The 2000 Chesapeake Bay Agreement, like its predecessors, also failed to achieve meaningful results.[59] Frustrated by the lack of progress, the Chesapeake Bay Foundation ("CBF") and other groups filed a lawsuit in 2009 against EPA for failure to implement the 2000 Agreement and the CWA.[60] CBF's suit included a long list of studies by EPA's Office of Inspector General and the Congressional General Accountability Office, demonstrating the failure of the federal government, primarily EPA and the United States Department of Agriculture ("USDA"), to take meaningful steps to control nonpoint source pollution into the bay.[61] In 2010, following the negative publicity for EPA generated by the lawsuit and the reports, EPA and CBF settled, relying on a series of commitments by the United States, including an executive order by President Obama and EPA's commitment to establish the Chesapeake Bay TMDL.[62]

President Obama's Executive Order 13508 established a "Federal Leadership Committee," chaired by EPA and made up of federal officials, including some from USDA, tasked with developing a strategy to "protect and restore" the bay.[63] Following the Executive Order, and with the active support and participation of the six affected states and the District of Columbia, EPA developed the necessary scientific information models and the policy framework necessary to adopt a TMDL for Chesapeake Bay.[64] EPA also worked with the states to support their development of WIPs

58. *See Watershed Implementation Plans*, CHESAPEAKE BAY PROGRAM, https://www.chesapeakebay.net/about/programs/watershed (last visited Mar. 11, 2016) (giving a brief overview of WIPs and providing links to each phase of each state's WIPs).

59. Karl Blankenship, *After TMDL Process, Bay Program Finds Itself at a Crossroads*, BAY J. (May 1, 2011), http://www.bayjournal.com/article/after_tmdl_process_bay_program_finds_itself_at_a_crossroads (explaining where the Chesapeake 2000 fell short on restoration).

60. Complaint at 1–2, Fowler v. U.S. Envtl. Prot. Agency, No 1:09-cv-0005-CKK (D.D.C. Jan. 5, 2009), http://www.cbf.org/Document.Doc?id=311 [hereinafter *Fowler* Complaint]; *see also* Matt Chapman & Jen Duggan, *The Transition Towards the 2016 Lake Champlain TMDL: A Survey of Select Water Quality Litigation in Vermont from 2003–2015*, *infra* pp. 632–36 (discussing similar litigation filed by the Conservation Law Foundation against EPA for its approval of a Lake Champlain Phosphorus TMDL that was alleged to fall short of the requirements of the CWA).

61. *Fowler* Complaint, *supra* note 60, at 26–29.

62. Settlement Agreement at 2–7, Fowler v. U.S. Envtl. Prot. Agency, (D.D.C. May 10, 2010), http://www.cbf.org/Document.Doc?id=512.

63. Exec. Order No. 13508, 74 Fed. Reg. 23099, 23,099–100 (May 15, 2009).

64. *See Developing the Chesapeake Bay TMDL*, U.S. ENVTL. PROTECTION AGENCY (2015), https://www.epa.gov/chesapeake-bay-tmdl/developing-chesapeake-bay-tmdl (explaining the development of the Chesapeake Bay TMDL).

sufficient to support EPA's "reasonable assurances" finding.[65] This finding was required in order for EPA to adopt the nonpoint source load allocations in the Chesapeake Bay TMDL.[66] EPA adopted the TMDL on December 29, 2010, with a goal set to have the controls in place by 2025 as necessary to achieve the relevant water quality standards.[67]

III. CHESAPEAKE BAY TMDL ACCOUNTABILITY FRAMEWORK

In order to achieve the goal of the CWA and the Chesapeake Bay TMDL—to "restore and maintain the chemical, physical, and biological integrity"[68] of the Chesapeake Bay and its tributaries—EPA included accountability measures as a central and innovative feature of the TMDL.[69] EPA intended the accountability measures to drive demonstrable improvements in the quality of the bay's waters after nearly twenty-seven years since the first Chesapeake Bay agreement.[70]

Including such an accountability framework is also the equivalent of waving a red cape in front of a bull for the national groups advocating on behalf of agriculture and development interests. In fact, it led to a court challenge of the Chesapeake Bay TMDL by those organizations.[71] As discussed in the litigation and surrounding commentary, and depending on whom you ask, the Chesapeake Bay TMDL is either a model of state-federal cooperation and pathway to meaningful action, or a usurpation of state authority and an "EPA land grab."[72]

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65. *Developing the Chesapeake Bay TMDL*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/chesapeake-bay-tmdl/developing-chesapeake-bay-tmdl (last updated Oct. 1, 2015) (the timeline at November 4, 2009 explains how the EPA assisted states with WIPs).

66. The "reasonable assurances" requirement is based on EPA guidance documents that, in turn, are premised on CWA requirements that the combination of federally enforceable point-source controls and state implementation of nonpoint-source controls are sufficient to achieve water quality standards. U.S. ENVIRONMENTAL PROTECTION AGENCY GUIDELINES FOR REVIEWING TMDLS UNDER EXISTING REGULATIONS 4–5 (2002); ROBERT PERCIASEPE, U.S. ENVIRONMENTAL PROTECTION AGENCY, NEW POLICIES FOR ESTABLISHING AND IMPLEMENTING TOTAL MAXIMUM DAILY LOADS 5 (1997); 33 U.S.C. § 1313(d)(1)(C);40 C.F.R. § 122.44(d)(1)(vii)(A), (B).

67. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-2.

68. 33 U.S.C. § 1251(a).

69. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-4 to 7-12.

70. *Developing the Chesapeake Bay TMDL*, *supra* note 65 (timeline at May 12, 2009).

71. *Am. Farm Bureau Fed'n*, 792 F.3d at 281.

72. Timothy B. Wheeler, *CBF, U.S. Justice Ask Supreme Court to Rebuff Challenge to Chesapeake Pollution Diet*, BAY J. (Jan. 20, 2016), http://www.bayjournal.com/article/cbf_u.s._justice_ask_supreme_court_to_rebuff_challenge_to_chesapeake_pollut (noting that the Chesapeake Bay TMDL has been called both an EPA "power grab" and a "model of cooperative federalism").

The litigation over the Chesapeake Bay TMDL and its accountability framework is not the first time that this set of arguments has been aired in the context of TMDLs. In one of the more notable cases in this category arising in California, landowners frustrated with the cost of complying with water pollution controls on land where they wished to harvest timber challenged the TMDL for the Garcia River, a watershed significantly impacted by nonpoint-source pollution.[73] The plaintiffs argued that EPA had "upset the balance of federal-state control established in the CWA by intruding into the state's traditional control over land use."[74] The Ninth Circuit rejected the plaintiffs' argument as "unfounded" and found the language of the CWA dispositive, which left California the choice of if and how to implement that TMDL.[75]

Another notable battle over the use of TMDLs to create accountability for meaningful water pollution controls of nonpoint sources involved EPA's effort to adopt TMDL implementation regulations at the end of President Clinton's administration.[76] Over strong objections from the same groups that challenged the Chesapeake Bay TMDL and an attempted Congressional effort to stop them, EPA adopted regulations that set deadlines for states to prepare TMDLs and required state implementation plans with "reliable delivery mechanisms."[77] When President Bush assumed office, EPA put the TMDL implementation rules that could have jump-started the current TMDL movement on hold and they were never revived.[78]

As a result of EPA's failure to put TMDL regulations into place, the stubborn challenge of how to ensure that the necessary steps to implement strategies for controlling nonpoint-source pollution has remained. As documented by Professors Houck and Owen in their respective articles critiquing TMDLs, the track record for states implementing the multitudes of TMDLs that have been adopted over the past several decades is checkered.[79] It is plain that, absent strong federal oversight, states are

73. Pronsolino v. Nastri, 291 F.3d 1123, 1124 (9th Cir. 2002).

74. *Id.* at 1140.

75. *Id.*

76. Oliver A. Houck, *The Clean Water Act Returns (Again): Part I, TMDLs and the Chesapeake Bay*, ENVTL. L. REP. NEWS & ANALYSIS 10,208, 10,222 (2011).

77. *Id.* at 10,210.

78. *Id.*; *see also* OLIVER A. HOUCK, CLEAN WATER ACT TMDL PROGRAM: LAW, POLICY, AND IMPLEMENTATION 165–69 (2d ed. 2002) (discussing the context surrounding the adoption of the TMDL implementation rules and the immediate aftermath).

79. *The Clean Water Act Returns*, *supra* note 76, at 10,215 (explaining that even though the Chesapeake Bay TMDL process was fully in motion, the bordering state of Virginia and the District of Columbia had yet to join in); Dave Owen, *After the TMDLs*, *infra* pp. 851–55.

unable or unwilling to take the steps required to address the causes of polluted stormwater runoff.[80]

Considering the challenge of the state of implementation, the checkered history of TMDLs, and the particular history of failed voluntary efforts in the Chesapeake Bay watershed, it was no surprise that EPA looked for a way to use the TMDL process to drive stronger and more definite actions by the implementing states and the District of Columbia. It was also no surprise when the American Farm Bureau, National Homebuilders Association, and others challenged the Chesapeake Bay TMDL on January 10, 2011, shortly after EPA adopted it.[81] To understand the legal battle that ensued, it is helpful to understand the basic framework of the Chesapeake Bay TMDL accountability provisions.

There are four elements to the Chesapeake Bay TMDL accountability framework:

(1) WIPs submitted by each of the states and the District of Columbia describing the steps they would take to reduce pollution into the Bay;[82]
(2) interim milestones, set every two years, against which EPA can measure progress toward meeting the actions identified in the WIPs;[83]
(3) a tracking and monitoring system by which EPA can assess the states' and District's progress;[84] and
(4) consequences in the form of "federal actions if the jurisdictions fail to develop sufficient WIPs, effectively implement their WIPs, or fulfill their 2-year milestones."[85]

The Accountability Framework is intended to ensure that states and the District of Columbia follow through on their plans to improve water quality in Chesapeake Bay.[86] As described in letters sent by EPA to each of the affected jurisdictions, the Accountability Framework was a necessary precondition to EPA's adoption of the TMDL.[87] As a result of the

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80. *The Clean Water Act Returns*, *supra* note 76, at 10,211–212.
81. *Am. Farm Bureau Fed'n*, 792 F.3d at 281.
82. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-4 to 7-12.
83. *Id.*
84. *Id.*
85. *Id.*
86. *Id.*
87. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-4 to 7-12; Letter of Shawn M. Garvin, Reg'l Adm'r, Region III, Envtl. Prot. Agency to the Honorable L. Preston Byrant Jr., Sec'y of Nat. Res., Richmond, Va. (Dec. 29, 2009), http://www.epa.gov/sites/production/files/2015-07/documents/bay_letter_1209.pdf.

commitments made by the six states and the District of Columbia, EPA found "reasonable assurances"[88] that load reductions will be achieved.[89]

In the same manner that the Accountability Framework is central to success in achieving the pollutant load reductions in the TMDL, the WIPs are central to the Accountability Framework.[90] These WIPs are required to address all sources of the pollutants, including both point sources—municipal sewage treatment plants and operational wastes from industries—and nonpoint sources—polluted stormwater runoff from farms, urban and suburban developments, and streambank and channel erosion.[91] The WIPs required to be submitted as a precondition of EPA's adoption of the Chesapeake Bay TMDL were required to include "a description of the authorities, actions, and, to the extent possible, control measures that will be implemented to achieve these point source and nonpoint source target loads and TMDL allocations."[92] EPA expects the control measures to be enforceable and binding.[93] To date, the states and District of Columbia have submitted two sets of Watershed Implementation Plans, described as Phase I and Phase II WIPs, with the second phase plans providing refined pollutant load estimates based on improved scientific modeling and substantially greater detail and clarity about their commitments.[94]

The single most critical feature of whether this accountability framework is successful in terms of achieving water quality goals is the degree to which it results in greater reductions of nonpoint sources of pollution, primarily the stormwater runoff from farms and developed

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88. REASONABLE ASSURANCE—ACHIEVING WATER QUALITY STANDARDS THROUGH TMDLS 3 (2011), https://www.eli.org/sites/default/files/docs/Martinez_001.pdf; *see also supra* note 66 (defining reasonable assurance).

89. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-1.

90. *Id.* at 7-6 to 7-8 (explaining that WIPs are a central element of demonstrating reasonable assurance for the Chesapeake Bay TMDL because WIPs serve as a roadmap for how states will meet and maintain the bay's nutrient and sediment allocations); *see also* Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *infra* pp. 681–83. (discussing the State of Vermont implementation plan for the Lake Champlain Watershed).

91. *Id.* at 7-2 to 7-3 ("Develop WIP that identify how point and nonpoint source will reduce nitrogen, phosphorus, and sediment loads sufficient to meet . . . .").

92. Letter from William C. Early, Acting Reg'l Adm'r, Region III, Envtl. Prot. Agency, to the Honorable L. Preston Bryant Jr., Sec'y of Nat. Res., Richmond, Va. 3 (Nov. 4, 2009), http://www.epa.gov/sites/production/files/2015-07/documents/tmdl_implementation_letter_110409.pdf.

93. *Id.* at 16.

94. *See Watershed Implementation Plans*, *supra* note 60 (giving a brief overview of WIPs and providing links to each phase of each state's WIPs that have been implemented to date).

areas.[95] As noted above, the different statutory approach in the CWA used for addressing "point" versus "nonpoint" source pollution is a structural challenge that has not been sufficient to address nutrient pollution, much of which is not subject to federally enforceable discharge permits.[96] EPA has much stronger authority over discharges from point sources, under Section 402,[97] leaving the work of addressing nonpoint-source pollution to states with little EPA oversight.[98] Most states have relied on voluntary programs to address stormwater pollution, which makes it difficult for EPA to hold them accountable for results.[99] The Chesapeake Bay TMDL and associated Accountability Framework navigate this gap between EPA's authority and the states' responsibilities. States have the flexibility to design specialized programs to control polluted stormwater runoff if they can demonstrate that these plans will deliver the required pollution reductions.[100]

In response, and relying on their own authority, the Chesapeake Bay states have proposed a range of actions. These actions rely on projected reductions of pollution by significantly increasing controls on nonpoint sources, such as stormwater runoff from developed land and farm fields in addition to increasing the stringency of permit limits on point sources.[101] In the arena of precipitation-driven pollution—a.k.a. stormwater runoff—the solutions to this problem can be difficult to implement but are simple in concept,[102] often referred to as "best management practices" ("BMPs"). BMPs are ways to reduce the flow of nutrients off of the landscape by implementing practices that slow down stormwater and allow it to seep into the ground or to be filtered by constructed or natural systems.[103] BMPs include "hard" solutions like stormwater retention ponds and pervious pavement for developed areas like cities and suburbs, but may also include

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95. Because regulating point sources in the past has not successfully cut down on stormwater runoff pollution, the accountability framework is intended to fill the gaps in past water pollution reduction plans.

96. 33 U.S.C. § 1342(l)(1)–(2).

97. *Id.* §1311(b)(1)(A).

98. *Id.* § 1329(b), (e).

99. VALENTINA CABRERA-STAGNO, DEVELOPING EFFECTIVE TMDLS: AN EVALUATION OF THE TMDL PROCESS 2 (2007).

100. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-6 to 7-8 (indicating that states can create specialized watershed implementation plans, but they must show reasonable assurance that these plans will meet water quality standards).

101. *Watershed Implementation Plans*, *supra* note 60.

102. *National Menu of Best Management Practices (BMPs) for Stormwater*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu (last updated Jan. 11, 2016) (explaining how BMPs can be used to address precipitation-driven water pollution and explaining already identified ways to halt such pollution).

103. *Id.*

solutions that rely on protection and restoration of natural and biological systems that help to filter water and absorb pollutants.[104]

In that vein, and as an intriguing and hopeful aside, many communities and businesses are increasingly investing in sets of BMPs known as "green stormwater infrastructure" and "low-impact development" as a means of achieving the pollution reduction targets in the TMDL.[105] These practices include modifying rooftops to be "green" or "blue," planting vegetation in swales and ditches, and creating rain gardens and artificial wetlands.[106] Where possible, communities are also designing, and re-designing, developed areas using a concept known as low-impact development, in which sites are built to maintain and enhance the natural hydrology in the affected watershed.[107]

The same concepts apply to farm pollution. Farmers are increasing the use of practices available to slow stormwater runoff and keep nutrients and soil on the land where they are most useful to farm production.[108] Farmers across the Chesapeake Bay implement many practices promoted by USDA: planting cover crops to avoid periods of bare soil; using conservation tillage to minimize the disturbance of soil; using grassed filter strips; and practicing contour cropping to provide vegetation that filters surface runoff.[109] In all cases, the goal is to keep water, soil, and nutrients on the land and out of our rivers and streams. While many of these practices have been known for years, the combination of increased awareness and the

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104. *See generally* MARIA CAHILL ET AL., POROUS PAVEMENT, http://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/sgpubs/onlinepubs/g11002-lid-porous-pavement.pdf (explaining what porous pavement is and how it manages stormwater runoff); *see also* DENNIS JURRIES, OR. DEP'T OF EVNTL. QUALITY, BIOFILTERS (BIOSWALES, VEGETATIVE BUFFERS, AND CONSTRUCTED WETLANDS) FOR STORM WATER DISCHARGE POLLUTION REMOVAL 3–11 (2003), http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf (explaining how natural biological preservation and reconstruction filters pollutants from stormwater runoff).

105. *Green Infrastructure*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/green-infrastructure (last updated Mar. 10, 2016) (providing links to learning material about green infrastructure and providing information on designing and building green infrastructure); *see Green Street Project*, TOWN OF EDMONSTON, http://www.edmonstonmd.gov/greenstreetproject.html (last visited Mar. 13, 2016) (serving as an example of a community within Maryland that is using green water infrastructure to reach reduce pollution).

106. *See What is Green Infrastructure*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/green-infrastructure/what-green-infrastructure (last updated Nov. 2, 2015) (listing and explaining each type of green infrastructure, how they work, and how they can be created).

107. *See Stormwater Strategies, Community Responses to Runoff Pollution*, NAT. RES DEF. COUNCIL (last visited Mar. 13, 2016) (identifying what low impact development is, explaining why it is important, especially in already urbanized communities, and providing examples of communities that are already implementing low impact developments).

108. *See* U.S. DEP'T OF AGRIC., BEST MANAGEMENT PRACTICES TO MINIMIZE AGRICULTURAL PHOSPHORUS IMPACTS ON WATER QUALITY 4 (2006) (providing a table for BMPs in agriculture).

109. *Id.*

pressure of state and federal attention has increased the rate of adoption by farmers.[110] The WIPs adopted by the Chesapeake Bay watershed states include commitments to more aggressively promote and require the greater use of a range of agricultural BMPs throughout the watershed.[111]

To ensure that these practices are actually adopted and maintained (and that the 2010 Chesapeake TMDL does not suffer the same fate as past efforts with ambitious long-term goals that did little to drive near-term actions), the accountability framework includes the requirement that the states and the District of Columbia track progress of the TMDL goals in two-year increments.[112] EPA expects these milestones to ensure implementation of the WIPs "by identifying specific near-term pollutant reduction controls and a schedule."[113] Further, the tracking and accountability system will show if the milestones are met and EPA will evaluate these milestones to determine if they are adequate to reach pollution reduction goals.[114]

If progress is insufficient, EPA may take "actions to ensure pollution reductions."[115] For instance, EPA may use its authority to increase the stringency of pollution limits on point sources of pollution by adopting more stringent effluent limitations on sewage treatment plants, urban stormwater discharges, and large feedlot operations.[116] Other consequences include withholding or conditioning federal grants, increasing federal enforcement against polluters, and "more tightly overseeing states' pollution control" strategies.[117]

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110. B. L. Benham et al., *Comparison of Best Management Practice Adoption Between Virginia's Chesapeake Bay Basin and Southern Rivers Watersheds*, 45 J. EXTENSION 1 (2007), http://www.joe.org/joe/2007april/rb3.php.

111. DEL. CHESAPEAKE INTERAGENCY WORKGROUP, DELAWARE'S PHASE I CHESAPEAKE BAY WATERSHED IMPLEMENTATION PLAN 132–43 (2010), http://www.dnrec.delaware.gov/swc/wa/Documents/ChesapeakePhaseIWIP/DE_PHASE1_WIPwAppendices_11292010.pdf; MD. DEP'T NAT. RES., MARYLAND'S PHASE I WATERSHED IMPLEMENTATION PLAN FOR THE CHESAPEAKE BAY TMDL 5-14 to 5-17 (2010), http://www.mde.state.md.us/programs/Water/TMDL/Documents/www.mde.state.md.us/assets/document/MD_Phase_I_Plan_12_03_2010_Submitted_Final.pdf; N.Y. STATE DEP'T OF ENVTL. CONSERVATION, FINAL PHASE I NUTRIENT AND SEDIMENT WATER QUALITY IMPROVEMENT AND PROTECTION PLAN FOR NEW YORK SUSQUEHANNA AND CHEMUNG RIVER BASINS AND CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD 66–72 (2010), http://www.dec.ny.gov/docs/water_pdf/finalphaseiwip.pdf.

112. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-6 to 7-8 (outlining EPA's expectations for each bay jurisdiction under the accountability framework and how the jurisdictions are expected to measure progress every two years).

113. *Id.* at ES-8.

114. *Id.* at 7-10 to 7-11.

115. *Id.* at ES-8.

116. *Id.* at 7-12.

117. *Am. Farm Bureau Fed'n*, 792 F.3d at 303; Letter of Shawn M. Garvin, *supra* note 87, 3–4 (listing potential actions that EPA can take to ensure jurisdictions "develop and implement appropriate Watershed Implementation Plans").

Further, this framework includes opportunities to adjust state plans as they learn what is or is not working in each phase of implementation.[118] In EPA's words, the accountability framework "incorporates an adaptive management approach that documents implementation actions, assesses progress, and determines the need for alternative management measures based on the feedback of the accountability framework."[119] EPA established the legal foundation of the Chesapeake Bay TMDL upon the inclusion of this adaptive-management feature of the TMDL and the premise that, while motivated by the need to meet the reasonable-assurances standard, the states and the District of Columbia voluntarily adopted their WIPs.[120] It was this premise that the American Farm Bureau and other plaintiffs challenged.[121]

IV. AMERICAN FARM BUREAU AND NATIONAL HOMEBUILDERS' CHALLENGE

On January 10, 2011, less than two weeks after EPA adopted the Chesapeake Bay TMDL, the American Farm Bureau Federation and the National Association of Homebuilders, among others (collectively referred to as the "Farm Bureau"), challenged the TMDL as a violation of the CWA and also argued that EPA had exceeded the Constitutional limits of its authority.[122] None of the affected states or the District of Columbia joined the Farm Bureau's challenge.[123] The U.S. District Court for the Middle District of Pennsylvania, Judge Sylvia Rambo, found that EPA's approach was consistent with the CWA and granted summary judgment for EPA.[124] The Farm Bureau appealed to the United States Third Circuit Court of Appeals.[125]

In their appeal, the Farm Bureau argued that EPA exceeded its CWA authority by setting deadlines and allocations within the TMDL and by requiring the states to provide reasonable assurance that the WIPs would

118. CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16, at 7-8 to 7-12.

119. *Id.* at 7-2 to 7-3.

120. *Watershed Implementation Plans*, *supra* note 58; *Am. Farm Bureau Fed'n*, 792 F.3d at 308.

121. *Am. Farm Bureau Fed'n*, 792 F.3d at 287.

122. Am. Farm Bureau Fed'n v. U.S. Envtl. Prot. Agency, 984 F. Supp. 2d 289, 294–95 (M.D. Penn. 2013).

123. Though West Virginia joined in an amicus brief in support of the American Farm Bureau in the Third Circuit appeal. Brief of the States of West Virginia et al. as Amici Curiae in Support of Reversal, *Am. Farm Bureau Fed'n*, 792 F.3d 281.

124. *Am. Farm Bureau Fed'n*, 984 F. Supp. 2d at 334.

125. *Am. Farm Bureau Fed'n*, 792 F.3d at 281.

work.[126] Noting that the term "total load" was "just a number,"[127] the Farm Bureau argued that EPA's interpretation of Section 303(d) co-opted state authority and interfered in the states' traditional authority to regulate land use.[128] The Third Circuit, made up of a panel of Judges Ambro, Scirica, and Roth, in a decision authored by Judge Ambro, unanimously disagreed.[129] The Farm Bureau and other plaintiffs then filed a petition for certiorari with the United States Supreme Court, which was denied.[130]

A. EPA's Authority Under the Clean Water Act

At the outset, the Third Circuit tackled the different uses of the term "TMDL" by the parties.[131] As has become common among those working to implement the CWA, EPA's usage of the term "TMDL" is typically intended to encompass a comprehensive framework for pollution reduction for impaired waters—a concept that includes the various implementation documents associated with the TMDL, regulatory requirements enforceable under EPA's NPDES program, and requirements established under state or local law.[132] In contrast, the Farm Bureau argued, at least in part, that the development of a TMDL as used in Section 303(d) of the CWA is just a mathematical exercise to determine what level of pollution a water body can assimilate without violating water quality standards and nothing more.[133]

The court agreed with EPA that while TMDLs are not self-executing, they "serve as the cornerstones for pollution-reduction plans that do create enforceable rights and obligations."[134] Rejecting the Farm Bureau's argument that the term "total maximum daily load" is unambiguous, the Third Circuit looked to other federal court decisions,[135] the language of Section 303(d), and the goals and objectives of the CWA to find that the TMDL provision is ambiguous and that EPA therefore had the authority to

126. *Id.* at 292.
127. *Id.* at 297.
128. *Id.* at 301–02.
129. Lawrence R. Liebesman & Julie B. Kuspa, *Third Circuit Federal Appellate Court Upholds EPA's Chesapeake Bay TMDL*, MASS. STATE BAY ASS'N (Aug. 15, 2015), http://www.msba.org/Bar_Bulletin/2015/08_-_August/Third_Circuit_Federal_Appellate_Court_Upholds_EPA_s_Chesapeake_Bay_TMDL.aspx.
130. *Am. Farm Bureau Fed'n*, 729 F.3d 281, *cert. denied*, 136 S. Ct. 1246 (2016).
131. *Am. Farm Bureau Fed'n*, 792 F.3d at 287.
132. *Id.*
133. *Id.*
134. *Id.* at 291.
135. *Id.* at 301–302.

interpret and implement that provision in a reasonable and legitimate manner.[136]

Analyzing the language of Section 303(d) in light of the goals of the CWA, the Third Circuit panel rejected the Farm Bureau's arguments that EPA lacked authority to adopt the TMDL.[137] Specifically, the court held that EPA may include in TMDLs allocations of permissible levels of pollutants among the various sources and set target dates for achieving the necessary pollutant reductions.[138] The court also held that EPA was authorized, using the reasonable-assurances standard, to require commitments from the affected jurisdictions to implement plans for meeting those targets.[139] The court reasoned that because the CWA expects a partnership between states and federal government "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters,"[140] EPA's approach using "allocations, target dates, and reasonable assurances" in coordination with the states was allowable.[141]

B. Traditional State Power to Regulate Land Use

The Third Circuit also rejected the Farm Bureau's argument that EPA's approval of the Chesapeake Bay TMDL encroaches on the traditional role of state and local governments.[142] Specifically, the Farm Bureau argued that EPA overstepped its authority by interpreting the CWA in a manner that co-opted traditional state power to regulate land use.[143] The court rejected the Farm Bureau's argument and explained that although the TMDL's requirements could appear to effect land use, those provisions were "either explicitly allowed by federal law or too generalized to supplant state zoning powers in any extraordinary way."[144]

Relying on the structure of the TMDL, in which the states voluntarily adopted the WIPs as a means of ensuring federal funding and avoiding certain consequences, the court found that EPA gave "the states flexibility in achieving the limits EPA set—preserving state autonomy in land-use and zoning."[145] For this reason, the panel concluded that "the TMDL does not

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136. *Id.* at 296; *see* Chevron, U.S., Inc. v. Nat. Res. Council, 467 U.S. 837 (1984) (recognizing that deference must be given to the agency if a term in a statute is ambiguous).
137. *Am. Farm Bureau Fed'n*, 729 F.3d at 299–300.
138. *Id.*
139. *Id.*
140. 33 U.S.C. § 1251(a).
141. *Am. Farm Bureau Fed'n*, 792 F.3d at 299.
142. *Id.* at 304.
143. *Id.* at 302.
144. *Id.*
145. *Id.* at 303.

prescribe land use rules that excessively intrude on traditional state authority."[146] Further, the court held that the provisions of the TMDLs accountability framework, specifically EPA actions used as backstops in the event of failure of the states to implement their WIPs, are "plainly within the EPA's authority."[147]

C. Constitutional Questions

The Third Circuit also dispensed with the Farm Bureau's argument that EPA's exercise of CWA authority in adopting the Chesapeake Bay TMDL exceeded the bounds of its authority under the Commerce Clause.[148] The court noted the long-standing recognition of federal authority to regulate interstate waterways and concluded that there is no serious question whether Chesapeake Bay is a channel of interstate commerce.[149] As the court pointed out, Chesapeake Bay produces large amounts of seafood per year, many ships navigate the bay to reach port towns, and Chesapeake Bay's economic value is estimated at more than one trillion dollars.[150] Further, distinguishing the U.S. Supreme Court decisions relating to limits on the reach of CWA authority over certain waters, namely *SWANCC* and *Rapanos*, the Third Circuit noted that "we are not concerned here with a small intrastate area of wetland; we are dealing with North America's largest estuary."[151]

D. EPA's Legitimate Policy Choice

Applying *Chevron* deference, the Third Circuit held that EPA's interpretation of CWA Section 303(d) was reasonable in light of the gap left by Congress and upheld the Chesapeake Bay TMDL as "a legitimate policy choice by the agency in administering a less-than-clear statute."[152] The court reasoned that the pollution limits and allocations for states to regulate water pollution found in the TMDL are necessary to achieve the goals of the CWA.[153]

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146. *Id.* at 304.
147. *Id.* at 303–04.
148. *Id.* at 306.
149. *Id.* at 304–05.
150. *Id.* at 305.
151. *Id*. at 306; *cf.* Rapanos v. United States, 126 S. Ct. 2208 (2006), *and* Solid Waste Agency v. U.S. Army Corps of Eng'rs, 121 S. Ct. 675 (2001) (explaining the limited reach of the CWA, of which the Act could not apply in these cases because these cases involved small intrastate area of wetland).
152. *Am. Farm Bureau Fed'n*, 792 F.3d at 309.
153. *Id.* at 306–07.

The court rejected Farm Bureau's claims that Chesapeake Bay would be restored, independent of EPA engagement. With obvious incredulity, the Third Circuit states that this "contention defies common sense and experience"[154] in light of the fact that in 2010, 25 years past the date by which the CWA sought to eliminate water pollution, "62% of the Bay had insufficient oxygen to support aquatic life, and only 18% of the Bay had acceptable water clarity."[155]

The court concludes its opinion by noting, with approval, the importance of allowing EPA "to coordinate among all the competing possible uses of the resources that affect the Bay."[156] Relying on the uncontroverted fact that a substantial portion of the pollutant load into Chesapeake Bay is the result of nonpoint source pollution in the form of runoff from farms and cities, the Court notes the need to avoid limiting EPA's authority in a manner that would "shift the burden of meeting water quality standards to point source polluters" when "regulating them alone would not result in a clean Bay."[157]

V. PETITION FOR CERTIORARI TO THE U.S. SUPREME COURT

On February 29, 2016, with Justice Scalia's seat on the Court still draped in black following his death two weeks earlier, the U.S. Supreme Court denied the Farm Bureau's request to hear an appeal of the Third Circuit's decision.[158] This result is not a surprise given that there was no split among the circuit courts on the issues raised, the lack of any obvious error of law in the Third Circuit's decision, and the absence of any real constitutional issues. The Farm Bureau attempted to manufacture a circuit split by arguing that the Third Circuit's decision was inconsistent with the Eleventh Circuit decision in *Sierra Club v. Meiburg*.[159] In *Meiburg*, the Eleventh Circuit answered, in the negative, a different question: whether EPA could be required by a federal court to develop a TMDL implementation plan.[160] In *American Farm Bureau v. EPA*, however, the Third Circuit never suggested that EPA could or should develop the implementation plans for the states. That authority was left to the states themselves by the TMDL being challenged and so the parties never argued

154. *Id.* at 309.
155. *Id.*
156. *Id.*
157. *Id.*
158. *Am. Farm Bureau Fed'n*, 729 F.3d 281, *cert. denied*, 136 S. Ct. 1246 (2016).
159. Petition for Writ of Certiorari at ii, *Am. Farm Bureau Fed'n*, 729 F.3d 281; Sierra Club v. Meiburg, 296 F.3d 1021 (2002).
160. *Meiburg*, 296 F.3d at 1023.

and the court never decided whether EPA could develop its own implementation plan.

The Supreme Court may have considered it relevant that none of the affected jurisdictions (the six States or the District of Columbia) supported the Farm Bureau's Petition for Certiorari.[161] Those states and the District are fully engaged in implementing the Chesapeake Bay TMDL,[162] were not parties to the original challenge by the Farm Bureau,[163] and likely saw little to gain from the delay and confusion that would result from further appeal.

VI. LAKE CHAMPLAIN TMDL AND ACCOUNTABILITY FRAMEWORK

EPA and the State of Vermont can take heart from the Third Circuit Decision in *American Farm Bureau v. EPA* because the Lake Champlain Phosphorus TMDL adopted by EPA on June 17, 2016, includes an approach that follows the same basic roadmap used in Chesapeake Bay.[164] As discussed in several of the articles in this issue of the *Vermont Journal of Environmental Law*, the Lake Champlain Phosphorus TMDL includes the same three elements at issue in the Chesapeake Bay TMDL litigation: (1) pollution allocations among the various sources; (2) a timetable for achieving the required reductions in pollutant load; and (3) reliance upon phased implementation plans developed by the State of Vermont to address both point and nonpoint sources of pollution as the basis of EPA's reasonable assurances finding.[165] Further, the Lake Champlain TMDL includes a similar accountability framework with milestones and EPA backstops in the event that Vermont does not implement its plan.[166]

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161. Petition for Writ of Certiorari at ii, *Am. Farm Bureau Fed'n*, 729 F.3d 281; Sierra Club v. Meiburg, 296 F.3d 1021 (2002). (indicating the parties who joined the petition for writ of certiorari).

162. *See Watershed Implementation Plans*, *supra* note 58 (showing all seven jurisdictions' Watershed Implementation Plans).

163. *Am. Farm Bureau Fed'n*, 984 F. Supp. 2d at 294–95.

164. *Compare* PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 21, *with* CHESAPEAKE BAY TMDL FOR NITROGEN, PHOSPHORUS, AND SEDIMENT, *supra* note 16.

165. *See generally* PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 21, at chs. 6–8 (chapter six discusses establishing allocations, chapter seven lays out the Reasonable Assurance and Accountability Framework, and chapter eight explains the implementation process).

166. Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *infra* pp. 683–84.; Matt Chapman & Jen Duggan, *The Transition Towards the 2016 Lake Champlain TMDL: A Survey of Select Water Quality Litigation in Vermont from 2003–2015*, *infra* pp. 646–48 (discussing the weaknesses of the 2002 Lake Champlain TMDL that were addressed in the 2016 TMDL).

CONCLUSION

The Third Circuit decision in *American Farm Bureau v. EPA*, upholding EPA's authority to issue the Chesapeake Bay TMDL, provides a strong legal foundation for EPA and states to work together to develop plans for controlling all sources of pollution, especially nonpoint sources, in the many large, complex, and impaired watersheds across the country. From the Great Lakes to the Gulf of Mexico and from the Long Island Sound to the Puget Sound, the nation, the states, and many communities have a significant stake in finding collaborative solutions so that we can recover the full ecological and economic health of our most precious waters and their watersheds.

While the *American Farm Bureau v. EPA* litigation is over, the fight over the role of the CWA in addressing polluted runoff from farms and development is not. The President of the American Farm Bureau, Zippy Duvall, released a statement in response to the U.S. Supreme Court's denial of his organization's petition for certiorari:

> EPA has asserted the power to sit as a federal zoning board, dictating which land can be farmed and where homes, roads[,] and schools can be built. We remain firm in opposing this unlawful expansion of EPA's power. We will closely monitor the agency's actions in connection with the Bay blueprint, as well as any efforts to impose similar mandates in other areas. This lawsuit has ended, but the larger battle over the scope of EPA's power is not over.[167]

Will Baker, President of the Chesapeake Bay Foundation, offers a less combative tone:

> We have consistently urged partnership[,] not litigation, and now we hope to achieve it. Let's show the world that the polarization[,] which poisons so much of our society today[,] can be rejected here on the Bay. Our collective and collegial efforts to Save the Bay, a true national treasure, can be a model for other waters worldwide.[168]

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167. *Statement by Zippy Duvall, President, American Farm Bureau Federation, Regarding Supreme Court Petition for Certiorari*, VOICE AGRIC.: AM. FARM BUREAU FED'N (Feb. 29, 2016), http://www.fb.org/newsroom/news_article/405/.

168. Press Release, Chesapeake Bay Found. Supreme Court Allows Chesapeake Bay Blueprint to Stand (Feb. 29, 2016), http://www.cbf.org/news-media/newsroom/fed/2016/02/29/supreme-court-allows-chesapeake-bay-blueprint-to-stand.

Despite the likelihood of future lawsuits and ongoing Congressional pressure, EPA should franchise the approach taken in the Chesapeake Bay watershed in order to bend the curve of nutrient pollution downward by creating accountability in programs to control polluted stormwater runoff. For those who care about restoring Lake Champlain, the saga of the efforts to restore Chesapeake Bay have particular relevance and is not just instructive, but inspirational.

THE LAKE CHAMPLAIN BASIN PROGRAM: ITS HISTORY AND ROLE

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INTRODUCTION

The Lake Champlain Basin Program ("LCBP") is a collaborative partnership of state, federal, provincial and municipal leaders, and several non-governmental members, presenting a strong international foundation for cooperation and action to protect and restore the water quality of Lake Champlain. Now in its 25th year of operations, the LCBP reflects the strengths of the convergent mandates of two very dissimilar governmental initiatives: an international Memorandum of Understanding ("MOU") between two U.S. states and a Canadian province in 1988 and an Act of the United States Congress in 1990.

The 1988 MOU between the States of Vermont and New York and Quebec bound the parties to communicate on Lake Champlain issues and established a Joint Committee for this purpose. The Joint Committee, which later came to be called the "Lake Champlain Steering Committee," was not provided with operational funds.

The Lake Champlain Special Designation Act of 1990 ("LCSDA"), an amendment of the U.S. Federal Clean Water Act, designated Lake Champlain as a resource of national significance.[2] This Act directed the U.S. Environmental Protection Agency ("EPA") to convene a multi-jurisdictional "Lake Champlain Management Conference" to develop a restoration plan for Lake Champlain, and it authorized federal funding.[3] In 1991, EPA Region I assembled the Lake Champlain Management Conference, which began working in June of that year.[4] In 1992, the Management Conference established the LCBP as the organizational vehicle to accomplish its work.[5] In 1996, the Management Conference concluded its work, resulting in the comprehensive management plan: Opportunities for Action: An Evolving Plan for the Future of the Lake Champlain Basin ("OFA-1996").[6] The new plan assigned plan implementation and oversight of the LCBP to the Lake Champlain Steering Committee, and expanded its membership, adding U.S. federal agencies, municipalities, and non-governmental members. In the course of its work

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2. Lake Champlain Special Designation Act of 1990, Pub. L. No. 101-596, § 301, 104 Stat. 3006 (1990) (codified at 33 U.S.C. § 1251).

3. § 210, 104 Stat. 3006.

4. Meeting Minutes from Lake Champlain Management Conference (June 3, 1991) (on file with author and Vermont Journal of Environmental Law).

5. Meeting Minutes from Lake Champlain Management Conference (Mar. 5, 1992) (on file with author and Vermont Journal of Environmental Law).

6. LAKE CHAMPLAIN MGMT. CONFERENCE, OPPORTUNITIES FOR ACTION: AN EVOLVING PLAN FOR THE FUTURE OF THE LAKE CHAMPLAIN BASIN (1996), http://www.lcbp.org/wp-content/uploads/2013/03/OFA-1996.pdf [https://perma.cc/DBB2-777Y].

developing a management plan, the Lake Champlain Management Conference became a forum for dialogue, debate, and the development of working relationships among leaders from each jurisdiction.

The role of the LCBP is to regularly bring together jurisdictional partners from Vermont, New York, Quebec, numerous U.S. federal agencies, and others to examine, debate, and coordinate the environmental management of Lake Champlain and its watershed. Several inter-jurisdictional agreements advancing the stewardship of the Lake Champlain watershed have been facilitated by the LCBP, resulting in a robust culture of cross-boundary collaboration to protect and restore the water quality of the lake. The Lake Champlain Steering Committee annually allocates funds to: long-term goals; basin-wide monitoring of water resources; local plan implementation grants; direct pollution prevention projects; targeted research; educational programs; operational assistance to watershed organizations; and heritage and recreational programs that connect people to the lake.

I. HISTORY OF THE LAKE CHAMPLAIN BASIN PROGRAM

A. Convergent Mandates

The 1988 MOU among the States of Vermont and New York and the Canadian Province of Quebec established a Joint Committee on environmental management of Lake Champlain. This MOU represented the first cross-boundary, whole-watershed effort to manage Lake Champlain water quality and establish a forum to address a wide range of stewardship initiatives. The agreement provided a scope and specific objectives in the three-jurisdiction relationship that had been developing informally during the previous few years. Although no funds were allocated to directly support the work of the Joint Committee, the MOU triggered a significant boost in communication among personnel from each jurisdiction, as reflected by several collaborative agreements among the two states and the province. By 1992, the Joint Committee was commonly known as the Lake Champlain Steering Committee.[7]

Following the MOU by two years, the LCSDA, an amendment of the U.S. Federal Clean Water Act, was signed into law.[8] The new law—introduced by Vermont's U.S. Senator Patrick Leahy and co-sponsored by U.S. Senators Jeffords (VT), Moynihan (NY), and D'Amato (NY)—was

7. LAKE CHAMPLAIN PROJECT DIRECTORY 2 (1992).
8. Lake Champlain Special Designation Act § 301.

included as a component of the larger Great Lakes Critical Programs Act of 1990, sponsored by U.S. Senator Levin (MI). The LCSDA established the lake as a special project area under the U.S. Department of Agriculture Conservation Program, and it directed the EPA to convene a multi-agency Lake Champlain Management Conference to develop a pollution prevention, control, and restoration plan for Lake Champlain. The Act established a Technical Advisory Committee ("TAC") of experts from federal and state agencies and local research institutions to provide technical and scientific advice to the Management Conference and to ensure that policy and budget decisions would be well informed by contemporary science.

Throughout the five-year period (1991–1996) of management plan formulation by the Lake Champlain Management Conference, several conference members also served on the Joint Committee (later called the Lake Champlain Steering Committee) established by the 1988 MOU. Following an extensive review, vigorous public comments, and significant draft revisions, the first comprehensive management plan for Lake Champlain and its drainage basin, OFA-1996, was signed by the Governors of Vermont and New York and the Regional Administrators of EPA Regions I and II. The Lake Champlain Management Conference, having fulfilled its planning mandate, dissolved itself. Implementation of the new plan and continuing oversight of the LCBP was assigned to an expanded Lake Champlain Steering Committee, in accord with the implementation strategy specified in OFA-1996.[9]

Following the completion of OFA-1996, the Special Designation Act was ripe for reauthorization to reflect the transition from plan formulation to plan implementation, and to increase the level of EPA funding authorized for the LCBP. The Daniel Patrick Moynihan Lake Champlain Act of November 2002 amended Section 120 of the Federal Water Pollution Control Act to codify the establishment of the LCBP.[10] This amendment recognized the new management plan, calling for it to be "reviewed and revised, as necessary, at least once every five years, in consultation with the Administrator and other appropriate Federal agencies." [11] It also increased authorized support for the LCBP to $11 million annually via funds to the

9. LAKE CHAMPLAIN BASIN PROGRAM, BACKGROUND TECHNICAL INFORMATION FOR: OPPORTUNITIES FOR ACTION-AN EVOLVING PLAN FOR THE FUTURE OF THE LAKE CHAMPLAIN BASIN (June 1996), http://www.lcbp.org/wp-content/uploads/2013/03/16_BackgroundTechnicalInformation_OpportunitiesForAction.pdf [https://perma.cc/62E4-CW89].

10. Daniel Patrick Moynihan Lake Champlain Basin Program Act of 2002, Pub. L. No. 107-303, §201, 116 Stat. 2358 (2002) (codified at 33 U.S.C. § 1251).

10. *Id.*

EPA from the Department of the Interior appropriations.[12] Although annual EPA appropriations for Lake Champlain have not approached this level of support, they have increased significantly in the years since the Moynihan Act was passed.

New York, Vermont, and Quebec have reconfirmed he trilateral MOU of 1988 numerous times (1992, 1996, 2000, 2003, and 2010), adjusting and updating it each time to reflect contemporary priorities of the signing parties.[13] Were this agreement merely between the two states, it likely would be termed an interstate compact; however the inclusion of both U.S. states and a Canadian province made the term "MOU" (more often applied to binational agreements) seem more appropriate to the signers. However, unlike many MOUs describing international commitments, this agreement is not binding under international law as it is not an agreement among national governments; it is not registered in the United Nations Treaty Collection.

Conversely, each edition of OFA (1996, 2002, 2010) does involve one national government, as each has been endorsed by the U.S. government through the signature of the Administrators of EPA Regions I and II, in addition to the signatures of the contemporary governors of Vermont and New York. In order for OFA to become an international agreement, there would need to be parity among the signers from both the U.S. and Canada, reflecting commitments by both executive branches. However, in view of the predominate responsibilities and virtual control of Quebec over the management of its natural resources, and Quebec's strong role in the work of the LCBP, a need to pursue a Canadian federal role on the Lake Champlain Steering Committee has not developed. This perspective also reflects the contemporary political realities of Quebec's storied history spanning more than 400 years since its earliest days as New France in North America.

Although the absence of international parity between the U.S. government and the Province of Quebec prevents a binational agreement, and the U.S. federal endorsement precludes Quebec's signature on OFA, recent editions of the plan feature a strong supportive letter from the Premier. The inclusion of Quebec content and expression of commitment does result in a U.S. Department of State protocol review of each revision draft of OFA prior to EPA's signatures, and past editions of the plan have met approval.

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12. *Id.* at 2360.

13. Lake Champlain Basin Program Archives. (on file with author and Vermont Journal of Environmental Law).

The convergent mandates of the Federal Clean Water Act and the cross-boundary MOU from 1988 have resulted in the Lake Champlain Steering Committee charged with oversight of the LCBP. The multi-jurisdictional foundation and collective mandate of the Lake Champlain Steering Committee draws substantial legitimacy from the two very different jurisdictional actions simultaneously. Without a single over-arching agreement, this would not be possible to achieve due to complexities of international and homeland policy constraints on each side of the international border.

B. Federal Program Coordination

The LCSDA authorized collaborative efforts to benefit Lake Champlain by several U.S. federal agencies, and mandated specific tasks for each through a series of instructions to the Secretaries of the Interior and of Agriculture.[14]

The EPA was authorized to provide annual federal funding of $2 million for the five years succeeding the LCSDA to organize and lead the work of the Management Conference. The Management Conference initiated a long-term lake-and-tributary-monitoring program, which was based on the preliminary results of a diagnostic feasibility study conducted by Vermont and New York in response to the 1988 MOU,[15] to inform the planning process. The Management Conference also designed and funded numerous research projects to answer critical planning and management questions in the years of plan formulation. Throughout the planning process, the Management Conference funded numerous local grants to reduce lake pollution, impede the spread of aquatic invasive species, and to increase public access for lake users. Annual appropriations were generally consistent with the authorization and, subsequent to reauthorization in 2002, funding has continued in the years since.

The U.S. Department of Agriculture was mandated to designate the Lake Champlain watershed as a special project area under the Agriculture Conservation Program established in the Soil Conservation and Domestic Allotment Act.[16] This designation increased the soil conservation and

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14. Lake Champlain Special Designation Act, §301, 104 Stat. at 3006–3010.

15. VT. DEP'T ENVTL. CONSERVATION & N.Y. STATE DEP'T ENVTL. CONSERVATION, A PHOSPHORUS BUDGET, MODEL, AND LOAD REDUCTION STRATEGY FOR LAKE CHAMPLAIN: LAKE CHAMPLAIN DIAGNOSTIC-FEASIBILITY STUDY (1997), http://www.vtwaterquality.org/lakes/docs/lp_lcdfs-finalreport.pdf [https://perma.cc/EF6M-X3SV].

16. Lake Champlain Special Designation Act, §304, 104 Stat. at 3008 (codified at 33 U.S.C. § 1270).

technical-assistance funds ceiling and authorized a comprehensive agricultural monitoring and evaluation network for all major drainages in the basin. It also instructed the Secretary of Agriculture to implement these new programs in consultation with the Lake Champlain Management Conference, and to allocate assistance at sites prioritized by the Management Conference. The language of the mandate made clear the legislative intent to reduce and control nonpoint sources of water pollution in the Lake Champlain basin.

The U.S. Geological Survey of the New York and New England Districts were mandated to enhance and expand data collection and monitoring in the Lake Champlain basin and to collaborate with many partners to develop an integrated GIS database for the watershed. This mandate specified the upgrade of intermittent-stream-gauging stations to continuous-stream-gauging stations, and the addition of monitoring stations for water quality and sediment in tributaries.

The U.S. Fish and Wildlife Service ("FWS"), in cooperation with both the existing Lake Champlain Fish and Wildlife Cooperative and the Management Conference, was tasked with establishing and implementing a fisheries restoration, development, and conservation program. The program was to include the maintenance or increase of fish culture operations within the watershed. The service was also mandated to conduct a wildlife and species habitat assessment survey in the watershed to assess species that are listed or proposed for listing as rare or threatened under the Endangered Species Act and to assess migratory nongame species that frequent the watershed. Significantly, the Secretary of the Interior also was instructed to control sea lampreys and other nonindigenous aquatic animal nuisances and improve the health of the fishery resource.

Each of the congressional mandates to the Secretaries of the Interior and of Agriculture included an authorization of funds. The Director of Water Programs at EPA Region 1 convened and chaired the Management Conference. Representatives from EPA Region II, the United State Department of Agriculture-Natural Resource Conservation Service State Conservationists from New York and Vermont, and the manager of the U.S. Fish and Wildlife Service Lake Champlain Complex Office were included as members of the Management Conference. After the approval of OFA-1996, they continued as members of the Lake Champlain Steering Committee. Moreover, a significant and continuous level of collaboration and fund allocations to implement the management plan has persisted from each of these agencies and the U.S. Geological Survey continuously in the years since the Special Designation Act of 1990.

1. The Lake Champlain Management Conference

As mandated by the Special Designation Act of 1990, the EPA Region I office convened the Lake Champlain Management Conference in the summer of 1991. The Management Conference began its work with a visioning exercise that brought its members, many of them unknown to others in the group, to some common ground by identifying shared goals. At its first meeting, the Management Conference established the LCBP as the organizational vehicle to accomplish its work. Early in its deliberations, the Management Conference recognized that the management plan would be an advisory rather than a regulatory enforcement tool. Although the group held widely disparate views on this and other topics, the Management Conference chose a consensus model for most of its decision making. Votes were held when it was necessary for the record or when members wished to record that consensus was not reached; progress could be maintained in this way. The thirty-one-member Management Conference met nearly monthly, from 1991 to its dissolution in 1996, to direct the operations of the LCBP and to develop the comprehensive management plan.

One of the motivating factors leading to the 1988 MOU was the compelling need for cross-boundary collaboration to establish common, lake-wide, numeric phosphorus concentration targets for Lake Champlain. Through Steering Committee member dialogue, New York, Vermont, and Quebec agreed to endorse specific in-lake phosphorus criteria as interim management goals until a consistent set of state water quality criteria could be formalized in each jurisdiction.[17] The interim in-lake criteria developed together, were separately codified as water quality standards in Vermont and New York, and also were accepted as water quality targets where applicable in Quebec.

The Management Conference benefitted from the pattern of collaborative cross-boundary problem solving that followed the 1988 MOU in a number of ways and it seems certain that the reciprocal also was true. As the leadership in each jurisdiction developed confidence in and familiarity with each other, the increased professional regard and mutual trust grew incrementally with each successful agreement.

The Management Conference allocated EPA funds provided to the LCBP, establishing a long-term-monitoring program at optimal locations in Lake Champlain and tributary rivers. The LCBP also supported: targeted

17. ERIC SMELTZER, HISTORY OF THE LAKE CHAMPLAIN PHOSPHORUS TMDL (2013), http://www.emcenter.org/wp-content/uploads/2013/02/History-of-Lake-Champlain-T.M.D.L..pdf [https://perma.cc/NH9W-UAZ2].

research to clarify planning and management needs; a vigorous local grants program to reduce pollution; management of aquatic invasive species and increased public access to the waterfront; and a number of educational and outreach programs.

The Management Conference established and relied upon several advisory committees to ensure that these efforts remained informed by and relevant to the community of the lake basin.

The TAC assumed a critically important role in developing the key specifications of requests for proposals subsequently released by the LCBP and assisting in the review and ranking of proposals received. The TAC prepared technical task proposals at the request of the Management Conference. The TAC also worked with LCBP technical staff to interpret anonymous peer reviews of final task deliverables and make recommendations regarding the acceptance of final reports. The TAC has provided technical and scientific advice to the LCBP continuously since its establishment.

The Plan Formulation Team ("PFT") was established as a subcommittee of the Management Conference to develop the draft document that would become the comprehensive management plan. The PFT memorialized many decisions of the group in the language of goals, objectives, and tasks as it worked over the course of years in developing the management plan. Its membership included the chair of the TAC and the director of the Lake Champlain Research Consortium in order to ensure that the language of the draft plan hewed meticulously to technical realities. The PFT worked with LCBP technical staff to ensure that the key technical background information, which provided the basis for management actions called for in the plan was assembled in a supplemental document as the plan took shape.[18] The PFT was dissolved when the management plan was approved in 1996.

The Education and Outreach Committee ("E&O") was established as a subcommittee of the Management Conference to promote a better understanding among citizens and visitors about the stewardship issues in the lake and watershed and the importance of individual action in addressing those issues. E&O provided advice to the Management Conference on the design and cost of education and outreach initiatives needed to inform and improve public involvement in stewardship.

Citizens Advisory Committees ("CACs") were established in Vermont, New York, and Quebec under the 1988 MOU to inform the jurisdictions about public concerns related to Lake Champlain. Appointments to each

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18. BACKGROUND TECHNICAL INFORMATION, *supra* note 9, at 1.

CAC are unique to their respective jurisdiction. Although not mandated in the Special Designation Act, the Vermont and New York chairpersons were invited to be members of the Management Conference.

The Vermont CAC was established in 1988 by Executive action and re-established and expanded in 1990 by the Vermont Legislature. The Vermont House, Senate, and Executive each appointed four members to comprise the twelve member Vermont CAC. The Vermont CAC is charged with presenting its advice pertaining to Lake Champlain management in an annual report to the legislature.

The New York CAC was established by Executive action and is comprised of fourteen members appointed by the New York Department of Environmental Conservation Commissioner.

The Quebec CAC is comprised of eight members appointed by the Ministry of Environment and Climate Change Mitigation. The Quebec CAC became involved with the LCBP in 1996, at the time of the approval of the management plan and the renewal of the 1988 MOU.

2. The Role of New England Interstate Water Pollution Control Commission.

In the earliest days of the Management Conference, LCBP staff resources were provided directly by EPA Regions I and II, and by Vermont Agency Natural Resources and New York Department of Environmental Conservation (with EPA funding). External grants (for pollution prevention or educational programs) and research contracts were issued on behalf of the LCBP by EPA Region I. As the program grew, the number of small grants and contracts became ill-suited for regional EPA office management and there was growing inconsistency in the management of human resources. In 1992, the Management Conference invited the New England Interstate Water Pollution Control Commission ("NEIWPCC") to serve as the fiscal agent for the operations of the LCBP. NEIWPCC accepted the role of fiscal manager for the LCBP and since that time, has received the bulk of EPA funds in order to employ LCBP human resources and to handle contracts and accounting.

"Established by Congress in 1947, NEIWPCC is a 501(c)(3) corporation that also operates under a seven-state compact."[19] NEIWPCC's primary mission is to assist member states (the six New England states and

19. *A Strategy for Implementing the Plan*, LAKE CHAMPLAIN BASIN PROGRAM, http://plan.lcbp.org/ofa-database/chapters/a-strategy-for-implementing-the-plan [https://perma.cc/4HRW-GW2J] (last visited June 10, 2016).

New York) by providing coordination, public education, training, and leadership in the protection of water quality and related work in the region.[20] The LCBP-NEIWPCC relationship has proved a successful model in the years since 1992. LCBP operational policy, budgeting, and contract selection decisions remained the domain of the Management Conference and its successor, the Lake Champlain Steering Committee, with implementation professionally managed by NEIWPCC staff.

II. THE MANAGEMENT PLAN EVOLVED

A. Opportunities for Action: 1996

In 1996, the Lake Champlain Management Conference concluded its plan formulation assignment, resulting in the comprehensive management plan for Lake Champlain, OFA-1996.[21] Public involvement in the development of the plan was extensive, including twenty-eight formal public meetings around the basin, a public comment period, a period of extensive re-writing, and additional public meetings prior to the completion of the final draft. When the plan was signed by the Governors of New York and Vermont and the Regional Directors of EPA Regions I and II, the Management Conference ceased operations. Because the management plan bears the signatures of U.S. federal agencies, it does not include a signature from Quebec—that would trigger international agreement protocols that would not be achievable in this case. However, Quebec assumed a vital partnership role in both the oversight and the implementation of OFA-1996 and subsequent editions of the plan with up to six seats on the Lake Champlain Steering Committee.

The new management plan assigned the oversight of the implementation work of the LCBP to the Lake Champlain Steering Committee and expanded that committee to include municipal representatives, non-governmental members, and several U.S. federal agencies, including those that provide funds to the LCBP. Since 1996, the Lake Champlain Steering Committee has set the policies of the LCBP and guided the expenditures of U.S. federal funding annually appropriated to the LCBP for plan implementation. The active involvement of Quebec on the Lake Champlain Steering Committee arises from its party status in the New York-Vermont-Quebec MOU, which was not signed by either U.S. or Canadian officials.

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20. *Id.*
21. LAKE CHAMPLAIN MGMT. CONFERENCE, *supra* note 5.

OFA-1996 provided for the Lake Champlain Basin Program to be a multi-partner, watershed-based, non-regulatory, collaborative stewardship effort. The plan recognized three highest-priorities action areas and included specific task descriptions to accomplish each:

- Reduce phosphorus in targeted watersheds of the lake. Based on phosphorus loading information for tributaries and concentrations in thirteen lake segments, the plan called for major point source and nonpoint source load reductions.
- Prevent and control persistent toxic contaminants found lake-wide or in localized areas of the lake. This action area was primarily concerned with mercury and polychlorinated biphenyls ("PCB") contamination and both ecosystem impact and human health protection.
- Develop and implement a comprehensive management program for nuisance non-native aquatic species. This program aimed to stop both the invasion and spread of nuisance non-native aquatic species and included efforts such as sea lamprey control and water chestnut harvesting.

OFA-1996 also accorded high priorities to other pressing management concerns, with chapters addressing water quality and the health of the lake, living natural resources, recreation and cultural resources, and a written strategy for plan implementation.

B. Opportunities for Action: 2003

The management plan was intended to evolve to reflect changing stewardship needs. It was extensively revised in April of 2003, and signed by the Governors of New York and Vermont and the Regional Directors of the EPA Regions I and II. The new plan (OFA-2003) was published in hardcopy in English[22] and in French.[23] Although the Premier of Quebec did not sign the document, it does contain a letter from the Premier pledging support for the implementation of the plan.

OFA-2003 retained the three highest priorities of OFA-1996, and added a fourth:

- Minimize the risks to humans from water-related health hazards in the Lake Champlain Basin. The objectives under

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22. *Id.*

23. LAKE CHAMPLAIN BASIN PROGRAM, PERSPECTIVES D'ACTION: UN PLAN PROGRESSIF POUR L'AVENIR DU BASSIN DU LAC CHAMPLAIN (2003), http://www.mddelcc.gouv.qc.ca/eau/bassinversant/bassins/missisquoi/champlain.pdf [https://perma.cc/VZT3-96F2].

> this priority were focused on pathogens and closed beaches, drinking-water quality, health risks from blue-green algae blooms, and the danger of consumption of mercury contaminated fish.

The U.S. Congress established the Champlain Valley National Heritage Partnership ("CVNHP") in 2006. This national heritage area was designated to recognize the importance of the historical, cultural, and recreational resources of the Champlain Valley; to preserve, protect, and interpret those resources; to enhance the tourism economy; and to encourage partnerships among state, provincial, and local governments and nonprofit organizations in New York, Vermont, and Quebec to carry out the purposes of the legislation. It is uncommon for U.S. federal legislation to include specific recognition of the importance of collaboration of management with interests in another country. However, the CVNHP authorization did reference the importance of cross-boundary coordination with resource managers in Quebec, Canada and it designated the LCBP to be the management entity for the new National Heritage Area.

Most of the CVNHP is located within the Lake Champlain Basin; however, the partnership area also includes Bennington, Vermont and Saratoga, New York counties—areas outside the basin to the south. A three-year CVNHP management plan development process resulted in its approval by the U.S. Secretary of the Interior in 2010, as required by the congressional authorization. The CVNHP Management Plan addresses three approved themes: the making of nations; corridor of commerce; and a culture of conservation. The strategic issues associated with these three themes—the goals, objectives, and actions of the CVNHP management plan—were then included as a chapter in the new online OFA-2010.

C. Opportunities for Action: 2010

The most recent revision of OFA occurred in November of 2010 and included a major overhaul of plan structure and content.[24] The increase in frequency and severity of blue-green algae blooms in the northern part of Lake Champlain since the plan's first edition resulted in a surge of public concern about both the condition of the lake and the inadequacy of efforts to improve water quality. OFA-2010 was designed to be highly responsive to the growing public need for transparency and communication about public sector follow-through in implementing key management actions.

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24. LAKE CHAMPLAIN BASIN PROGRAM, LAKE CHAMPLAIN OPPORTUNITIES FOR ACTION MANAGEMENT PLAN (2010), http://plan.lcbp.org/ [https://perma.cc/7K5A-NZJW].

OFA-2010 identifies eight goals to protect and restore the ecological and cultural resources of the Basin while maintaining a vital regional economy. Based on comments from citizens and other stakeholders at public meetings and on the recommendations of advisory committees, eight goals were designated the highest priorities of the plan:

- promote a better understanding and appreciation of Lake Champlain Basin resources and threats and also personal responsibility that leads to behavioral changes and actions to reduce pollution;
- reduce phosphorus inputs to Lake Champlain to promote a healthy and diverse ecosystem and provide for sustainable human use and enjoyment of the lake;
- reduce contaminants that pose a risk to public health and the Lake Champlain ecosystem;
- maintain a resilient and diverse community of fish, wildlife, and plants in the Lake Champlain Basin;
- prevent the introduction, limit the spread, and control the impact of non-native aquatic invasive species in order to preserve the integrity of the Lake Champlain ecosystem;
- identify potential changes in climate and develop appropriate adaptation strategies to minimize adverse impacts on Lake Champlain's ecosystem and natural, heritage, and socioeconomic resources;
- promote new discoveries of the history, culture, and special resources of the Champlain Valley National Heritage Partnership and make this information accessible to all; and
- promote healthy and diverse economic activity and sustainable development principles within the Lake Champlain Basin while improving water quality and conserving the natural and cultural heritage resources on which the regional economy is based.

In an effort to provide information and transparency, the plan was published in an online database format that allows the public to review which government or management entity has committed to achieving each listed task and to observe updated progress reports (including lack of progress in some cases).[25] This approach was novel and has been met with mixed success and failure. A review of the task status does provide the reader with a clear understanding of the status of task implementation, with notes about how progress is being achieved. However, agency resources

25. *Id.*

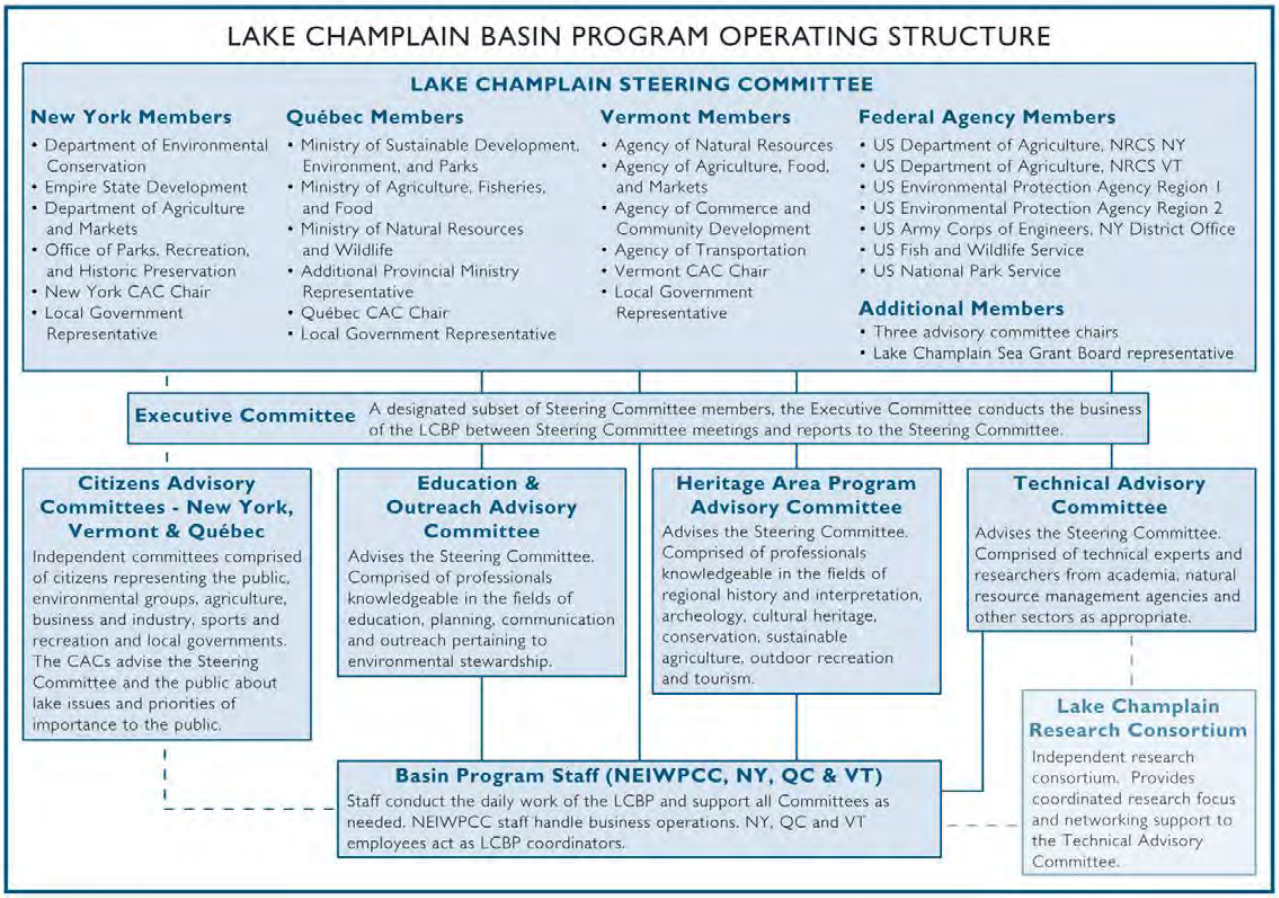
and commitments changed through the years of implementation and reporting discipline faltered during that period. The plan also is available online as a PDF document,[26] but was not published in hardcopy.

D. Lake Champlain Basin Program Governance Refined

From 1996 to 1998 the governance of the LCBP was accomplished solely by the Steering Committee in the course of its usual four meetings each year. The leadership protocol provides that the Steering Committee meet in rotation in each jurisdiction: New York, Quebec, Vermont, and so forth. Each Steering Committee meeting is chaired by the lead environmental officer for the host jurisdiction, and the meeting protocols of the host jurisdiction are applicable. However, as the level of U.S. federal funding for LCBP programs was increasing through the years, the number of decisions on grant and contract awards correspondingly increased and the Steering Committee found its agenda dominated by award decisions rather than policy collaborations. Moreover, a sense developed that the LCBP operations would benefit from more consistent leadership than was provided by the rotation of Steering Committee meetings and chairs.

In 1998, the Steering Committee established an Executive Committee drawn from its members to handle the increased work load. The Executive Committee would be chaired, in rotation of two-year terms, by the lead environmental officer from New York, EPA Region I, and Vermont. The length of the chair's term provides two-year periods of continuity in leadership for the LCBP. The Executive Committee is charged by the Steering Committee and conducts its work between Steering Committee meetings.

26. LAKE CHAMPLAIN STEERING COMM., OPPORTUNITIES FOR ACTION: AN EVOLVING PLAN FOR THE FUTURE OF THE LAKE CHAMPLAIN BASIN (2010), http://www.lcbp.org/wp-content/uploads/2013/03/OpportunitiesForAction2010.pdf [https://perma.cc/29ZU-7ADN].



III. THE PLAN IMPLEMENTATION ROLE OF THE LCBP

A. Background

In the quarter century since the LCBP was established, its role has been to bring jurisdictional partners from the states of New York and Vermont and Quebec together with numerous U.S. federal agencies to coordinate the multi-jurisdictional management of Lake Champlain and its entire watershed.

In practice, the Lake Champlain Steering Committee meets regularly about four times annually and the Executive Committee meets about five times each year. Committee members have developed a comfortable practice of working together, recognizing common issues, and managing resources to address them. This working history of many individual members over the course of years (for example, to prioritize tasks and allocate financial resources) has resulted in an important level of professional respect and personal trust at a member-to-member level. This familiarity and trust has been especially helpful in the dialogue required to address challenging problems.

B. Financial Support

The research, monitoring, outreach, and pollution prevention tasks regularly undertaken by the LCBP include all parts of the Lake Champlain Basin. In the U.S. sector of the basin, federal funding has supported this work primarily through annual appropriations to EPA (since the inception of the program), the National Park Service ("NPS"), and the Department of Agriculture's Natural Resource Conservation Service. Since 2010, the International Great Lakes Fishery Commission ("GLFC") also provided significant support for tasks performed by the LCBP. The International Joint Commission ("IJC") has supported LCBP tasks supported by federal appropriations from the State Department and, to a much lesser degree, Canada's Foreign Affairs office. Since the 1988 MOU, Quebec has provided resources through its Ministry of Environment for management plan tasks implemented in Quebec. The Province maintains close collaboration and cooperation with LCBP partners south of the international border, but funds its own work. LCBP tasks, when funds appropriated for international use are available, are located in Quebec.

Every successful watershed initiative funded with U.S. federal resources relies on a congressional champion to support funding authorizations and to shepherd federal appropriations through the annual budgeting process. Vermont's U.S. Senator Patrick Leahy, regularly a member of the Senate Appropriations Committee and at times Chair of the Senate Judiciary Committee, has provided focused and consistent support for the LCBP, beginning with his sponsorship of the Special Designation Act in 1990 and through annual appropriations in every year since. Vermont's late U.S. Senator Jim Jeffords, former Chair of the Senate Committee on Environment and Public Works, took an active role in the reauthorization of the program in the Daniel Patrick Moynihan Lake Champlain Basin Program Act of 2002, honoring the late New York Senator Moynihan. The federal congressional delegations of Vermont and New York, comprised of four senators and two to three congressional representatives, regularly work as a non-partisan caucus to maintain the funding that allows the LCBP to thrive.

1. United States Environmental Protection Agency Support

EPA regularly enters into grant agreements with NEIWPCC, New York, and Vermont to implement tasks according to a single coordinated LCBP work plan approved by the Lake Champlain Steering Committee. Most tasks are implemented by LCBP staff who, as NEIWPCC employees, provide task management and continuity through annual budget cycles and who coordinate the advisory committees and procedures involved in annual operations. The states of New York and Vermont each enter into grant agreements with EPA to manage implementation tasks that may be more efficiently accomplished by state personnel. Both states maintain Lake Champlain Coordinators, with LCBP funding, who ensure that implementation managed by the states reflects the intentions of the Lake Champlain Steering Committee.

2. Great Lakes Fishery Commission Support

In 2010, following an increase in U.S. federal funding (up to $10 million) provided to GLFC and intended to support expanded work in Lake Champlain, a MOU was endorsed by GLFC, NEIWPCC, and FWS, entailing a commitment of cooperation and coordination on native species, habitat restoration, and water quality improvements in the basin.[27] The MOU recognized that the Great Lakes and Lake Champlain share many natural resource characteristics and management challenges, including many of the same native species, economically important species, and aquatic habitat characteristics. The MOU pledged sharing of expertise, funding, and human resources to benefit fish and wildlife resources and water quality in the Great Lakes and Lake Champlain. This MOU has guided the sharing of annual U.S. federal appropriations made to the GLFC with the LCBP and the FWS.

3. National Park Service Support

Cultural heritage tasks implemented by the LCBP, in its role as management entity of the Champlain Valley National Heritage Partnership in the U.S. sector of the basin, are funded by federal appropriations to NPS and through other federally funded agencies and commissions. U.S. federal

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27. Memorandum of Understanding between the Great Lakes Fishery Commission, the New England Interstate Water Pollution Control Commission, and U.S. Fish and Wildlife Service, for Cooperation and Coordination on Native Species and Habitat Restoration and Water Quality Improvements in the Lake Champlain Basin (July 26, 2010).

appropriations reflect both the executive branch priority and congressional commitments in targeted earmarks through 2010 and in fluctuating programmatic support through budget lines in subsequent years.

4. Quebec Support

Quebec provides direct financial support for ministerial oversight of Lake Champlain in the Quebec sector of the basin. Although these funds are not budgeted by the LCBP in the manner that is applied to U.S. federal funds, Quebec regularly provides staff support, project funding, and local organizational and municipal support to implement aspects of OFA that apply to the Quebec sector of the watershed. Many of the tasks implemented by Quebec are embedded in the five-year management plans regularly prepared and updated by the Ministry of Environment, Sustainable Development and Adaptation to Climate Change to provide operational guidance in the stewardship of Lake Champlain.

IV. WORKING COLLABORATIONS AND PARTNERSHIPS

A. Long-Term Monitoring Project

Since it was established in 1991, the LCBP has developed and maintained a robust long-term monitoring data set, characterizing nutrient concentrations in fifteen lake locations, and concentrations and load at the lower reaches of eighteen tributary streams, along with a broad array of other physical chemical and biological parameters at each location. The Long-Term Monitoring Project is probably the single most important collaborative success through the quarter century of LCBP activities. Through this program, monitoring data are acquired at fifteen fixed sample locations and at the mouths of eighteen tributaries, in accord with a single common annual LCBP work plan developed by all parties through their participation on the TAC. Both LCBP and EPA approve the Quality Assurance Project Plan ("QAAP") and work plan for the U.S. sector activities annually.[28] To ensure continuity and constancy, LCBP provides funds to the governments of both Vermont and New York for staff support for this project, assigns direct LCBP staff support, and provides a sampling

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28. VT. DEP'T OF ENVTL. CONSERVATION WATERSHED MGMT. DIV. & N.Y. STATE DEP'T OF ENVTL. CONSERVATION DIV. OF WATER, QUALITY ASSURANCE PROJECT PLAN FOR THE LAKE CHAMPLAIN LONG-TERM WATER QUALITY AND BIOLOGICAL MONITORING PROJECT 1 (2015).

boat in Vermont, sample equipment, supplies, and reimbursal of laboratory expenses.

Quebec participates directly in the work plan and QAAP development for the Long-Term Monitoring Project and funds and implements tributary sampling north of the international border, following the same criteria and sample parameters and using identical laboratory equipment and analysis protocols. Due to the special interest of Vermont and Quebec for quality assurance of sampling and analysis in the shared Missisquoi Bay watershed, which both jurisdictions sample, an exchange of split samples and reciprocal analysis is regularly practiced. Both Quebec and the U.S. Geological Survey have installed and maintain stream gauging stations so that tributary discharge and nutrient concentration data may be used to calculate tributary load. Numerous other physical, biological, and chemical parameters (such as plankton populations and diversity, surface water temperature, and water clarity) are sampled throughout the soft water season (ice-free) and entered into a comprehensive database that is available to researchers, managers, regulators, and the public.

The long run of monitoring data pertaining to nutrient concentrations, most recently interpreted by LCBP in the State of the Lake 2015 report,[29] has provided a sound basis for Lake Champlain phosphorus Total Maximum Daily Load ("TMDL") calculations.[30] In an operational extension of the LCBP's familiarity with the technical issues and objective perspective on the challenges of achieving water quality standards, staff have facilitated numerous public informational meetings, on behalf of Vermont and EPA, through the course of the revision of the Vermont-Lake Champlain Phosphorus TMDL to be finalized by EPA in 2016.

B. Special Projects

Eighty-one published LCBP Technical Reports present the results of research that has targeted critical management questions.[31] In the initial plan formulation period (from 1991 to 1996), a number of demonstration projects were completed, providing essential information on the efficacy

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29. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATORS REPORT (2015), http://sol.lcbp.org/images/State-of-the-Lake_2015.pdf [https://perma.cc/ZMU4-RCQC].

30. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN (Aug. 14, 2015), http://winooskinrcd.org/wp-content/uploads/phosphorus-tmdls-vermont-segments-lake-champlain.pdf [https://perma.cc/6BZG-KR2Q].

31. *See Technical Reports*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/media-center/publications-library/technical-reports/ [https://perma.cc/SGE7-2ADM] (last visited Mar. 26, 2016) (giving a list of all the completed reports).

and cost of management practices, leading to ten published Demonstration Project Reports.[32] The LCBP local grants program is particularly effective in implementing the priorities of OFA through direct support to communities and organizations to prevent pollution, halt the spread of invasive species, prevent or mitigate toxic or pathogenic contamination, or to promote and deliver education and outreach materials in the watershed. By winter of 2015, LCBP made over 1,000 local grant awards to provide more than $7 million in small awards to improve conditions in Lake Champlain. The larger of these awards have resulted in completion reports that are included in the LCBP grants database.[33]

Many of the research projects chosen for funding by the LCBP have provided essential insight for lake resource managers and policy leaders at state, provincial, and U.S. federal levels. As one example, the Cumberland Bay PCB Study[34] reported on the transport and fate of PCB contamination within Cumberland Bay, New York and estimated the PCB flux from the bay to the main lake. PCBs are persistent industrial chemicals found worldwide that are suspected to cause cancer. Like mercury, they accumulate in larger predatory fish.[35] The resulting report triggered action on the part of the New York State Department of Environmental Conservation to initiate a remediation and brought the adjacent Georgia Pacific paper mill to provide significant funds to the task.[36] "The two-year $35 million cleanup of Cumberland Bay, New York, completed in 2001 by the NY State Department of Environmental Conservation [], removed PCB-laden sediments that had been left in the bay from industrial discharges."[37] On March 27, 2013, Cumberland Bay was removed from the New York

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32. *Id.*

33. *LCBP Grants Map*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-us/grants-rfps/grants-database/lcbp-grants-map-2/ [https://perma.cc/B2ZW-TJ2A] (last visited Apr. 1, 2016).

34. CLIFF CALLIHAN ET AL., CUMBERLAND BAY PCB STUDY 1 (1998), http://www.lcbp.org/wp-content/uploads/2013/03/27_Cumberland_Bay_PCB_Study_1998.pdf [https://perma.cc/HPL3-Q8TN].

35. LAKE CHAMPLAIN BASIN PROGRAM, STATE OF THE LAKE: LAKE CHAMPLAIN IN 2005–A SNAPSHOT FOR CITIZENS 7 (2015), http://www.lcbp.org/wp-content/uploads/2013/03/sol_web.pdf [https://perma.cc/Q336-PFZX].

36. *See* CITY OF PLATTSBURG LOCAL WATERFRONT REVITALIZATION PROGRAM, CITY OF PLATTSBURG LOCAL WATERFRONT REVITALIZATION PROGRAM 17, 43 (2010), http://www.cityofplattsburgh-ny.gov/DocumentCenter/View/157 [https://perma.cc/4732-GVHP] (discussing PCB contamination adjacent to the Georgia Pacific site and past and continuing mitigation efforts in the area).

37. STATE OF THE LAKE: LAKE CHAMPLAIN IN 2005, *supra* note 35.

State Toxic Superfund Site list as it no longer presented a public hazard due to PCB contamination.[38]

Mimeault and Manley describe the cooperative efforts of Quebec and Vermont in forming the Missisquoi Bay Phosphorus Reduction Task Force in 1997 and charging it to assess phosphorus load in their respective jurisdictions.[39] LCBP provided facilitation and recording of minutes for the Task Force meetings as it developed a proposal for an equitable division of responsibilities for the nutrient problems in the bay. The Task Force recommended an allocation of responsibility for phosphorus loading of Missisquoi Bay at sixty percent Vermont and forty percent Quebec based on the best information then available. Continued work by the Task Force led to a landmark agreement between Quebec and Vermont codifying the apportionment of phosphorus reduction commitments made by each jurisdiction. This agreement has provided the jurisdictional goals for public and private investments to reduce phosphorus pollution in the Missisquoi Bay watershed ever since.[40]

C. Lake Champlain Basin Program Projects on the Ground

The LCBP annual budget and work plans implement Lake Champlain research, monitoring, education, and stewardship tasks prioritized in OFA that other jurisdictional partners find more difficult to achieve. The LCBP office is located in an island community in the north central part of Lake Champlain at the Gordon Center House in Grand Isle, Vermont. LCBP staff guide and oversee LCBP-funded plan implementation tasks.

From 1998 to 2015, five State of the Lake reports have presented objective analyses and interpretations of the evolving condition of Lake Champlain and its watershed. The reports focus on nutrient status, phosphorus load from point sources and nonpoint sources, aquatic invasive species, toxins, human health risks, recreational opportunities, public access, and heritage resources of special interest.[41]

The 2010 MOU among New York, Vermont, and Quebec mandates an LCBP State of the Lake report at three-year intervals. The 2015 edition of

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38. *Cumberland Bay Removed from Superfund List*, LAKE CHAMPLAIN BASIN PROGRAM (Apr. 2, 2013), http://www.lcbp.org/2013/04/cumberland-bay-removed-from-superfund-list/ [https://perma.cc/39A7-VXB7].

39. Martin Mimeault & Tom Manley, *Missisquoi Bay: An International Partnership Towards Restoration*, *in* LAKE CHAMPLAIN: PARTNERSHIPS AND RESEARCH IN THE NEW MILLENNIUM 1–6 (T. Manley et al. eds., 2004).

40. *Id.* at 6.

41. *State of the Lake*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/media-center/publications-library/state-of-the-lake/ [https://perma.cc/RR3Q-42QE] (last visited Apr. 1, 2016).

the State of the Lake report[42] is a thirty-four-page summary of the condition of Lake Champlain presented in a segment-by-segment format, with descriptions of trends, problems, and accomplishments. The key characteristic of the State of the Lake report is the presentation of an objective analysis of the best available information firmly based on monitoring data, peer reviewed science, and public records (for example, beach closures).

The State of the Lake reports are structured around frequently asked questions and aim to inform all demographics from policy-makers and funding agencies to resource managers, residents, visitors, and students. LCBP provides a conceptual meeting place for many jurisdictional partners, but the staff are not government employees and so answer to the multi-partner Lake Champlain Steering Committee as a whole. This relationship, together with the considerable reliance on the TAC, allows LCBP technical analyses, such as the presented in the State of the Lake reports, to be objectively based on contemporary science virtually unfiltered by agency policies from any jurisdiction. The institutional culture of LCBP places a high value on the independence and objectivity of the analyses presented in technical reports.

The flagship task of the LCBP is a vigorous competitive Local Implementation Grants program. From 1992 to 2015, the LCBP awarded more than 1,000 small grants to support stewardship activities at the local level. In 2015, the Local Implementation Grants budget exceeded $1.1 million dollars. These local grants enable people in a community to address problems that they know best, achieving solutions that benefit from local relationships and often leverage substantial matching in-kind resources.

LCBP staff work closely with community organizations over the span of decades, assisting their development (Organizations Support Grants), supporting their education programs (Education Grants), and supporting the direct reduction of contaminants reaching the lake (Pollution Prevention Grants). The CVNHP also supports a vigorous local grants program with improved resource interpretation, conservation projects, and educational programs. The array of local grants awarded by the LCBP directly supports the essential work of a large number of organizations, resulting in a practice of collaboration and partnership that produces a strong sense of community among LCBP staff and many stewardship organization leaders.[43]

42. 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATORS REPORT, *supra* note 29.

43. *See Grants Database*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-us/grants-rfps/grants-database/ [https://perma.cc/J2EP-7BR8] (last visited Apr. 1, 2016) (giving a review of the full scope of the LCBP small grant project descriptions).

Focused scientific research and monitoring to answer specific resource management questions is a long tradition for LCBP and regularly yields results that inform jurisdictional policy makers and guides related management decisions. Research and monitoring projects, and related technical tasks, to reduce pollution or to enhance ecosystem integrity, may be proposed to the LCBP by any party in the LCBP annual budgeting process. Most research, monitoring, and technical proposals are developed by the TAC to address priorities in OFA, or in response to contemporary Steering Committee direction to advisory committees. Each fall, the TAC deliberates on numerous proposals, develops cost estimates, and prepares a prioritized ranking of all tasks, with commentary, for consideration by the Executive and Steering Committees which finalize the LCBP budget. Several technical tasks are regular features of the LCBP annual work plan. Examples include:

- Agricultural best management practice research tasks and implementation programs are regularly supported by LCBP in view of the importance of agricultural nonpoint source tributary loading. Phosphorus nonpoint source tributary load directly from overland agricultural surface runoff is approximately forty percent of the total load and a significant part of additional load entering tributaries from collapsing streambanks also comes from agricultural lands. LCBP research has examined the efficacy of best management practices through paired tests on a number of adjacent fields with and without certain management practices. Additional research is examining the impact of agricultural tiling on nutrient concentrations and load from tile outflows compared to fields without tile.
- Critical sources of phosphorus nonpoint source loading in the Missisquoi Bay watershed of the northern Lake Champlain Basin were mapped in an LCBP project with support from the IJC. LCBP worked with a community of agricultural and water quality experts to develop the specifications for the modeling effort so that the resulting product would include an interactive online map that shows the annual amounts of phosphorus expected to be lost to tributaries by the landscape. High resolution LiDAR micro-topographic data was acquired for much of the watershed in preparation for this project and a subcontracting engineering firm determined the likely phosphorus loss (not considering possible management

practices that might be in place) using the U.S. Department of Agriculture Soil and Water Assessment Tool.[44]

- Awards of larger competitive Pollution Prevention and aquatic invasive species spread prevention grants by the LCBP normally number in the dozens annually. These awards tend to respond to immediate—sometimes urgent—needs in which prevention activities allow avoidance of pollution that would be costly to remediate or nuisance species invasions that would be impossible to contain. In recent years, LCBP has provided the landowner matching funds that enable more farms to install best management practices, with the U.S. Department of Agriculture's Natural Resources Conservation Service support, to reduce nonpoint source nutrient loading. Other awards have addressed such areas as urban area stormwater management, illicit discharge detection, roadside ditches, and culvert capacities and the outcomes of the larger awards are described in ninety-one LCBP Technical and Demonstration Project Reports and made available online.[45]
- Education and Outreach programs (and also hard copy and online publications) have been an enduring priority for the LCBP through public and schoolroom presentations throughout the basin, and both hard copy and online publications.
- The program operates and staffs the LCBP Resource Room located at ECHO, the science center and aquarium at the Leahy Center for Lake Champlain, to field questions that arise among ECHO visitors, resulting in direct interactions with over 250,000 visitors during the last decade. The room features exhibits, hands-on activities, computer stations, a library of Lake Champlain information, educator resources, and technical documents.
- The LCBP website is extensively developed and includes a significant array of resources about the LCBP and the lake, water and environmental issues, culture and recreation, education and publications, and personal involvement.[46]

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44. ERIC HOWE ET AL., MODELING EFFORTS AND IDENTIFICATION OF CRITICAL SOURCE AREAS OF PHOSPHORUS WITHIN THE VERMONT SECTOR OF THE MISSISQUOI BAY BASIN 6–7 (Dec. 2011), http://www.lcbp.org/wp-content/uploads/2013/07/63A_Missisquoi_CSA-3.pdf [https://perma.cc/K9HY-NNT2].

45. *Technical Reports*, *supra* note 31.

46. LAKE CHAMPLAIN BASIN PROGRAM, www.lcbp.org (last visited Mar. 19, 2016).

Special web resources include Casin' the Basin e-News, a quarterly newsletter of Lake Champlain interest sent to over 5,000 email contacts.[47]

- The Lake Champlain Atlas presents maps and graphics that address frequently asked questions and interests expressed by the public.
- WatershED Matters provides professional development resources for curriculum development, and learning outside the classroom.
- Champlain Basin Education Initiative is a partnership of several regional environmental education organizations facilitated, staffed, and funded by the LCBP to provide professional and curriculum development through continuing education credit programs for teachers. The program produces a five-credit field course in partnership with St. Michael's College to increase teacher knowledge-base of Lake Champlain stewardship issues and natural history.
- LCBP offers dozens of classroom programs and organizational meeting presentations throughout the year. In recent years, at the request of federal and state agencies, LCBP staff have convened and facilitated numerous public informational meetings concerning the phosphorus TMDL regulatory process and various IJC projects concerning Lake Champlain.

CONCLUSION

The LCBP works cooperatively with many partners to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The program is well guided by the Lake Champlain Steering Committee, a board comprised of a broad spectrum of representatives of government agencies and the chairs of advisory groups, representing citizen lake users, scientists, and educators. During the past two decades, the LCBP has sponsored a great variety of projects to reduce pollution in the lake, educate and involve the public, and gather information about lake issues. The LCBP also has funded education, planning, demonstration, research, and monitoring projects to support the restoration and protection of water quality and the diverse natural and cultural resources of the Lake Champlain Basin.

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47. *E-News*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/category/e-news/ [https://perma.cc/647P-YLJQ] (last visited Apr. 1, 2016).

The convergent mandates of the MOU of 1988 and the Special Designation Act of Congress in 1990 serve Lake Champlain very well. The Lake Champlain Steering Committee directs the activities of the LCBP through a consensus-driven institutional culture of partnership and collaboration. Although many Steering Committee members are state, federal, or provincial authorities with regulatory responsibilities, the LCBP has evolved as an objective, non-regulatory influence to inform, enhance, and support the protection of water quality, the environment, and the related economic vitality of Lake Champlain and its basin in ways that none of the participating jurisdictions could accomplish working independently. Although it is a product of governmental actions, the multi-jurisdictional Steering Committee structure tends to isolate it from the political will of any individual partner; LCBP relies heavily on objective science to inform its work.

OFA-2010 establishes a plan for coordinated action by each jurisdiction and community in the Basin to restore and protect water quality and the diverse natural and cultural resources of the Lake Champlain Basin. It continues to incorporate by reference and intent numerous other more-specialized management plans, such as the TMDL implementation plans for impaired waters, the Aquatic Invasive Species Rapid Response Plan,[48] the CVNHP management plan, and the Toxic Chemical Management Strategy. In the years ahead, more widespread use of integrated permitting, ramping up of regulatory enforcement and compliance, increased tributary and subwatershed monitoring, enhanced transparency in public policy development, significantly improved public education about ecosystem issues, and personal responsibility offer hope of movement toward the third theme of the CVNHP: a Culture of Conservation. As congressional support for the management of Lake Champlain resources continues undiminished and the implementation tasks of OFA and related management plans are accomplished by many joint efforts and partnerships among natural resource agencies, citizens, and other Lake and watershed stakeholders, the future of Lake Champlain and its watershed are made more secure.

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48. LAKE CHAMPLAIN BASIN PROGRAM AQUATIC NUISANCE SPECIES SUBCOMM., LAKE CHAMPLAIN BASIN RAPID RESPONSE ACTION PLAN FOR AQUATIC INVASIVE SPECIES (2009), http://www.lcbp.org/wp-content/uploads/2012/08/2009-AIS-Rapid-Response-Plan.pdf [https://perma.cc/P7RQ-428P].

HISTORY OF VERMONT'S LAKE CHAMPLAIN PHOSPHORUS REDUCTION EFFORTS

Eric Smeltzer[1]

INTRODUCTION

Vermont's first efforts to confront the problem of excessive eutrophication in Lake Champlain began during the 1960s in St. Albans Bay. Algal blooms and growth of aquatic plants in the bay prompted the formation of the St. Albans Bay Association, which sponsored treatments of the bay with the algicide copper sulfate. The benefits of these treatments were temporary at best and algal blooms continued to plague the bay.[2]

Paleolimnological research[3] has since shown that eutrophication in St. Albans Bay accelerated during the early part of the 20th century, coincident with the construction of sewer lines serving the growing urban population and industrial users in the bay's watershed. Analysis of sediment cores

1. Eric Smeltzer received a Master's degree in ecology with a specialization in limnology from the University of Minnesota and an undergraduate degree in biology from Bates College. He worked at the Vermont Department of Environmental Conservation for thirty-five years as an Environmental Scientist before retiring in 2015. Most of his work focused on Lake Champlain, including the development of water quality standards for the lake, the design and oversight of the Lake Champlain Long-Term Monitoring Program, and the execution of scientific and management studies of the lake. He led the development of the 2002 Lake Champlain Phosphorus TMDL and worked closely with the EPA on the modeling for the 2016 TMDL. He lives in Waterbury Center, Vermont and can be reached at smeltzerde@gmail.com.

2. Author's personal knowledge; *see also Blue-Green Algae in Lake Champlain*, LAKE CHAMPLAIN COMM., https://www.lakechamplaincommittee.org/lcc-at-work/algae-in-lake/ [https://perma.cc/XK9D-5Y8K] (last visited Apr. 2, 2016) (highlighting that blooms still persist on Lake Champlain).

3. Suzanne N. Levine et al., *The Eutrophication of Lake Champlain's Northeastern Arm: Insights from Paleolimnological Analyses*, J. GREAT LAKES RES. 25, 38 (2012).

indicated that severe algal blooms in Missisquoi Bay did not appear until much later, beginning in the 1970s with the intensification of regional agriculture.[4]

I. EARLY PLANNING AND LEGISLATIVE EFFORTS

Vermont began to address these problems in Lake Champlain as an international scientific and policy debate unfolded about the causes of lake eutrophication and the appropriate management responses.[5] A scientific consensus emerged during the 1970s that phosphorus was the key nutrient limiting algal growth in freshwater. Attention turned to detergents and wastewater as major controllable sources of phosphorus in the Great Lakes.[6]

Lake Champlain was the subject of a series of studies during the 1970s that produced the first estimates of phosphorus loading to the lake from its tributaries and various source categories.[7] These studies estimated the total load of phosphorus to the lake at the time was 637 metric tons per year ("mt/yr"), of which wastewater discharges contributed 307 mt/yr (48%).[8]

Vermont responded quickly to the growing scientific understanding of the phosphorus issue. Legislation passed in 1977 prohibited the sale of household laundry detergents containing phosphorus above trace amounts and required phosphorus removal to a 1.0 milligram per liter ("mg/L") concentration or less in wastewater effluent from designated facilities in the Lake Champlain Basin.[9]

The New England River Basins Commission produced a comprehensive Lake Champlain Basin Study in 1979 that recommended a number of actions designed to hold constant or reduce phosphorus inputs to the lake until 1990.[10] The recommended actions included: a continuation of phosphorus detergent bans in Vermont, New York, and Quebec; the

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4. *Id.*
5. JOHN R. VALLENTYNE, THE ALGAL BOWL: LAKES AND MAN 5 (J.C. Stevenson et al. eds., 1974).
6. INT'L JOINT COMM., POLLUTION OF LAKE ERIE LAKE ONTARIO AND THE INTERNATIONAL SECTION OF THE ST. LAWRENCE RIVER 7, 23 (1970), http://ijc.org/files/publications/ID364.pdf [https://perma.cc/R6LU-DQXK].
7. ENVTL. PROT. AGENCY, LAKE CHAMPLAIN NEW YORK AND VERMONT: EPA REGIONS I AND II 5-6 (1974); E.B. HENSON & GERHARD K. GRUENDLING, THE TROPHIC STATUS AND PHOSPHORUS LOADINGS OF LAKE CHAMPLAIN IV–V (1977); KENNETH BODGAN, LAKE CHAMPLAIN BASIN STUDY, ESTIMATES OF THE ANNUAL LOADING OF TOTAL PHOSPHOROUS TO LAKE CHAMPLAIN 2–21 (1978).
8. BOGDAN, *supra* note 7.
9. VT. STAT. ANN. tit. 10, §§ 1266a, 1382(a) (2012).
10. LAKE CHAMPLAIN BASIN STUDY, SHAPING THE FUTURE OF LAKE CHAMPLAIN: THE FINAL REPORT OF THE LAKE CHAMPLAIN BASIN STUDY 83 (1979).

construction of phosphorus removal facilities at a number of Vermont municipal wastewater treatment plants; and increased efforts to curtail nonpoint sources of phosphorus loading, particularly from agricultural sources.[11]

Vermont implemented many of the recommendations from the Lake Champlain Basin Study during the 1980s. Phosphorus detergent bans remained in effect in all three jurisdictions and the Vermont law was estimated to have reduced the amount of phosphorus discharged from municipal wastewater treatment plants by forty percent.[12] Of the sixteen wastewater treatment plants in the Lake Champlain Basin initially designated for phosphorus removal under the 1977 statute, twelve such facility upgrades were operational by 1990.[13] Vermont expanded the statutory wastewater treatment requirements in 1992 by lowering the maximum effluent phosphorus concentration limit to 0.8 mg/L at 29 of the largest facilities in the Lake Champlain Basin.[14] The State and the U.S. Department of Agriculture implemented best management practices during the 1980s throughout the Shelburne Bay and St. Albans Bay watersheds under programs that included ten years of intensive water quality monitoring to document the benefits of the practices. Significant reductions in agricultural phosphorus loading did not occur in either watershed. This is possibly due to insufficient numbers, types of conservation practices implemented, or long time lags in response to treatment.[15]

When Vermont proposed a new fish hatchery for Kingsland Bay State Park in 1983, the controversial project exposed several weaknesses in Vermont's phosphorus management policies for Lake Champlain.[16] The discharge from the hatchery would contain significant amounts of phosphorus from uneaten fish food and feces. However, no water quality

11. *Id.* at 87.

12. VT. DEP'T OF WATER RES. & ENVTL. ENG'G WATER QUALITY DIV., SPECIAL REPORT TO THE VERMONT GENERAL ASSEMBLY ON THE EFFECTIVENESS OF THE PHOSPHORUS DETERGENT PROHIBITION IN HOUSEHOLD CLEANSING PRODUCTS AND COMPLIANCE WITH A 1.0 MILLIGRAM PER LITER DISCHARGE LIMITATION 16 (1981), https://anrweb.vt.gov/PubDocs/DEC/WSMD//lakes/docs/lp_phosphorusdetergentbanreport.pdf [https://perma.cc/2DAE-7XLL]; LAKE CHAMPLAIN BASIN PROGRAM & MISSISQUOI BAY PHOSPHORUS REDUCTION TASK FORCE, A DIVISION OF RESPONSIBILITY BETWEEN QUÉBEC AND VERMONT FOR THE REDUCTION OF PHOSPHORUS LOADS TO MISSISQUOI BAY 10 (2000) [hereinafter QUÉBEC & VERMONT FOR THE REDUCTION OF PHOSPHORUS LOADS].

13. VT. AGENCY OF NAT. RES., PHOSPHORUS REDUCTION PLAN (1990), http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/ANR1990_PhosphorusReductionPlan.pdf [https://perma.cc/G2KK-UGNY].

14. *Id.*; VT. STAT. ANN. tit. 10, § 1266a.

15. *Hatchery Plan on Lakes Stirs a Vermont Dispute*, N.Y. TIMES (Nov. 2, 1986), http://www.nytimes.com/1986/11/02/us/hatchery-plan-on-lake-stirs-a-vermont-dispute.html [https://perma.cc/569U-TMTG].

16. *Id.*

standards were in place that defined maximum acceptable concentrations of phosphorus in the lake region that would be affected by the hatchery discharge. There was no cap on the lake's total loading capacity for phosphorus that could be used to evaluate and control the cumulative impacts from individual small phosphorus sources, such as the proposed fish hatchery. Lacking clear policy guidance regarding the regulation of new phosphorus sources, the Vermont Department of Environmental Conservation relied on ad hoc modeling and other case-specific considerations in developing a discharge permit for the facility.[17] The Weed Fish Culture Station was eventually built in Grand Isle, Vermont where the lake's assimilative capacity was greater, and the facility was permitted with tight phosphorus limits, but the need for a more comprehensive phosphorus management framework for Lake Champlain was apparent.[18]

II. DEVELOPMENT OF A COMPREHENSIVE PHOSPHORUS MANAGEMENT FRAMEWORK

The signing of the Vermont, New York, and Quebec Memorandum of Understanding on Environmental Cooperation on the Management of Lake Champlain in 1988 and the creation of the Lake Champlain Management Conference in 1990 provided the vehicle to develop a comprehensive phosphorus management framework for the lake.[19] This framework included: (1) adoption of in-lake phosphorus criteria to serve as the ultimate management targets; (2) completion of a phosphorus source assessment and budget for the lake; (3) development of a lake phosphorus mass balance model linking loads to in-lake concentrations; (4) determination of the total loading capacity for each segment of the lake; and (5) allocation of the maximum phosphorus loads to the various sources.[20]

In 1991, Vermont adopted in-lake total phosphorus concentration criteria for twelve segments of Lake Champlain that still remain in effect in the Vermont Water Quality Standards.[21] These criteria were generally lower

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17. Author's personal knowledge.

18. *Ed Weed Fish Culture Station*, VT. FISH & WILDLIFE, http://www.vtfishandwildlife.com/fish/fish_stocking/vist_a_hatchery/ed_weed_fish_culture_station/ [https://perma.cc/6HLW-XAWR] (last visited Apr. 4, 2016).

19. ERIC Smeltzer, *Phosphorus Management in Lake Champlain*, *in* LAKE CHAMPLAIN IN TRANSITION: FROM RESEARCH TOWARD RESTORATION 435–51 (Tom Manley et al. eds., 1999) https://anrweb.vt.gov/PubDocs/DEC/WSMD/lakes/docs/lp_phosmanage99.pdf [https://perma.cc/S99J-WG53].

20. *Id.*

21. VT. AGENCY OF NAT. RESOURCES, VERMONT WATER QUALITY STANDARDS ENVIRONMENTAL PROTECTION RULE CHAPTER 29(a) 5 (2014),

than the existing phosphorus levels in the lake and significant phosphorus reductions were therefore mandated. The Lake Champlain Steering Committee appointed a Lake Champlain Phosphorus Management Task Force. The task force reviewed and endorsed the Vermont phosphorus criteria with minor modifications and New York, Quebec, and Vermont formally accepted the criteria in a 1993 Water Quality Agreement as joint management goals for the lake.[22]

In order to obtain the data needed to support a comprehensive phosphorus management framework for Lake Champlain, Vermont and New York initiated a phosphorus budget and modeling study in 1990 with funding and technical support from the U.S. Environmental Protection Agency ("EPA") and the U.S. Geological Survey.[23] The study measured phosphorus loads to the lake from all major sources during a two-year period, including thirty-one tributaries, eighty-eight wastewater discharges, and direct precipitation to the lake's surface.[24] The study recorded phosphorus concentrations at fifty-two locations within the lake.[25] The data supported the development of a mass balance model that simulated the effects of phosphorus loads on the concentration of phosphorus in each segment of Lake Champlain. The states then used the model with a minimum-cost optimization procedure to define preliminary phosphorus loading targets for each state and each lake segment in a manner predicted to achieve the in-lake phosphorus concentration criteria.[26]

The Lake Champlain Management Conference incorporated these preliminary phosphorus loading targets into early drafts of its comprehensive plan for Lake Champlain.[27] However, a change of political administration in New York in 1995 caused the state to reconsider its commitment to these targets. A central issue was whether New York would adopt a wastewater phosphorus removal policy equivalent to Vermont's statutory 0.8 mg/L concentration limit as a required component of achieving the loading targets.[28] A dispute emerged between the two states

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http://dec.vermont.gov/sites/dec/files/documents/WSMD_WaterQualityStandards_2014.pdf [https://perma.cc/BPX7-DES9].

22. LAKE CHAMPLAIN PHOSPHORUS MGMT. TASK FORCE, REPORT OF LAKE CHAMPLAIN PHOSPHOROUS MANAGEMENT TASK FORCE (1993), https://anrweb.vt.gov/PubDocs/DEC/WSMD/lakes/docs/lp_phostaskforce93.pdf [https://perma.cc/E6GQ-2GRE].

23. Eric Smeltzer & Scott Quinn, *A Phosphorus Budget, Model, and Load Reduction Strategy for Lake Champlain*, 12 J. LAKE & RESERVOIR MGMT. 381, 381 (1996); SMELTZER & QUINN, *supra* note 20.

24. *Id.* at 382.

25. *Id.* at 383.

26. *Id.* at 392.

27. *Id.*

28. *Id.*

with newspaper headlines such as "N.Y. balks at limits on phosphorus"[29] and "Dispute threatens lake cleanup plan,"[30] highlighting the issue publically. Without a phosphorus reduction agreement between Vermont and New York as the centerpiece of the Management Conference plan, the entire effort was at risk of failure.

EPA, charged with the responsibility for approving the Management Conference plan under the Lake Champlain Special Designation Act, stepped in at this point and mediated negotiations between the two states to reach a resolution.[31] The states agreed to the phosphorus loading targets for each sub-watershed developed by their joint modeling work while retaining flexibility regarding the balance of wastewater versus nonpoint source reductions implemented to achieve the loading targets.[32] The Lake Champlain Management Conference incorporated the Vermont and New York phosphorus reduction agreement into its 1996 comprehensive plan called *Opportunities for Action*, which was signed by the Governors of both states and the two EPA Regional Administrators.[33] The agreement divided the lake's estimated total loading capacity of 439 mt/yr, assigning Vermont and Quebec 319 mt/yr and New York 120 mt/yr, with specific loading targets assigned to each sub-watershed in each state.[34] The plan specified the overall net loading reductions required to achieve these targets to be 56 mt/yr in Vermont and 1.0 mt/yr in New York, relative to 1995 levels.[35]

The 1996 *Opportunities for Action* plan[36] indicated that Vermont would seek an agreement with the Province of Quebec on sharing responsibility for phosphorus reduction in Missisquoi Bay. Vermont and Quebec subsequently established a Missisquoi Bay Phosphorus Reduction Task Force ("Task Force") charged with the tasks of (1) reviewing the phosphorus loading data and modeling analyses used to establish the total loading capacity for Missisquoi Bay; (2) assessing the magnitude of

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29. Nancy Bazilchuk, *N.Y. Balks at Limits on Phosphorus*, BURLINGTON FREE PRESS, July 25, 1995, at A1.

30. Nancy Bazilchuk, *Dispute Threatens Lake Champlain Cleanup Plan New York Questions Phosphorus Study*, BURLINGTON FREE PRESS, Oct. 12, 1995, at B1.

31. *Lake Champlain Nutrient Pollution Policy and Data*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/nutrient-policy-data/lake-champlain [https://perma.cc/9QRH-6RHE] (last visited Apr. 4, 2016).

32. *Phosphorus Reduction Strategies*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/water-quality/nutrients/phosphorus-reduction-strategy/ [https://perma.cc/9AQD-ZA7S] (last visited Apr. 4, 2016).

33. LAKE CHAMPLAIN MGMT. CONFERENCE, OPPORTUNITIES FOR ACTION: AN EVOLVING PLAN FOR THE FUTURE OF THE LAKE CHAMPLAIN BASIN (1996), http://www.lcbp.org/wp-content/uploads/2013/03/OFA-1996.pdf [https://perma.cc/83QM-4YJD].

34. *Id.* at 11.

35. *Id.*

36. *Id.* at 10.

phosphorus loading from sources in Vermont and Quebec; (3) reviewing policies and programs in Vermont and Quebec to implement point and nonpoint source phosphorus reductions; and (4) proposing a fair and practical division of responsibility between Vermont and Quebec for achieving the target load reductions for Missisquoi Bay.[37]

The Task Force issued its report to the Lake Champlain Steering Committee in 2000.[38] The Task Force reaffirmed the acceptance of the in-lake phosphorus concentration criterion of 0.025 mg/L, which had been previously established for Missisquoi Bay.[39] But, the October 5, 2001 addendum proposed that the total loading capacity of 109.7 mt/yr defined for Missisquoi Bay in the 1996 *Opportunities for Action* be reduced to 97.2 mt/yr in order to fully attain the bay's concentration criterion. After reviewing land use data and a watershed phosphorus export modeling analysis conducted for the Lake Champlain Basin Program, the Task Force determined that Vermont contributed 60% of the phosphorus load to the bay and Quebec contributed 40%.[40] Using this information, the Task Force recommended a simple 60/40 basis for a division of load reduction responsibility between the two jurisdictions.[41] Vermont would be assigned 60% (58.3 mt/yr) of the total loading capacity and therefore 60% of the load reduction responsibility while Quebec would be assigned 40% (38.9 mt/yr) of the total capacity and 40% of the load reduction responsibility.[42] The two governments accepted these recommendations in an agreement concerning phosphorus reduction in Missisquoi Bay signed in 2002.[43]

III. THE 2002 LAKE CHAMPLAIN PHOSPHORUS TMDL

With acceptance by Vermont, New York, and Quebec of a consistent set of in-lake phosphorus concentration criteria, the establishment of total loading capacities for each lake segment, and agreements on a division of responsibility for load reduction between the three jurisdictions, the

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37. MISSISQUOI BAY PHOSPHORUS REDUCTION TASK FORCE, A DIVISION OF RESPONSIBILITY BETWEEN QUÉBEC AND VERMONT FOR THE REDUCTION OF PHOSPHORUS LOADS TO MISSISQUOI BAY 2–3 (2000), http://www.lcbp.org/wp-content/uploads/2012/08/missbay_final.pdf [https://perma.cc/UB3D-YQVB]; SMELTZER & QUINN, *supra* note 20, at 124.

38. *Id.*

39. *Id.* at 1; QUÉBEC & VERMONT FOR THE REDUCTION OF PHOSPHORUS LOADS, *supra* note 12, at 6.

40. MISSISQUOI BAY PHOSPHORUS REDUCTION TASK FORCE, *supra* note 38, at 8.

41. *Id.* at 9.

42. *Id.*

43. AGREEMENT BETWEEN THE GOUVERNEMENT DU QUÉBEC AND THE GOVERNMENT OF THE STATE OF VERMONT CONCERNING PHOSPHORUS REDUCTION IN MISSISQUOI BAY (2002), http://www.lcbp.org/wp-content/uploads/2012/08/missbay_agreeEN.pdf [https://perma.cc/74QP-P8RS].

building blocks were in place to develop a total maximum daily load ("TMDL") for Lake Champlain.[44] Vermont and New York jointly prepared a Lake Champlain Phosphorus TMDL document in 2002[45] and submitted the TMDL to their respective EPA regional offices where it was approved.[46]

The 2002 Lake Champlain Phosphorus TMDL included individual phosphorus wasteload allocations for each treatment facility in Vermont and New York.[47] The Vermont TMDL wastewater limits incorporated additional restrictions beyond previous policy in two respects. First, annual phosphorus load allocations for 25 of the larger Vermont facilities were calculated based on an effluent concentration of 0.6 mg/L at their permitted flow rate rather than at the 0.8 mg/L limit specified in statute.[48] Second, the TMDL applied the 0.8 mg/L limit to 5 facilities using aerated lagoon treatment processes, which had been previously exempted from phosphorus removal requirements.[49] Vermont subsequently amended the phosphorus discharge statute to remove the aerated lagoon exemption for consistency with the TMDL.[50] The maximum wastewater phosphorus load allowed by the 2002 Lake Champlain TMDL for the 60 Vermont facilities in aggregate was 55.8 mt/yr.[51]

The 2002 Lake Champlain TMDL allocated the remaining non-wastewater loads within the maximum target loads established for each lake segment watershed in the 1996 Lake Champlain Management Conference Plan and in the 2002 Vermont-Quebec Water Quality Agreement.[52] Vermont made small adjustments to the total loading capacities for some lake segments. The TMDL assigned phosphorus allocations to sources including runoff from developed land, agricultural land, and forest land within each lake segment watershed.[53] Allocations to forest land were

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44. William G. Howland, *The Lake Champlain Basin Program: Its History and Role*, *infra* p. .

45. VT. AGENCY OF NAT. RES. DEP'T OF ENVTL. CONSERVATION & N.Y. STATE DEP'T OF ENVTL. CONSERVATION, LAKE CHAMPLAIN PHOSPHORUS TMDL (2002), http://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_2002_LC%20P%20tmdl.pdf [https://perma.cc/DW7L-VPJ9] [hereinafter LAKE CHAMPLAIN TMDL 2002].

46. Letter from Linda M. Murphy, Dir., Office Ecosystem Prot. to Christopher Recchia, Comm'r, Vt. Dep't Envtl. Conservation (Nov. 4, 2002).

47. LAKE CHAMPLAIN TMDL 2002, *supra* note 46, at 20.

48. *Id.* at 24.

49. *Id.*

50. VT. STAT. ANN. tit. 10, §1266a.

51. LAKE CHAMPLAIN TMDL 2002, *supra* note 46, at 22; S. 96, 2007-2008 Leg. Sess. (Vt. 2007).

52. *Id.* at 20.

53. *Id.* at 33.

specified at their existing base levels.[54] With the wastewater and forest load allocations determined, loads allocated to developed land and agricultural land were reduced by equal proportions from their estimated base levels in each lake segment watershed until the total loading capacity for the lake segment was achieved.[55]

The TMDL for the Vermont portion of the Missisquoi Bay watershed included a special "other" category of load allocation as a result of uncertainty about whether the available agricultural conservation practices were adequate to achieve the full extent of the required load reductions in that watershed.[56] The TMDL suggested that phosphorus loads associated with stream channel instability should be examined as a way to achieve the additional reductions.[57]

Vermont and New York used the lake model based on hydrologic conditions occurring during 1991 to develop the total loading capacities and load reduction amounts. Vermont and New York chose the base year of 1991 because average river flows during 1991 were comparable to median annual flows recorded over several previous decades at stream gauges in the Lake Champlain Basin.[58] The 2002 Lake Champlain TMDL established a total loading capacity of 427 mt/yr for the entire lake under 1991 hydrologic conditions, including 268 mt/yr for Vermont distributed among 12 lake segment watersheds.[59] The Vermont total loading capacity mandated a 35% reduction from the 1991 Vermont base load of 414 mt/yr.[60]

The 2002 Lake Champlain TMDL contained a detailed Vermont implementation plan with cost estimates for phosphorus reduction actions across several program areas, including wastewater discharges, agricultural sources, construction stormwater, local roads and other municipal sources, river corridor management, wetland protection and restoration, management of internal phosphorus loading in St. Albans Bay, river basin planning, long-term monitoring, implementation tracking, and program

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54. *Id.*
55. *Id.*
56. *Id.* at 36.
57. *Id.* at 78.
58. ERIC SMELTZER & SCOTT QUINN, *supra* note 20, at 75; LAKE CHAMPLAIN TMDL 2002, *supra* note 46, at 33.
59. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD & MARKETS, PROGRESS IN ESTABLISHING AND IMPLEMENTING THE TOTAL MAXIMUM DAILY LOAD (TMDL) PLAN FOR LAKE CHAMPLAIN 4 (2008), http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/CandC2007RptANRACT43-Final011508.pdf [https://perma.cc/Z4YJ-YV4E] [hereinafter ANR & VAAFM 2008].
60. LAKE CHAMPLAIN TMDL 2002, *supra* note 46, at 15.

administration.[61] The TMDL estimated the total cost of the Vermont implementation plan to be $139 million over 14 years (2003–2016).[62]

IV. THE VERMONT CLEAN AND CLEAR WATER ACTION PLAN

The "reasonable assurances" section of the 2002 Lake Champlain TMDL referenced the phosphorus reduction commitments made by Vermont and New York in the 1996 *Opportunities for Action* plan and the formation of the Lake Champlain Basin Program to oversee implementation of the plan.[63] However, the TMDL document contained no specific strategy or commitment to fund the $139 million Vermont implementation plan.[64] Governor James Douglas addressed this gap in September 2003 when he announced the Vermont Clean and Clear Water Action Plan on the shore of Missisquoi Bay.[65] Governor Douglas stated that Vermont would "accelerate pollution reduction measures for Lake Champlain from [implementation in] 2016 to 2009 in every possible instance" using a combination of federal, state, local, and private funds.[66] The 20-year (1996–2016) phosphorus reduction timeline stated in *Opportunities for Action* and incorporated into the Vermont TMDL implementation plan would be shortened with a new deadline coinciding with the 2009 quadricentenniel of Samuel de Champlain's initial exploration of the lake.[67]

Over the next six years, the Governor proposed and the Legislature approved nearly $60 million in new state funds for the Clean and Clear initiative to implement the Lake Champlain TMDL and to address similar water quality problems statewide.[68] The state secured comparable amounts of federal funds to complement this effort. The Agency of Natural Resources and the Agency of Agriculture, Food and Markets increased staffing by about twenty-eight positions to support watershed management program expansions in the areas of stormwater, rivers, agriculture, wetlands, and forestry.[69] The Vermont Agency of Natural Resources

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61. *Id.* at 48.
62. *Id.* at 95
63. *Id.* at 46.
64. *Id.* at 95.
65. Gov. James H. Douglas, Clean and Clear Water Action Plan (Sept. 30, 2003), https://votesmart.org/public-statement/23255/clean-and-clear-water-action-plan-remarks-of-governor-james-h-douglas#.VvmWzxIrKCQ [https://perma.cc/XQ4C-YX5S].
66. *Id.*
67. *Id.*
68. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD, & MKTS., CLEAN AND CLEAR ACTION PLAN 2010 ANNUAL REPORT (2011), http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/CleanAndClear2010AnnualReport.pdf [https://perma.cc/C39S-6E5N] [hereinafter ANR & VAAFM 2011].
69. LAKE CHAMPLAIN TMDL 2002, *supra* note 46, at 86.

established an Ecosystem Restoration Grant Program to support implementation work by local partner organizations.[70] The Legislature appropriated state capital funds for additional wastewater treatment facility upgrades needed to comply with the TMDL limits.[71] Of the fifty-five individual action items specified in the Vermont implementation plan in the 2002 TMDL, five had been completed by 2008, forty-seven were in progress (some with changes in scope), and only three saw no action.[72]

Despite this progress and less than three years after the first state appropriations for the Clean and Clear initiative were approved, the Vermont Senate introduced legislation declaring that the control measures under the Lake Champlain TMDL for phosphorus had failed and would not achieve the pollutant load reduction required to meet water quality standards.[73] As a result, the General Assembly enacted and the Governor signed Act 43 in 2007, requiring the Vermont Agency of Natural Resources to reopen the Lake Champlain TMDL, pending the results of a reassessment of the TMDL with respect to the efficacy of the Vermont implementation plan, the adequacy of the hydrologic data used for the TMDL modeling, and the feasibility and cost of additional wastewater phosphorus reduction requirements.[74] Act 43 also required that an independent program audit be conducted on the progress and efficacy of the Clean and Clear initiative.[75] Fortunately for the lake, the negative tone of the political discussion of the Clean and Clear program did not deter Governor Douglas from proposing, or the General Assembly from approving, appropriations for the program at a sustained level.[76]

The Agency of Natural Resources responded with a report in 2008 recommending against reopening the Lake Champlain TMDL on the grounds that the loading targets in the 2002 TMDL already provided clear direction regarding the large magnitude of phosphorus reductions needed.[77] The report concluded that the staffing and funding resources needed to redo the TMDL and to further upgrade wastewater phosphorus treatment processes would be better directed at controlling nonpoint sources of phosphorus loading to Lake Champlain.[78] The report also recommended

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70. *Ecosystem Restoration Program*, WATERSHED MGMT. DIV., http://www.watershedmanagement.vt.gov/erp.htm [https://perma.cc/V5PU-JGN9] (last visited Apr. 4, 2016).
71. VT. STAT. ANN. tit., 10 § 1625(e).
72. ANR & VAAFM 2008, *supra* note 60, at 5.
73. S. 96, 2007-2008 Leg. Sess. (Vt. 2007)
74. H.154, 2007-2008 Leg. Sess. (Vt. 2007).
75. *Id.* § 6.
76. ANR & VAAFM 2011, *supra* note 69, at 10.
77. ANR & VAAFM 2008, *supra* 60, at 8.
78. *Id.* at 1, 33.

that the Vermont Lake Champlain TMDL implementation plan should be periodically reevaluated and revised as experience was gained going forward and noted that this could be accomplished without reopening the entire TMDL.[79]

The Vermont General Assembly considered these agency recommendations and passed Act 130 in 2008, which postponed the date for reopening the Lake Champlain TMDL until 2013, but required the Agency of Natural Resources to issue a revised Vermont-specific implementation plan for the TMDL.[80] The agency released a revised Vermont Lake Champlain TMDL implementation plan in 2010 following a year-long public consultation process.[81] The revised TMDL implementation plan identified two-hundred potential actions to improve water quality in Lake Champlain and identified the ten next steps that were of highest priority for immediate action.[82] These steps included increasing staffing for agronomists to provide on-farm water quality technical assistance, requiring additional stormwater treatment at existing developed sites, and implementing water quality-based standards for municipal road maintenance. The Agency of Natural Resources took into account the experience gained in implementing the Clean and Clear program and revised the total cost estimate to implement the TMDL sharply upwards to $500–800 million.[83]

By the end of 2010, the magnitude of the challenge facing Vermont in achieving the Lake Champlain TMDL targets had become more fully apparent. Analysis of long-term water quality monitoring data showed few improving trends in phosphorus loading to the lake from any tributary.[84] Lake phosphorus concentrations remained above the criteria values in most lake segments and concentrations were increasing in some areas.[85] Vermont had achieved dramatic reductions in wastewater phosphorus loads with wastewater discharges contributing only three percent of the total phosphorus load to the lake from Vermont.[86] However, similar success had

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79. *Id*. at 1.
80. H. 873, 2007-2008 Leg. Sess. (Vt. 2008).
81. VT. AGENCY OF NAT. RES., REVISED IMPLEMENTATION PLAN: LAKE CHAMPLAIN PHOSPHORUS TMDL (2010), http://dec.vermont.gov/sites/dec/files/wsm/lakes/docs/erp_revisedtmdl.pdf [https://perma.cc/XMU4-VGNL] [hereinafter ANR 2010].
82. *Id.* at 2.
83. *Id.* at 5.
84. ERIC SMELTZER ET AL., LAKE CHAMPLAIN PHOSPHORUS CONCENTRATIONS AND LOADING RATES, 1990-2008 27 (2009), http://www.lcbp.org/techreportPDF/57_Phosphorus_Loading_1990-2008.pdf [https://perma.cc/5YJ4-LVTN].
85. *Id.* at 1.
86. *Id.* at 33.

not been demonstrated in reducing nonpoint sources of phosphorus despite the greatly expanded program efforts.

Progress in reducing nonpoint sources of phosphorus can be slow and difficult for a number of reasons.[87] The time scale of nature's response to management actions can vary from years to decades, depending on the practices involved. This is because of the intermittent nature of runoff events, the large variability in annual runoff rates, and the long time it takes for soils, vegetation, farm fields, river channels, and lake sediments to respond to improved management.[88] Furthermore, most nonpoint source control practices require human behavioral changes by private landowners that are difficult to regulate and do not occur immediately. The main reason for the lack of progress, however, is that insufficient resources have been committed to the effort. The 2010 revised TMDL Implementation Plan[89] and a subsequent report by the Vermont Agency of Natural Resources to the Vermont General Assembly required by Act 138 of 2012[90] made clear that hundreds of millions of dollars and a sustained commitment over many years would be needed.

In early 2011, EPA revoked its approval of the Vermont portion of the 2002 Lake Champlain Phosphorus TMDL in response to a settlement of a lawsuit brought in federal court by the Conservation Law Foundation. EPA then embarked on what became a five-year process to produce a new Vermont TMDL for Lake Champlain.[91] The administration of Governor Peter Shumlin sustained Vermont's Lake Champlain TMDL implementation efforts during this period and the state produced a new TMDL implementation plan in 2014,[92] designed to achieve the higher standards of reasonable assurances and accountability required of Vermont by EPA for the new Lake Champlain TMDL. The Vermont Clean Water Act of 2015[93] provided additional authority, staffing, and funding resources

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87. ANR 2010, *supra* note 82, at 5, 26.

88. *Id.* at 26.

89. *Id.* at 5.

90. VT. GEN. ASSEMBLY, WATER QUALITY REMEDIATION, IMPLEMENTATION AND FUNDING REPORT: PART 1: CLEAN WATER NEEDS, FINANCIAL TOOLS, AND ADMINISTRATION, PART 2: LAKE SHORELAND PROTECTION AND RESTORATION MANAGEMENT OPTIONS 4 (2013), http://dec.vermont.gov/sites/dec/files/wsm/erp/docs/Act-138-Report-Water-Quality-Funding-Report-Jan-2013.pdf [https://perma.cc/E93C-RX4T].

91. David K. Mears & Trey Martin, *Foreward: Restoring and Maintaining the Ecological Integrity of Lake Champlain*, *supra* p. 474.

92. STATE OF VT., VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL PHASE 1 IMPLEMENTATION PLAN 1 (2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/Ph%201_plan_Version_4.pdf [https://perma.cc/F9QX-MP9R].

93. H.35, 2015-2016 Leg. Sess. (Vt. 2015).

toward the state's commitments to implement the TMDL. These more recent efforts are described in other articles of this volume.

THE TRANSITION TOWARDS THE 2016 LAKE CHAMPLAIN TMDL: A SURVEY OF SELECT WATER QUALITY LITIGATION IN VERMONT FROM 2003–2015

Matt Chapman and Jen Duggan

INTRODUCTION

Lake Champlain is treasured by Vermonters. Vermonters sail, fish, and swim in the lake. The lake also provides drinking water for Vermonters, "attracts businesses and tourists to the region and is a major driver of the State's economy."[1] Lake Champlain is also a very real indicator of the health of Vermont's beautiful streams and rivers: nine of Vermont's fourteen counties are located in the Lake Champlain Basin.[2] At the same time, phosphorus pollution from "farm fields, barnyards, homes, roads, parking lots and streambanks, and in wastewater discharges" have significantly degraded the water quality in Lake Champlain.[3] "In excessive amounts, phosphorus and the associated algal growth can impair

1. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD & MKTS., VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL PHASE 1 IMPLEMENTATION PLAN 1 (2015) [hereinafter ANR PHASE 1 IMPLEMENTATION PLAN].

2. *Political Boundaries*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.atlas.lcbp.org/HTML/nat_political.htm [https://perma.cc/87BD-PC4H] (last visited Apr. 3, 2016).

3. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 1.

recreational uses and aesthetic enjoyment, reduce the quality of drinking water, and alter the biological community. In some cases, algal blooms—particularly cyanobacteria (or blue-green algae)—can produce toxins that harm animals and people."[4]

Vermont identified numerous lake segments as high priority "impaired" waters more than decade ago,[5] but the water quality in the "lake has been slow to improve."[6] Under the federal Clean Water Act, Vermont must identify waters that do not or are not expected to meet the Vermont Water Quality Standards after requiring technology-based effluent limits for point sources.[7] These waters are "impaired," and the State must include these waters on a "Section 303(d) list."[8] Once a State identifies a water as impaired for one or more pollutants, Vermont must develop a pollution budget (i.e., Total Maximum Daily Load or TMDL) for the water that ensures compliance with water quality standards.[9] Although the State received approval from EPA for a Lake Champlain TMDL in 2002, EPA later withdrew its approval.[10] EPA and the Agency of Natural Resources ("ANR") recently released a revised and more robust TMDL for the Lake,[11] which was finalized on June 17, 2016.[12]

Vermonters are passionate about protecting Lake Champlain and other lakes, rivers, and streams. It should come as no surprise then that Vermonters have often turned to the courts to protect the waters they cherish. This article provides a high-level survey of key water quality litigation that has helped highlight the deficiencies in the 2002 Lake Champlain phosphorus TMDL and set the stage for the adoption of the 2016 Lake Champlain Phosphorus TMDL. Specifically, this article summarizes state litigation related to phosphorus pollution from stormwater

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4. *Id.* at 14.

5. U.S. ENVTL. PROT. AGENCY NEW ENGLAND, REVIEW OF THE VERMONT PORTION OF LAKE CHAMPLAIN PHOSPHORUS TMDL 4 (2002) [hereinafter 2002 PHOSPHORUS TMDL APPROVAL].

6. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 1.

7. Clean Water Act § 303(d)(1)(a), 33 U.S.C. § 1313(d)(1)(A) (2012).

8. *See id.* (requiring all states to identify and rank waters where the water quality is insufficient).

9. *See id.* § 1313(d)(1)(C) (requiring all states to establish total maximum daily loads for waters with insufficient water quality).

10. U.S. ENVTL. PROT. AGENCY, RECONSIDERATION OF EPA'S APPROVAL OF VERMONT'S 2002 LAKE CHAMPLAIN PHOSPHORUS TOTAL MAXIMUM DAILY LOAD ("TMDL") AND DETERMINATION TO DISAPPROVE THE TMDL 2 (Jan 24, 2011), http://www.epa.gov/sites/production/files/2015-09/documents/2002-lake-champlain-tmdl-disapproval-decision.pdf [https://perma.cc/697S-WEVY] [hereinafter EPA DISAPPROVAL DETERMINATION].

11. *See* ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 1 (discussing the plan for a new TMDL for Lake Champlain).

12. *Lake Champlain Phosphorus TMDL: A Commitment to Clean Water*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/tmdl/lake-champlain-phosphorous-tmdl-commitment-clean-water [https://perma.cc/R8CM-ESHD] (last visited at July 22, 2016).

discharges, wastewater treatment plants, and agricultural activities.[13] In addition, the article provides a summary of the federal lawsuit that ultimately led to the U.S. Environmental Protection Agency's ("EPA") disapproval of the 2002 Lake Champlain TMDL.

I. STORMWATER DISCHARGE PERMITS

Stormwater runoff is a significant contributor to the phosphorus problem in Lake Champlain.[14] Water that runs off roofs, roads, parking lots, and other paved surfaces carries pollution into Vermont waters, which includes phosphorus, nitrogen, metals, sediment, and other pollutants.[15] One area of water quality law that has been particularly fraught with litigation in Vermont relates to the State's residual designation authority ("RDA") for stormwater discharges under the federal Clean Water Act and Vermont's delegated National Pollutant Discharge Elimination System ("NPDES") program. The increase in litigation is due to the significant pollution threat caused by stormwater discharged and the challenges associated with treating these discharges.

With respect to stormwater, discharges from municipal sewer systems and those associated with industrial activity must obtain a state NPDES permit.[16] In addition, discharge permits are required for any stormwater "discharge which the [State] . . . or the EPA Regional Administrator[] determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States."[17] This provision is known as the "RDA" for stormwater discharges.[18] Federal regulations set forth specific factors that a state or EPA Regional Director must consider when making this determination, including the location and size of the discharge, quantity and nature of the discharged pollutants, and

13. For a comprehensive overview of water pollution in Vermont, see generally Daniel D. Dutcher & David J. Blythe, *Water Pollution in the Green Mountain State: A Case Study of Law, Science, and Culture in the Management of Public Water Resources* 13 VT. J. ENVTL. LAW 705 (2012).

14. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 16.

15. *See* U.S. ENVTL. PROT. AGENCY, PROTECTING WATER QUALITY FROM URBAN RUNOFF 1 (2003) (describing the different sources of urban runoff and pollutants contained within that runoff).

16. 33 U.S.C. § 1342(p)(2); 40 C.F.R. § 122.26(a)(1) (2015).

17. 33 U.S.C. § 1342(p)(2)(E); 40 C.F.R. § 122.26(a)(1)(v).

18. Act 64 of 2015 expressly incorporates this authority into state law. *See* VT. STAT. ANN. tit. 10, § 1264(e) (2015) ("The Secretary shall require a permit . . . for a discharge or stormwater runoff from any size of impervious surfaces upon a determination by the Secretary that the treatment of the discharge or stormwater runoff is necessary to reduce the adverse impacts to water quality . . . .").

"other relevant factors."[19] As EPA has recognized, RDA can be an important tool for states to clean up and protect water quality.[20]

Over the course of five years, the Conservation Law Foundation ("CLF"), Vermont Natural Resources Council ("VNRC"), ANR, and other stakeholders fought at the Water Resources Board, the Vermont Supreme Court, and Vermont's Environmental Court to determine the scope of the State's RDA as it applied to five impaired streams: Potash, Englesby, Morehouse, Centennial, and Bartlett Brooks.[21] The issue at the heart of the litigation was when the Agency must "exercise its residual designation authority."[22] After the dust settled, it appears clear that "residual designation authority is not optional."[23] Although the state has some discretion to determine whether an existing stormwater discharge contributes to water quality standard violations, Vermont must exercise its RDA and require a discharge permit once it makes this determination.[24] As discussed, this RDA is a powerful tool to clean up and protect water quality in Vermont.

In 2003, CLF and VNRC filed a petition that kicked off the litigation.[25] The Petition sought individual NPDES permits for existing stormwater discharges into several streams that the Water Resources Board had previously determined were impaired due to stormwater discharges.[26] ANR denied the petition, and CLF and VNRC appealed the decision to the Water Resources Board.[27]

ANR and several intervenors initially argued that the Water Resources Board did not have jurisdiction to hear the appeal because the "Vermont Water Pollution Control Act does not contain any express authority for

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19. 40 C.F.R. § 122.26(a)(1)(v).

20. *See, e.g.*, National Pollutant Discharge Elimination System-Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges, 64 Fed. Reg. 68,722, 68,781 (Dec. 8, 1999) ("In today's rule, EPA believes, as Congress did in drafting section CWA 402(p)(2)(E), that individual instances of storm water discharge might warrant special regulatory attention, but do not fall neatly into a discrete, predetermined category. Today's rule preserves the regulatory authority to subsequently address a source (or category of sources) of storm water discharges of concern on a localized or regional basis. For example, as States and EPA implement TMDLs, permitting authorities may need to designate some point source discharges of storm water on a categorical basis either locally or regionally in order to assure progress toward compliance with water quality standards in the watershed.").

21. *See, e.g.*, *In re* Stormwater NPDES Petition, No. 14-1-07 (Vt. Envtl. Ct. Aug. 28, 2008).

22. *Id.*

23. *In re* Stormwater NPDES Petition, 2006 VT 91, ¶ 21, 180 Vt. 261, 910 A.2d 824, 833 (2006).

24. *Id.*

25. *Stormwater NPDES Petition*, No. 14-1-07.

26. *Id.*

27. *Id.*

ANR to act on petitions" to exercise the State's RDA.[28] Thus, ANR argued, the petition "must be characterized as a request for rulemaking under the Vermont Administrative Procedure Act" and the Water Resources Board lacked jurisdiction to review the Agency's decision.[29] The Board disagreed, noting that section 1258(b) of the Vermont Water Pollution Control Act directed "ANR to use 'the full range of possibilities' under section 402 to administer the state program and to meet its objectives."[30] The Board also found that Vermont law "specifically requires ANR's stormwater management program to be consistent with 'applicable requirements of the federal Clean Water Act.'"[31] Among other things, the Board was also persuaded by the fact that federal regulations require that delegated states have the authority to implement 40 C.F.R. § 122.26, which includes the RDA and petition process.[32] In total, the Board concluded that "Vermont does not directly apply federal law. However, the Vermont Water Pollution Control Act is broadly written and intended to authorize ANR to fully implement the Clean Water Act in Vermont."[33] Thus, the Water Resources Board determined the appeal was properly before it.[34]

Once the CLF and VNRC appeal cleared these initial procedural hurdles, the next issues before the Water Resources Board were whether: (1) Act 140 of 2004 excused ANR from exercising RDA; (2) "a discharge of stormwater [is] subject to NPDES permitting if the discharge contributes to a violation of water quality standards even if it has not been shown that the discharge also constitutes a significant contributor of pollutants" to impaired waters; and (3) a petitioner is required to "identify every discharge that contributes to violations of the Vermont Water Quality Standards in the waters at issue."[35]

First, the Board found that Act 140 did not excuse the State from exercising RDA where cleanup plans to protect water quality are not in place for the streams.[36] The Water Resources Board rejected ANR and opponent arguments that federal regulations allow delegated states to

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28. *Id.* at 11.
29. *Id.* at 11.
30. *Id.* at 12.
31. *Id.* at 13. (quoting VT. STAT. ANN. tit. 10, § 1264(b)(4).
32. *Id.* at 13 (citing 40 C.F.R. § 123.25(a)(9)).
33. *Id.* at 13.
34. The Water Resources Board also rejected a similar procedural argument advanced by ANR and the intervenors, which was that the Board lacked jurisdiction because this particular petition was a request for a rulemaking relating to its residual designation authority as opposed to a petition to force ANR to exercise its residual designation authority in specific instances. *Id.* at 15–17.
35. *Id.* at 18. ANR also raised several additional procedural issues that the Water Resources Board did not find persuasive. *Id.* at 2–5.
36. *Id.* at 6.

consider "other relevant factors" like state policy preferences expressed in Act 140 when determining whether to exercise its RDA. [37] When determining whether stormwater discharges "contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States . . . [ANR] may consider the following factors:

(A) The location of the discharge with respect to waters of the United States . . . ;
(B) The size of the discharge;
(C) The quantity and nature of the pollutants discharged to waters of the United States;
(D) Other relevant factors."[38]

The Board found that the section (D) category must be "reasonably read in the same fashion" as the other three factors, which "clearly relate to . . . technical considerations."[39] Thus, Act 140 alone does not excuse ANR from compliance with the federal Clean Water Act.[40] The Board made clear that "residual designation is not optional."[41]

Second, the Board rejected arguments that a petitioner must prove that the stormwater discharge alone would adversely impact water quality or that the discharge is a "significant contributor of pollutants to the receiving waters."[42] Finally, the Board agreed with CLF and VNRC that a petitioner is not required to identify all stormwater discharges that require a NPDES permit.[43] The Board stated that "[i]t would not be reasonable for the law to require NPDES permits for categories of stormwater discharges but to limit the petition process to one discharge at a time. Moreover, if a category were appropriate for NPDES permitting, it is the state's responsibility to effectuate the permitting process, rather than the responsibility of citizen petitioners to identify every discharge that might be involved."[44]

The Board denied the motions to dismiss the appeal, reversed ANR's denial of CLF and VNRC's petition, and remanded the matter back to ANR to exercise its RDA subject to a determination as to whether a *de minimis* threshold applied.[45]

ANR and other parties appealed the Water Resources Board decision to the Vermont Supreme Court in 2006. While the Supreme Court ultimately

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37. *Id.* at 5.
38. 40 C.F.R. § 122.26(a)(1)(v).
39. *Stormwater NPDES Petition*, No. 14-1-07.
40. *Id.*
41. *Id.* at 6.
42. *Id.* at 8.
43. *Id.* at 10.
44. *Id.* at 11.
45. *Id.* at 12.

did not find the Appellants' procedural arguments persuasive, the Court reversed the Board's decision because the "Board erroneously encroached on the Agency's authority in assuming that the discharges contribute to violations of water quality standards . . . ."[46] Implicit in the Board's decision was that existing stormwater discharges contribute to water quality standard violations in the streams identified in the CLF and VNRC petition.[47] In making this determination, the Board effectively applied the doctrine of collateral estoppel by relying on two prior cases that involved permits issued under the state stormwater program for stormwater discharges into the streams.[48] In both cases, the Board had expressly declined to address compliance with federal permit requirements.[49] The Court found that the Board incorrectly applied the doctrine of collateral estoppel because the issue raised in the prior cases was not the same issue in this case.[50] The Court noted that

> [t]he question before the Board in this case was whether, under the federal NPDES permitting program, the Agency was compelled to exercise its residual designation authority to require federal discharge permits. Resolution of this issue, which the Board was careful to avoid in both earlier decisions, involves a particularized, fact-specific determination on a case-by-case basis as to whether certain discharges or categories of discharges 'contribute to a violation of a water quality standard.'[51]

The Court noted that, "while the Agency's residual designation authority is not optional, its discretion in exercising that authority is broad . . . ."[52] The Court went on to state, however, that "[i]t is equally apparent . . . that the Agency erred in summarily denying the petition rather than undertaking the requisite fact-specific analysis under its RDA to determine whether NPDES permits were necessary for the discharges in question."[53] The Court reversed the Board's decision and remanded the matter back to ANR to determine whether the stormwater discharges identified in the CLF and VNRC petition contribute to water quality standard violations.[54]

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46. *In re Stormwater NPDES Petition*, 2006 VT ¶ 1, 180 Vt. at 264, 910 A.2d at 824.
47. *Id.* ¶ 23, 180 Vt. at 274–75, 910 A.2d at 834.
48. *Id.*
49. *Id.* ¶ 24, 180 Vt. at 275, 910 A.2d at 834.
50. *Id.*
51. *Id.* ¶ 26, 180 Vt. at 276, 910 A.2d at 835.
52. *Id.* ¶ 28, 180 Vt. at 276, 910 A.2d at 835.
53. *Id.* ¶ 29, 180 Vt. at 277, 910 A.2d at 836.
54. *Id.* ¶ 29–30, 180 Vt. at 277, 910 A.2d at 836.

After this decision, ANR denied the CLF and VNRC petition a second time.[55] In its denial letter, ANR determined it was "not prudent or necessary" to exercise its RDA and that ANR would "consider residually designating the discharges" after ANR issues a TMDL and a general watershed permit for the area.[56] Once again, CLF appealed—this time to the Environmental Court.[57] ANR had gathered site-specific data regarding existing discharges and the streams over the past two years.[58] The issue before the Environmental Court was, in light of ANR's fact-specific analysis, "whether ANR is now compelled to exercise RDA . . . ."[59] The court noted that "ANR has some discretion to determine whether a discharge 'contributes' to a violation, but once that determination is made in the affirmative, ANR is compelled to exercise RDA."[60] In order to make the contribution determination, the Court noted that ANR must identify stormwater discharges and loads. If these existing discharges "load more pollutants into the impaired [streams] than the existing remedial efforts remove—in a more than net 'de minimis' amount—then the discharges must be deemed to 'contribute' to violations of water quality standards."[61]

Based on a review of the data regarding the streams, the Court concluded that "it is undisputed that the five [streams] at issue in this case are impaired and that specifically identified stormwater discharges into these [streams] are causing material impairments" and that existing remedial efforts do not remove a sufficient amount of pollution.[62] The Court held that ANR was compelled to exercise its RDA authority, granted CLF's petition, and remanded the matter back to ANR to implement the RDA authority.[63] The Agency issued RDA General Permit No. 3-9030.[64] As of November 19, 2009, designated discharges into Bartlett, Centennial, Englesby, Morehouse, and Potash Brook watersheds require coverage under the general permit.[65]

In the aftermath of this litigation, Vermont has recognized the residual authority designation as an important tool in its toolbox to clean up and

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55. *Stormwater NPDES Petition,* No. 14-1-07.
56. *Id.* at 14.
57. *Id.*
58. *Id.* at 11–13.
59. *Id.* at 18.
60. *Id.* at 25.
61. *Id.* at 26.
62. *Id.* at 27, 33.
63. *Id.* at 36.
64. *Residual Designation Authority (RDA)*, DEP'T ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/stormwater/permit-information-applications-fees/rda#General Permit [https://perma.cc/KJ6Q-89XG] (last visited Apr. 3, 2016).
65. *Id.*

protect water quality in Lake Champlain and across the state. Act 64 of 2015 expressly incorporates the RDA into Vermont law. Section 1264(e) states that "[t]he Secretary shall require a permit under this section for a discharge or stormwater runoff from any size of impervious surfaces upon a determination by the Secretary that the treatment of the discharge or stormwater runoff is necessary to reduce . . . adverse impacts to water quality . . . ."[66] Further, in the draft Vermont Lake Champlain Phosphorus TMDL Phase I Implementation Plan, the Agency identifies its RDA as a tool to reduce phosphorus loading from stormwater discharges.[67] ANR notes that it plans to implement Tactical Basin Planning to identify specific instances when RDA is appropriate for impervious surfaces and individual or categories of point sources.[68]

II. WATER QUALITY AND WASTEWATER EFFLUENT LIMITS UNDER THE 2002 LAKE CHAMPLAIN TMDL

For most of the early decades of the implementation of the Clean Water Act, the implementation focus has been on point source discharges.[69] "Phosphorus loading to Lake Champlain is dominated by 'nonpoint sources,' which are generated by runoff and erosion across the landscape, as opposed to 'point sources' such as wastewater and certain stormwater discharges that are conveyed by a pipe and are more closely regulated."[70] Wastewater treatment facilities ("WWTFs") represent three percent of the total amount of phosphorus being discharged into the Lake.[71] Notwithstanding the small contribution of phosphorus loadings into the Lake, wastewater treatment plants have been the focus of several court challenges due to the legal structure of the Clean Water Act and the fact that point source discharges are generally easier to monitor and control compared to more diffuse water pollution like urban runoff and runoff from farms.

ANR is authorized to administer the federal Clean Water Act.[72] ANR must adopt water quality standards,[73] prevent direct and indirect discharges without a permit,[74] and establish the minimum criteria for discharge permits

66. VT. STAT. ANN. tit. 10, § 1264(e)
67. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 84.
68. *Id.*
69. U.S. ENVTL. PROT. AGENCY, INTRODUCTION TO THE CLEAN WATER ACT 2, http://cfpub.epa.gov/watertrain/pdf/modules/introtocwa.pdf [https://perma.cc/NPH7-AXDK].
70. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 1.
71. *Id*. at 32.
72. VT. STAT. ANN. tit. 10, Ch. 47.
73. VT. STAT. ANN. tit. 10, § 1252.
74. *Id.* § 1259(a).

within the state.[75] Vermont's Water Pollution Control Regulations heavily incorporate the federal requirements for the administration of the state's direct discharge program.[76]

The 2002 Lake Champlain TMDL established limitations on phosphorus at 60 WWTFs that were designed to reduce 22,300,000 metric tons per year of phosphorus.[77] The limitations within the 2002 Lake Champlain TMDL were expressed in an annual mass limit established for each facility discharging into the Lake Champlain basin.[78] For the majority of facilities, annual limits were defined by taking a 0.6 mg/l concentration limit and applying that to the design flow for the facility.[79] Since the actual discharges were less than the permitted discharge at design capacity for many facilities, ANR established an average monthly concentration limit of 0.8 mg/l was set for these facilities, which allowed them to meet a mass discharge amount of 0.6 mg/l.[80]

ANR determined that a mass limit was the more appropriate standard because

> [a]lthough 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 . . . the lake generally responds to loadings that occur over longer periods of time (e.g. annual loads).[81]

In addition to the limits established in the 2002 Lake Champlain TMDL, the Vermont General Assembly placed statutory limitations on the level of phosphorus concentrations from a WWTF.[82] A discharge into Lake Champlain or Lake Memphremagog with average monthly concentration greater than 0.8 mg/l was prohibited, and the Secretary could establish

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75. VT. STAT. ANN. tit. 10, § 1263(a).

76. *See generally* Vermont Water Pollution Control Permit Regulations, VT. STAT. ANN. tit. 10, § 1258.

77. VT. DEP'T OF ENVTL. CONSERVATION, FACT SHEET: LAKE CHAMPLAIN PHOSPHORUS TMDL 2 (2002), http://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_2002_LC%20P%20tmdl%20FS.pdf [https://perma.cc/64P5-5NYL].

78. *Id.* at 22.

79. *Id.* at 2.

80. *See id.* at 24, 26 (showing that the actual load was less than the permitted flow for many of the facilities).

81. *In re* City of S. Burlington, No. WQ-03-02, 2003 WL 23066940, at *3 (Vt. Water Res. Bd. Dec. 29, 2003).

82. VT. STAT. ANN. tit. 10, § 1266a(a).

phosphorus wasteload allocations or concentration limits that are necessary to comply with a TMDL or attain Vermont Water Quality Standards.[83] Further, this section required ANR to establish a schedule for compliance with these concentration limitations based upon the availability of funds; further, a municipal discharger was not required to comply with revised effluent limitations if funding was not available.[84] When effluent limits were required as a part of a Lake Champlain TMDL, ANR was obligated to pay 100 percent of the costs of any upgrade.[85] These funding provisions were eliminated as a part of Act 64 of 2015.[86]

A. In re City of South Burlington and Town of Colchester WWTF

The City of South Burlington operates a WWTF and contracts with the Town of Colchester to serve portions of the Town with wastewater service.[87] After the adoption of the 2002 Lake Champlain TMDL, the City applied for and was granted a renewal of its permit. The permit established an annual mass phosphorus limit consistent with the 2002 Lake Champlain TMDL, which was based on the WWTF's operation at design flows at a concentration limit of 0.6 mg/l. In addition to the annual mass limit, the permit also contained a condition that established an average monthly effluent limit of 0.8 mg/l.[88]

CLF appealed the permit asserting that the permit's annual phosphorus limitation would not meet the requirements of the 2002 Lake Champlain TMDL and that average monthly concentration limits of 0.6 mg/l are required.[89] CLF argued that because ANR failed to include a monthly average concentration limit of 0.6 mg/l in the permit, the facility would not meet its annual load limits when operating at design capacity.[90]

83. *Id.* § 1266a(a)–(b). Note that there was an exception to this general prohibition. If a facility had a discharge of less than 200,000 gallons per day and was permitted on or before July 1, 1991 it was not subject to the 0.8 mg/L restriction; however, the Secretary could establish a more stringent discharge as a part of a TMDL.

84. VT. STAT. ANN. tit. 10, § 1266a(c).

85. Awards for Pollution Abatement Projects to Abate Dry Weather Sewage Flows, Act 64 of 2015, VT. STAT. ANN. tit. 10, §1625(e) (proposed amendment).

86. *Id.*

87. *City of S. Burlington*, 2003 WL 23066940, at *2.

88. *Id.*

89. *Id.* at *3. In addition to the phosphorus limits in the permit, CLF also challenged the validity of effluent limits established for biological oxygen demand, total suspended solids, and ammonia, asserting that they cause or contribute to a violation of water quality standards and the sufficiency monitoring in the permit. *Id.* at *1. Since they are not related to the interrelationship between the TMDL and water quality based effluent limit they are not discussed as a part of this article.

90. *Id.* at *7.

The Water Resources Board found that state and federal law require that the limit must ensure compliance with the 2002 Lake Champlain TMDL and that permit conditions less stringent than the TMDL would not ensure compliance with water quality standards.[91] The Board went on to observe that the 2002 Lake Champlain TMDL does not establish average monthly concentrations for WWTFs; rather, the TMDL establishes an annual mass load for each facility's phosphorus discharge.[92] In light of the fact that the permit conditions met the requirements of the 2002 Lake Champlain TMDL, the Board affirmed the phosphorus discharge limits contained within South Burlington's permit and dismissed CLF's appeal.[93]

B. In re Village of Enosberg Falls WWTF

The Village of Enosberg Falls operates a WWTF that discharges into the Missisquoi River and ultimately Lake Champlain.[94] The Village of Enosberg Falls applied and received a renewal permit in 2003.[95] That permit was appealed by CLF.[96]

CLF raised four arguments in their appeal: (1) the 2002 Lake Champlain TMDL cannot act as a shield that allows discharges that cause or contribute to violations of water quality standards; (2) effluent limitations more stringent than those contained within the TMDL must be applied if necessary to protect water quality standards; (3) ANR failed to implement the TMDL; and (4) ANR violated its permitting regulations by failing to include daily average and maximum quantitative effluent limits.[97] Issues one, three, and four were dismissed on procedural grounds and the Board proceeded to the merits on issue two.[98]

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91. *Id.* at *8.
92. *Id.*
93. *Id.* at *9.
94. Village of Enosburg Falls No. WQ-03-03 1 (Vt. Water Res. Bd. Apr. 21, 2004) (decision).
95. *Id.*
96. *Id.*
97. *Id.* at 3.
98. *Id.* at 5–7. The Board found that the question of whether the permit was consistent with the TMDL was resolved by the *City of South Burlington* case. *Id.* at 5. With respect to the implementation of the TMDL, the Board found that CLF failed to support this claim with sworn affidavits and therefore the claim was not properly raised. *Id.* Finally, the Board found that in light of its prior findings it did not need to address CLF's argument that the "[p]ermit unlawfully authorizes water quality standards violations" because it failed to contain daily effluent limitations. *Id.* at 7. The Board found that CLF's claim that the failure to include daily effluent limits in the permit was also a separate and distinct violation of state regulations was waived because CLF did not identify this issue in the Notice of Appeal. *Id.*

CLF claimed that effluent limitations more stringent than those contained within the 2002 Lake Champlain TMDL must be applied until the TMDL is fully implemented and water quality standards have been attained.[99] CLF claimed that the 2002 Lake Champlain TMDL cannot authorize discharges that cause or contribute to the violation of a water quality standard.[100] According to CLF, the WWTF is required to meet those effluent limitations either through offsets or treatment.[101]

The Board rejected CLF's argument, finding that "a TMDL and its accompanying implementation plan provide the means of establishing water quality based effluent limitations in discharge permits."[102] The Board went on to state that "[t]he idea that effluent limitations for discharges of pollutants of concern into impaired waters cannot be justified by a valid TMDL defies the logic of water quality based permitting and would render the TMDL process meaningless."[103] The Board then affirmed the phosphorus limits within Enosburg Falls' permit and dismissed CLF's claim with respect to this issue.[104]

C. In re Montpelier WWTF Discharge Permit

The City of Montpelier operates a WWTF that discharges into the Winooski River, which ultimately discharges into Lake Champlain.[105] In 2008, Montpelier received a renewal of its permit that established an annual limit on phosphorus of 7,253 pounds of phosphorus.[106] In setting these limits, the Agency relied on the 2002 Lake Champlain TMDL and did not perform any additional analysis in setting the effluent limitations for phosphorus.[107] CLF appealed the permit claiming that the permit did not meet the requirements of the Clean Water Act or the Vermont Water Pollution Control Act because the phosphorus limits did not protect water quality.[108] The Court ultimately held that the phosphorus limits in the Montpelier permit were invalid for two reasons: (1) the automatic adoption of a water quality based effluent limit ("WQBEL") from a TMDL more than five years old "violates the five-year limitation on NPDES permits";

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99. *Id.* at 6.
100. *Id.*
101. *Id*.
102. *Id.*
103. *Id.*
104. *Id.* at 7–8.
105. *See generally In re Montpelier WWTF Discharge Permit*, No. 22-2-08, 2009 WL 4396740, at *2 (Vtec. June 30, 2009).
106. *Id.*
107. *Id.*
108. *Id*.

and (2) there was no "specific analysis . . . to determine whether [the] WQBEL . . . derived from [the] TMDL is 'consistent with the assumptions and requirements of [the] available wasteload allocation.'"[109] In reaching this conclusion, the Court noted that its decision "does not lead to a conflict with the Champlain TMDL, which remains the ceiling beyond which the permit WQBEL cannot pass."[110]

The Court distinguished this decision from the finding of the Water Resources Panel in *Enosburg Falls*, finding that in that instance only a year-and-a-half had run since the adoption of the Lake Champlain TMDL, whereas in the case of Montpelier more than six-and-a-half years had passed.[111] The Court observed that "[i]n that intervening period, the five year statutory time limit for NPDES permits has run, and there has been ample time to study whether the underlying assumptions of the Champlain TMDL have been met to bring Lake Champlain into compliance with water quality standards." [112] The Court found that relying on a WQBEL established more than five years ago violated the requirements of 33 U.S.C. § 1342(b)(1)(B).[113] The Court examined several other permit appeals when courts found that efforts of a permitting agency to place an effluent limit that extended beyond the permit terms were impermissible.[114] The Court then applied the same rationale with respect to wasteload allocations developed in a TMDL greater than five years old.[115] The Court found that those wasteload allocations cannot be used as a substitute for conducting an analysis to ensure that the statutory requirements of establishing a WQBEL for phosphorus at a facility have taken place.[116]

In addition to its conclusion with respect to the five-year permitting requirement, the Court found that the Agency failed to meet the requirements for establishing a WQBEL under 40 C.F.R. part 122.44(d)(1)(vii)(B).[117] The Court found that the regulation requires an analysis of the underlying assumptions of a TMDL prior to relying on the wasteload allocation for a facility under the TMDL.[118] The Court reviewed the 2002 Lake Champlain TMDL in depth, examining the assumptions

109. *Id*. at 3–5 (quoting 40 C.F.R. § 122.44(d)(1)(vii)(B)).
110. *Id.* at 15.
111. *Id.* at 8.
112. *Id*.
113. *Id.* at 8.
114. *Id*. at 7–10.
115. *Id*. at 8.
116. *Id.*
117. *Id*. at 14.
118. *Id*.

made in the document related to nonpoint reductions that were to take place under the TMDL.[119] The Court stated that

> the TMDL assumptions that were made in 2002 become problematic when they are used as the sole basis for setting a WQBEL in 2008, particularly when these assumptions were never checked in the actual permit application process, despite evidence that Lake Champlain is currently receiving roughly twice the levels of phosphorus compared to what was allowed under its approved loading capacity in the 2002 Champlain TMDL.[120]

The Court noted that its decision did not dictate what the results of the analysis of the TMDL assumptions would be; rather, ANR must review the assumptions a TMDL is based upon and ensure any WQBELs derived from a wasteload allocation are consistent with the underlying assumptions of the TMDL during the permit review.[121]

III. AGRICULTURAL WATER QUALITY AND MISSISQUOI BAY

Agricultural nonpoint source pollution represents approximately forty percent of the phosphorus load to the Lake, making it the largest single phosphorus source in the Basin.[122] With respect to Missisquoi Bay, the predominance of agricultural land in the Basin makes agricultural nonpoint sources the primary sources of phosphorus—the pollutant that supports algal blooms in Missisquoi Bay—and also sources for other pollutants.[123] In the 1990s, Vermont established an agricultural water quality program with the primary purpose of preventing animal wastes from reaching waters of the state.[124] In order to reach this goal, the State has adopted required agricultural practices (“RAPs”)[125] that apply to all farms.[126] The RAPs form the floor of management practices that farms are required to implement to prevent discharges of waste to surface or ground waters.[127] The RAPs

119. *Id.* at 15.
120. *Id*. at 15–16.
121. *Id*. at 18.
122. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 44.
123. AGENCY OF NAT. RES., MISSISQUOI BASIN PLAN 22 (2013).
124. *See* VT. STAT. ANN. tit. 6, Chapter 215 (2015); VT. STAT. ANN. tit. 6, § 4801(1) (2011).
125. Originally, required agricultural practices were referred to as “Accepted Agricultural Practices” and were changed to “Required Agricultural Practices” as a part of Act 64 of 2015. For purposes of consistency, both will be referred to as the “Required Agricultural Practices.” VT. STAT. ANN. tit. 6, § 4810(a)(1), *amended by* VT. STAT. ANN. tit. 6, § 4810(b).
126. VT. STAT. ANN. tit. 6, § 4810(b).
127. *Id.*

establish general standards and practices that apply to farms, such as prohibiting the direct discharge of an agricultural waste into a water of the state[128] and more specific requirements like requiring manure stacking 100 feet from a surface water.[129]

In addition to RAPs, the law establishes a process for the Secretary of the Agency of Agriculture, Food and Markets ("VAAFM") to require site specific best management practices ("BMPs") to address specific concerns that may exist on a farm.[130] Under Vermont law, BMPs are "site-specific on-farm conservation practices implemented in order to address the potential for agricultural pollutants to enter the waters of the State."[131] The regulations state that "[b]est management practices are site specific on-farm remedies implemented either voluntarily or as required in order to address water quality problems and in order to achieve compliance with state water quality standards."[132] Any person may petition the Secretary of VAAFM to require a BMP on a farm.[133] Prior to the enactment of Act 64 of 2015—before requiring that BMP—the Secretary of VAAFM was required to find that "sufficient financial assistance is available to assist the farmer in implementing the applicable BMP."[134]

In 2013, CLF petitioned the Secretary of VAAFM to require BMPs for farms throughout the Missisquoi Basin.[135] CLF asserted that Missisquoi Bay is the largest contributor of phosphorus to the lake when compared to all other lake segments and that agriculture is the primary source of phosphorus loadings in the lake segment.[136] CLF relied primarily on reports developed by the ANR and VAAFM in support of its claims.[137] CLF petitioned the VAAFM to develop a process to identify critical source areas of phosphorus and impose BMPs for farms in the region to reduce nonpoint phosphorus discharges to waters in the basin.[138]

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128. Agricultural Practices Rule for the Agricultural nonpoint Source Pollution Control Program, Act 64 of 2015 § 1.1–1.2 (proposed amendment) (Second draft).

129. *Id.* § 6.02(e).

130. VT. STAT. ANN. tit. 6, § 4810(c).

131. *Id.*

132. In comparison, EPA regulations state that BMPs "mean[] schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of 'waters of the United States.' BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage." 40 C.F.R. § 122.2.

133. VT. STAT. ANN. tit. 6, § 4813(a).

134. VT. STAT. ANN. tit. 6, § 4810(a)(2), *amended by* VT. STAT. ANN. tit. 6, § 4810(c) (Supp. 2015).

135. Petition from Anthony N. L. Iarrapino, Esq., Senior Attorney, Conservation Law Found. to Chuck Ross, Sec'y, Vt. Agency of Agric., Food & Mkts. (May 22, 2014).

136. *Id.*

137. *Id.*

138. *Id.*

VAAFM scheduled a public hearing on the petition to accept comments from the community and issued a final decision on CLF's petition on July 14, 2014.[139] VAAFM refused to grant CLF's petition on three grounds: (1) the petition impermissibly conflicts with EPA's TMDL process currently under way; (2) the petition impermissibly shifts the burden of identifying farms that have water quality violations to the Secretary of VAAFM; and (3) there is insufficient financial assistance available to assist farmers in achieving compliance with BMPs.[140]

CLF appealed the Secretary of Vermont Superior Court's decision to the Environmental Division, Superior Court on December 16, 2014.[141] The State of Vermont and CLF entered settlement negotiations to resolve their dispute. During the course of those settlement negotiations two key developments took place with respect to agricultural water quality.[142] First, the Vermont General Assembly passed Act 64 of 2015, which made significant changes to the law governing agricultural water quality, including eliminating the requirement that the Secretary of VAAFM consider the availability of financial assistance prior to requiring a BMP.[143] In addition, the Natural Resources Conservation Service significantly increased the funding available to assist with water quality improvements on a farm.[144]

On September 4, 2015, the Secretary of VAAFM issued an initial revised decision that made the threshold finding that BMPs are necessary in the Missisquoi Bay watershed in order to assure compliance with water quality standards and established a process for the implementation of a BMP program within that watershed.[145] That decision was finalized on February 3, 2016, following notice and a public hearing on the program.[146]

The program will provide for one year of education and outreach efforts by AAFM to explain the requirements of the RAPs and BMPs and the availability of financial assistance.[147] After the conclusion of that one-year period, VAAFM must notify all permitted large and medium farming

139. CHUCK ROSS, VT. AGENCY AGRIC., FOOD & MKTS., IN RE: CLF PETITION TO REQUIRE MANDATORY POLLUTION CONTROL BEST MANAGEMENT PRACTICES FOR AGRICULTURAL NON-POINT SOURCE IDENTIFIED IN THE MISSISQUOI BASIN PLAN 2 (2014).

140. *Id.* at 16–17.

141. *Id.* at 2.

142. *Id.* at 2–3.

143. *Id.* at 2.

144. *Id.* at 3.

145. CLF Petition to Require Mandatory Pollution Control Best Management Practices for Agricultural Non-Point Sources Identified in the Missisquoi Basin Plan. AAFM No. 2014-06-04 ARM 3 (Vt. Agency of Agric., Food, & Mkt. Feb. 2, 2016) (revised secretary's decision).

146. *See* ROSS, *supra* note 139, at 2, 15 (explaining that the decision went through notice and comment before the Secretary finalized it).

147. *Id.* at 12.

operations, farm operations that have a license to ship milk, and farms required to certify as meeting the RAPs of the requirement to have an assessment of the potential impacts of farm operations on water quality.[148] VAAFM is required to assess all farms and require BMPs where appropriate over a period of ten years.[149] Once assessed, the farm is required to submit a plan for financing and implementation of BMPs on a schedule developed by AAFM.[150] Additional flexibility is given to farms working with VAAFM to obtain funding and implement the BMP plan.[151]

As a part of the settlement, CLF agreed not to petition AAFM under the BMP statute or assist any third party in petitioning AAFM for a period of ten years provided VAAFM was in conformance with the revised decision.[152] VAAFM plans to assess several other watersheds that are significantly impaired due to agricultural pollutants to determine whether the BMP framework should apply to those watersheds.[153]

IV. DISAPPROVAL OF THE 2002 LAKE CHAMPLAIN TMDL

In addition to the water quality litigation related to stormwater discharges, wastewater treatment plants, and agricultural activities during this time period, the 2002 Lake Champlain TMDL itself was the subject of legal action.[154] Under the federal Clean Water Act, Vermont must identify waters that do not or are not expected to meet the Vermont Water Quality Standards after requiring technology-based effluent limits for point sources.[155] These waters are "impaired," and the State must include these waters on a Section 303(d) list.[156] Once a water is identified as impaired for one or more pollutants, Vermont must develop a pollution budget for the water that ensures compliance with water quality standards.[157] EPA must

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148. *Id.*
149. *Id.* at 13.
150. *Id.*
151. *Id.*
152. Draft Stipulation of the Parties for Remand at 4–5, *In re* CLF Petition to Require Mandatory Best Management Practices for Agricultural Non-point Sources Identified in the Missisquoi Basin Plan AAFM No. 2014-06-04 ARM, Vtec (Aug. 31, 2015) (No. 175-12-14) (draft stipulation).
153. *Id.* at 5.
154. Complaint at ¶¶ 1, 8, Conservation Law Foundation v. Envtl. Prot. Agency (D. Vt. Oct. 28, 2008) (No. 2:08-cv-00238) [hereinafter CLF Complaint].
155. 33 U.S.C. § 1313(d)(1)(A).
156. *See id.* (requiring all states to identify and rank waters where the water quality is insufficient).
157. *See id.* § 1313(d)(1)(C) (requiring all states to establish total maximum daily loads for waters with insufficient water quality).

approve the TMDL.[158] If EPA does not approve the TMDL, EPA must develop a TMDL that protects water quality.[159]

On November 4, 2002, EPA approved the Vermont portion of the 2002 Lake Champlain Phosphorus TMDL.[160] In 2008, CLF filed a lawsuit in federal district court challenging EPA's approval of the Vermont portion of the 2002 Lake Champlain Phosphorus TMDL.[161] CLF did not appeal the New York portion of the 2002 Lake Champlain TMDL and it remains in effect today. CLF and EPA ultimately settled the lawsuit in 2010 and EPA agreed to reconsider its decision to approve the Vermont portion of the TMDL.[162] On January 24, 2011, EPA withdrew its approval of the Vermont portion of the 2002 Lake Champlain Phosphorus TMDL.[163]

In its lawsuit, CLF asserted that the Vermont portion of the 2002 Lake Champlain Phosphorus TMDL violated the Clean Water Act in four ways: "margin of safety, stringency of WLAs in light of reasonable assurance that sufficient load reductions would occur, aggregation of stormwater WLAs, and climate change considerations associated with the loading capacity and hydrologic base year."[164] First, CLF claimed that ANR's "implicit" margin of safety—using conservative modeling assumptions—did not protect water quality or meet the requirements of the Clean Water Act.[165] A TMDL must include a margin of safety ("MOS") to account for any lack of knowledge

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158. *Id.* § 1313(d)(2).

159. *Id.* § 1313(d)(2).

160. 2002 PHOSPHORUS TMDL APPROVAL, *supra* note 5, at 2, 3.

161. Shortly before filing the complaint in federal court, CLF filed a petition with EPA seeking withdrawal of Vermont's authority to administer the federal NPDES program or a requirement that the State implement corrective actions to ensure compliance with the Clean Water Act. Envtl. & Natural Res. Law Clinic, Vt. Law Sch. for Conservation Law Found., Petition for Withdrawal of the National Pollutant Discharge Elimination System Program Delegation from the State of Vermont at 1 (Aug. 14, 2008) [hereinafter CLF, De-delegation Petition]. The petition alleged that Vermont had "failed to administer the NPDES program in accordance with the Clean Water Act" because Vermont did not: "adequately enforce against polluters; failed to comply with the public participation provisions of the CWA; failed to regulate concentrated animal feeding operations (CAFOs); and failed to promulgate and implement an anti-degradation implementation plan." *Id.* After five years of discussions and a corrective action plan for eight areas of the State's program, EPA determined that Vermont addressed all of EPA's concerns in December of 2013 except for one, which required a legislative amendment. *See* Letter from H. Curtis Spalding, Reg'l Adm'r, U.S. Envtl. Prot. Agency, to Laura Murphy, Envtl. & Nat. Res. Law Clinic, Vermont Law School, et al. (Dec. 13, 2013) (on file with recipient) (explaining the history of discussions concerning Vermont's potential corrective actions and stating the remaining issue of the need for a legislative amendment to create a permanent solution for regulating municipal discharges of phosphorus).

162. Letter from H. Curtis Spalding, Regional Administrator, U.S. Envtl. Prot. Agency, to Deborah Markowitz, Secretary, Vt. Agency of Nat. Res. (Jan. 24, 2011) (addressing discussions between CLF and EPA concerning the lawsuit that was settled in 2010) [hereinafter EPA Disapproval Letter].

163. *Id.*

164. *Id.* at 3.

165. *See* CLF Complaint at ¶¶ 61–67.

concerning the relationship between load and wasteload allocations and water quality.[166] The EPA guidance in effect during that time allowed states to incorporate an MOS into the TMDL through "conservative assumptions in the analysis" or by setting aside loadings for the MOS.[167] During its review, EPA found that while the two conservation assumptions ANR relied on "provide[] some level of MOS for certain segments, neither component provides an MOS for all segments."[168] Thus, EPA agreed with CLF that ANR's MOS did not meet the requirements of the Clean Water Act.[169]

CLF's second claim was that the TMDL failed to provide "reasonable assurances" that the projected nonpoint source phosphorus reductions would actually occur in light of the insufficiently stringent limits for wastewater treatment plants and other point sources.[170] Under the Clean Water Act, wasteload allocations may be less stringent "[i]f best management practices or other nonpoint source pollution controls make more stringent load allocations practicable."[171] EPA guidance provides that a "TMDL must provide 'reasonable assurances'[172] that nonpoint source control measures will achieve expected load reductions" if the TMDL relaxes wasteload allocations for point sources.[173] CLF asserted that ANR relied on unimplemented programs and "numerous, unproven nonpoint source controls" to support less stringent wasteload allocations for wastewater treatment plants and other point sources.[174] EPA agreed with CLF and concluded that ANR's reasonable assurances analysis was woefully inadequate.[175] The only actual program EPA identified that would provide reasonable assurance that phosphorus would be reduced from nonpoint source controls was expected to reduce "less than one percent of the reductions needed to meet the load allocations."[176] According to EPA,

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166. EPA Disapproval Determination Letter, *supra* note 162, at 3.
167. *Id.*
168. *Id.* at 8.
169. *Id.*
170. *See* CLF Complaint at ¶¶ 47–60.
171. EPA Disapproval Determination Letter, *supra* note 162, at 8 (quoting 40 C.F.R. § 130.2(h)–(i)).
172. *See* Memorandum from Robert Perciasepe, Assistant Administrator, U.S. Envtl. Prot. Agency, to Regional Administrators and Regional Water Division Directors, U.S. Envtl. Prot. Agency Re New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs) ("In watersheds impaired by a blend of point and nonpoint sources, this TMDL Process guidance document provides that where any wasteload load allocation to a point source is increased based on an assumption that loads from nonpoint sources will be reduced, the State must provide "reasonable assurances" that the nonpoint source load allocations will in fact be achieved.").
173. *Id.* at 8.
174. CLF Complaint at ¶¶ 49–52.
175. EPA Disapproval Determination Letter, *supra* note 162, at 11–12.
176. *See id.* at 11 (discussing the Watershed Improvement Permit program).

all other reasonable assurances in the TMDL implementation plan were just recommendations and relied on additional funding and voluntarily cooperation.[177] Thus, EPA found that ANR's reasonable assurances did not support the relaxed standards for point sources.[178]

CLF also complained that the TMDL did not comply with the Clean Water Act because the TMDL included a "gross wasteload allocation for nonwastewater point sources, rather than requiring individual allocations" and did not account for impacts associated with climate change.[179] EPA dismissed both of these arguments, finding that Vermont was allowed to establish a gross wasteload allocation based on the available data at the time the TMDL was prepared.[180] In addition, given the lack of specificity of guidance related to climate change and "high level of uncertainty associated with the regional impacts of climate change at the time," EPA concluded that Vermont's loading capacity analysis and hydrologic base year choice was "scientifically sound and adequately documented."[181]

Although EPA disapproved the TMDL based only on the MOS and "reasonable assurances" deficiencies, EPA made clear that the revised TMDL would be based on new available information and current EPA guidance, and "refinements" to other components of the TMDL were expected.[182] In its disapproval letter, EPA noted that it intended to work collaboratively with the Agency to develop a revised TMDL.[183] EPA recognized the "good work the State and other entities have been engaged in to restore Lake Champlain" and the "many excellent projects and programs implemented to reduce phosphorus inputs to the Lake."[184] During the years that followed, EPA, ANR, and VAAFM worked together to develop the new Phosphorus TMDL for Lake Champlain.[185] EPA issued the final TMDL on June 17, 2016.[186]

CONCLUSION

ANR states that "[p]hosphorous pollution is the greatest threat to clean water in Lake Champlain."[187] Phosphorus pollution from stormwater

177. *Id.*
178. *Id.* at 12.
179. CLF Complaint at ¶¶ 68–80.
180. EPA Disapproval Determination Letter, *supra* note 162, at 13.
181. *Id.* at 14.
182. *Id.* at 16.
183. EPA Disapproval Determination Letter, *supra* note 162.
184. *Id.*
185. *Lake Champlain Phosphorus TMDL: A Commitment to Clean Water*, *supra* note 12.
186. *Id.*
187. ANR PHASE 1 IMPLEMENTATION PLAN, *supra* note 1, at 1.

discharges, wastewater treatment facilities, and agricultural activities all contribute to the loadings that can choke the lake with algae, harming both wildlife and humans.[188] Despite identifying Lake Champlain as a high priority for cleanup more than a decade ago, past efforts have fallen far short of what is needed to restore the health of Lake Champlain. Water quality litigation related to phosphorus pollution from stormwater discharges, wastewater treatment plants, and agricultural activities over the last several years has helped to identify the deficiencies in the 2002 Lake Champlain TMDL and lay the foundation for a stronger and more effective 2016 Lake Champlain TMDL.

188. *Id.*

TECHNICAL EXPLANATION OF THE 2016 TMDL ISSUED BY EPA

Eric Smeltzer[1]

INTRODUCTION

The U.S. Environmental Protection Agency ("EPA") defines "total maximum daily load" ("TMDL") as "the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant."[2] In the case of phosphorus in Lake Champlain, the applicable state water quality standards in Vermont are expressed as in-lake total phosphorus concentration criteria (in milligrams per liter) in each of twelve Vermont segments of the lake.[3] In order to determine the maximum amount

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2. U.S. ENVTL. PROT. AGENCY, PROGRAM OVERVIEW: TOTAL MAXIMUM DAILY LOADS (TMDL), http://www.epa.gov/tmdl/program-overview-total-maximum-daily-loads-tmdl [https://perma.cc/E25F-S6EB] (last updated Dec. 11, 2015).

3. VT. AGENCY NAT. RES., WATER QUALITY STANDARDS ENVIRONMENTAL PROTECTION RULE CHAPTER 29(A) 36 (2014) [hereinafter ENVIRONMENTAL PROTECTION RULE CHAPTER 29(A)].

of phosphorus that could be allowed to enter Lake Champlain from its tributary rivers and wastewater discharges, it was necessary to develop a mathematical model for the lake that accurately predicted changes in the phosphorus concentrations in each lake segment in response to changes in phosphorus loading to the lake. The states of Vermont and New York based the 2002 Lake Champlain Phosphorus TMDL[4] on a lake model program called "BATHTUB," which took into account the phosphorus loading rates from all sources and the manner in which phosphorus is transported by water currents within the lake and lost from the water column by sedimentation process.[5] The states used the BATHTUB model to determine the total loading capacities for phosphorus in each lake segment consistent with achieving the in-lake phosphorus concentration criteria.[6]

When EPA reconsidered its approval of the 2002 Lake Champlain TMDL, the agency reviewed the technical modeling aspects of the TMDL as part of its reevaluation. EPA's review determined that the calculation of the loading capacities for the 2002 TMDL and the selection of the hydrologic base year for modeling were done in a scientifically rigorous manner consistent with EPA requirements.[7] Inadequacies in the modeling analyses supporting the 2002 Lake Champlain TMDL were not a basis for EPA's TMDL disapproval decision in 2011. However, EPA indicated that the development of a new TMDL for Lake Champlain would make use of all available current information.[8] This new information included twenty years of additional lake and tributary monitoring data obtained since the lake model supporting the 2002 TMDL was developed. New watershed modeling methods for the evaluation of phosphorus sources and new climate-prediction models were also available.

I. LAKE MODELING APPROACH

EPA began the process of developing a new Lake Champlain TMDL by convening a technical advisory group composed of local scientists and agency staff and hiring a consulting firm, Tetra Tech, Inc., to evaluate the range of lake modeling options. This group compared the relatively simple

4. VT. AGENCY NAT. RES. & N.Y. STATE DEP'T ENVTL. CONSERVATION, LAKE CHAMPLAIN PHOSPHORUS TMDL 12 (2002).

5. WILLIAM W. WALKER, JR., EMPIRICAL METHODS FOR PREDICTING EUTROPHICATION IN IMPOUNDMENTS. REPORT 4. PHASE III. APPLICATIONS MANUAL I-18 (1987); Eric Smeltzer & Scott Quinn, *A Phosphorus Budget, Model, and Load Reduction Strategy for Lake Champlain*, J. LAKE & RESERVOIR MGMT. 386 (1996).

6. LAKE CHAMPLAIN PHOSPHORUS TMDL, *supra* note 4.

7. Letter from H. Curtis Spalding, Reg'l Admin'r Region 1, U.S. Envtl. Prot. Agency, to Deborah Markowitz, Secretary, Vt. Agency Nat. Res. (2011) (on file with Vt. J. Envtl. L.).

8. *Id.*

BATHTUB model used for the 2002 TMDL[9] with alternative, multi-dimensional modeling frameworks that simulated hydrodynamic (water movement), chemical, and biological processes at high levels of spatial and temporal resolution. The group concluded that the BATHTUB model was best suited for use in the Lake Champlain TMDL revision.[10] Proper development and calibration of multi-dimensional process models would have required data at spatial and temporal scales beyond what was currently available for Lake Champlain and would have been expensive and technically difficult to implement within the necessary time frame. The BATHTUB model met the key management and regulatory requirements for a model to simulate annual average lake phosphorus concentrations in response to changes in annual loads.

The BATHTUB model application to Lake Champlain represented the lake as a linear branching network of thirteen lake segments (Figure 1) corresponding to the same lake segments for which in-lake total phosphorus concentration criteria had been established by Vermont, New York, and Quebec.[11] Each lake segment was modeled as a completely mixed reactor under steady-state conditions, meaning that the model simulated phosphorus concentrations averaged over space and time within each lake segment. The analysis accounted for water flow and transport of phosphorus in the water by modeling two general hydrodynamic processes. The first process was the net south-to-north flow of the lake from segment to segment as water entering the lake from its tributaries drained toward the outlet at the Richelieu River. The second process was the mixing of water back and forth between adjacent lake segments driven by wind-generated currents and other complex hydrodynamic mechanisms, the effects of which were lumped into a single model term representing two-way exchange flows at the interfaces between segments. Finally, the BATHTUB model simulated phosphorus loss from the water column as a net sedimentation rate that was a function of the phosphorus concentration in each lake segment.[12]

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9. *Id.*; WALKER, *supra* note 5.

10. TETRA TECH, INC. & WILLIAM W WALKER, JR., LAKE CHAMPLAIN TMDL SUPPORT: LAKE MODELING APPROACH RECOMMENDATION 23 (2011).

11. ENVIRONMENTAL PROTECTION RULE CHAPTER 29(A), *supra* note 3; LAKE CHAMPLAIN PHOSPHORUS MGMT. TASK FORCE, REPORT OF THE LAKE CHAMPLAIN PHOSPHORUS MGMT. TASK FORCE 14 (1993); U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 20–21 (2015).

12. Smeltzer, *supra* note 5 at 386–88; TETRA TECH, INC., LAKE CHAMPLAIN BATHTUB MODEL CALIBRATION REPORT 18 (2015).

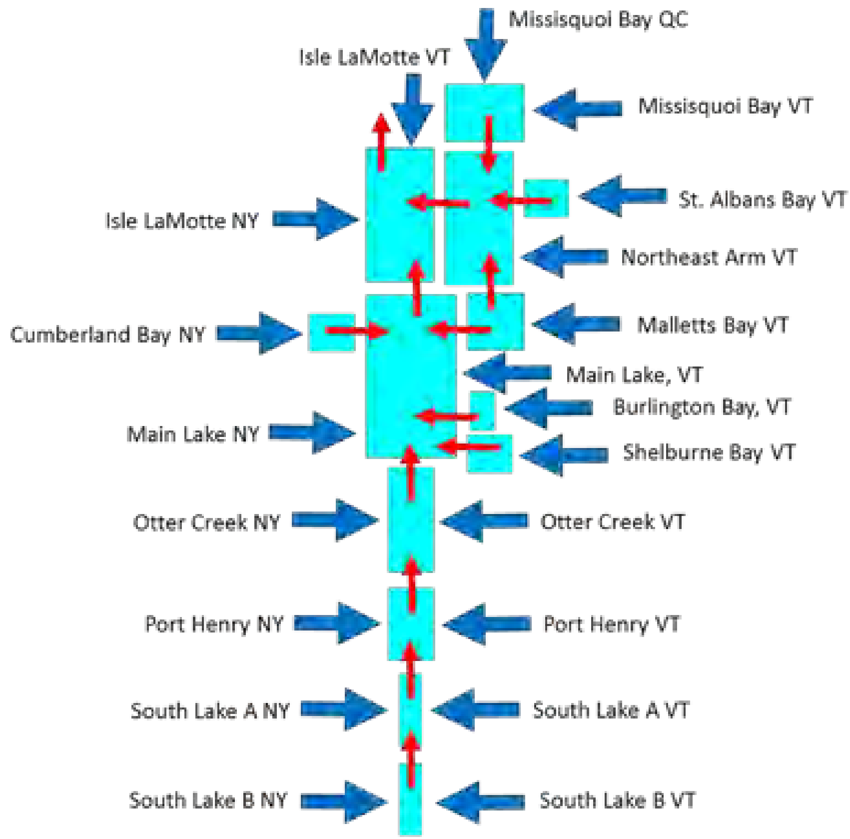

Figure 1: Schematic of the thirteen segments of Lake Champlain used for modeling and development of the TMDL. Large arrows represent the inflow of water and phosphorus from each lake-segment watershed in Vermont, New York, and Quebec. Small arrows represent the net flow of water from south to north toward the lake's outlet.

The Lake Champlain BATHTUB model predicted the phosphorus concentration in each lake segment from the balance of all phosphorus mass input loads and output losses.[13] Input loads included tributary inflows, wastewater discharges, and inflows from adjacent lake segments. Output losses included outflow to other lake segments and net sedimentation. Tetra Tech, Inc. calibrated model parameters for the exchange flows at each lake segment boundary and the net phosphorus sedimentation rate in each lake segment for the 2016 TMDL using lake and tributary monitoring data from a ten-year period (2001–2010) such that the calibrated model simulated the

13. LAKE CHAMPLAIN BATHTUB MODEL CALIBRATION REPORT, *supra* note 12.

actual phosphorus concentrations in each lake segment within statistically acceptable limits of error.[14]

II. MODELING ENHANCEMENTS FOR THE 2016 LAKE CHAMPLAIN TMDL

The lake and watershed models used to develop the 2016 Lake Champlain TMDL included several enhancements over the modeling conducted for the 2002 TMDL. The availability of a twenty-year monitoring record of lake phosphorus concentrations and tributary loads allowed for separate model calibration and validation periods of ten years each, representing the most current hydrologic conditions in the Lake Champlain Basin. Tetra Tech, Inc. used the model parameters calibrated to the 2001-2010 monitoring data to simulate phosphorus concentrations during the 1991-2000 validation period to ensure that the model performed adequately under conditions different from those under which it was calibrated.[15]

Tetra Tech, Inc. configured an established watershed process model known as "SWAT" (Soil and Water Assessment Tool) for the entire Lake Champlain Basin and used the SWAT model for three major purposes to support the 2016 TMDL.[16] First, the SWAT model provided estimates of phosphorus loading from specific source categories within each lake segment watershed, including loading from agricultural fields and farmsteads, runoff from developed land and roads, runoff from forest land, and loads contributed by river channel instability. Estimates of phosphorus loads from each source category were essential to the modeling and evaluation of alternative load allocation policies during the development of the TMDL. Second, Tetra Tech, Inc. used the SWAT model to estimate phosphorus loads from the small, unmonitored drainages near the lake that were not captured by the long-term tributary sampling program. The SWAT-derived loading estimates for these unmonitored areas were included in the BATHTUB lake model. Finally, the SWAT model provided a method for estimating phosphorus load reductions obtainable from certain agricultural and stormwater best management practices ("BMPs").

Tetra Tech used phosphorus load reduction estimates derived from the SWAT model and from the scientific literature on BMP treatment efficiencies to develop a spreadsheet-based Lake Champlain BMP Scenario

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14. *Id.* at 8.
15. *Id.* at 16.
16. TETRA TECH, INC., LAKE CHAMPLAIN BASIN SWAT MODEL CONFIGURATION, CALIBRATION AND VALIDATION 5 (2015).

Tool.[17] The Scenario Tool considered specific site conditions of land use, soil type, slope, and hydrologic setting in calculating the load reductions obtainable from various combinations of BMPs. EPA used the Scenario Tool to analyze alternative phosphorus reduction practices and policies to achieve the TMDL loading targets in each lake segment watershed.

A final enhancement to the modeling used to support the 2016 Lake Champlain TMDL was the use of an alternative phosphorus mass balance model for Missisquoi Bay in place of the BATHTUB model for that lake segment. A phosphorus model for Missisquoi Bay developed by LimnoTech, Inc., for the Lake Champlain Basin Program provided a more explicit simulation of the mechanisms of internal phosphorus loading from the bay's sediments and the influence of these mechanisms on the bay's long-term response to reductions in external phosphorus loads.[18]

III. ASSUMPTIONS ABOUT TOTAL LOADING CAPACITIES FOR NEW YORK AND QUEBEC

EPA conducted the lake modeling analysis for the 2016 Lake Champlain TMDL on a basin-wide basis and the analysis included water and phosphorus loads from tributaries and other sources in Vermont, New York, and Quebec. However, EPA disapproved only the Vermont portion of the 2002 Lake Champlain TMDL. New York chose not to reopen the TMDL for the New York watersheds during the process of developing a new TMDL for Vermont so EPA conducted the lake modeling analysis with the assumption that the total loading capacities for the New York lake segment watersheds would remain as specified in the 2002 Lake Champlain TMDL.[19] EPA derived new total loading capacities for the Vermont lake segments in a manner predicted by the updated lake modeling analysis to achieve the in-lake phosphorus concentration criteria with loads from the New York watersheds reduced to their 2002 TMDL target levels.[20]

The 2002 Quebec-Vermont Water Quality Agreement for Missisquoi Bay and the 2002 Lake Champlain TMDL incorporated a 60/40 division of the bay's total loading capacity between Vermont and Quebec,

17. TETRA TECH, INC., LAKE CHAMPLAIN BMP SCENARIO TOOL: REQUIREMENTS AND DESIGN 1 (2015).

18. LIMNOTECH, INC., DEVELOPMENT OF A PHOSPHORUS MASS BALANCE MODEL FOR MISSISQUOI BAY (2012).

19. PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 11, at 23–24.

20. *Id*.

respectively.[21] EPA assumed that the same division would apply to the new total loading capacity for Missisquoi Bay derived from the LimnoTech model[22] for the 2016 TMDL, with Quebec assigned 40% of the total.

IV. PROCESS FOR DETERMINING VERMONT TOTAL LOADING CAPACITIES AND ALLOCATIONS

The hydrodynamic connectivity between the thirteen segments of Lake Champlain and the interdependence of phosphorus loading and in-lake phosphorus concentrations among the lake segments meant that there was no single, unique set of total loading capacities that would achieve the in-lake phosphorus criteria in each lake segment. Loading capacities for individual lake segments were dependent on the extent of load reductions applied in other lake segment watersheds. EPA's determination of total loading capacities for the Vermont lake segments was therefore an iterative process involving the modeling analysis of multiple management scenarios in order to arrive at an optimum balance of phosphorus reduction efforts across the different lake segment watersheds and source categories.

EPA derived individual wasteload allocations for the fifty-nine Vermont wastewater treatment facilities in the Lake Champlain Basin by considering the relative magnitude of the phosphorus loads from these facilities and the degree of load reductions required from non-wastewater sources in each watershed.[23] The facilities in lake segment watersheds where the aggregate wastewater allocation under the 2002 TMDL exceeded ten percent of the total load to the lake segment from all sources during the 2001-2010 base period were targeted by EPA for further phosphorus reductions in the 2016 TMDL. This affected facilities in four lake segment watersheds, including the Main Lake, Shelburne Bay, Burlington Bay, and St. Albans Bay. In addition, EPA targeted facilities in the Missisquoi Bay watershed for further phosphorus reductions because of the large amount of overall load reduction required there.[24] Facilities in all other lake-segment watersheds retained the same wasteload allocations as specified in the 2002 TMDL.

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21. *Id.*; AGENCY OF NAT. RES. & MINISTRY OF ENV'T & WATER RES., AGENCY OF NAT. RES. & ENV'T & CLIMATE CHANGE CAN., AGREEMENT BETWEEN THE GOUVERNMENT DU QUÉBEC AND THE GOVERNMENT OF THE STATE OF VERMONT CONCERNING PHOSPHORUS REDUCTION IN MISSISQUOI BAY (2002), http://www.mddelcc.gouv.qc.ca/communiques_en/2002/Vermont-Quebec_Agreement_Missisquoi.pdf [https://perma.cc/ZCE2-J7GR].

22. PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 11, at 23–24.

23. *Id.* at 28.

24. *Id.* at 31.

EPA determined the wasteload allocations for the wastewater treatment facilities in the five watersheds targeted for further reductions based on the size of the facility.[25] Facilities larger than 0.2 million gallons per day (mg/d) in permitted wastewater flow rate received annual mass loading limits calculated assuming a 0.2 milligrams per liter (mg/L) effluent phosphorus concentration at their permitted flow rate.[26] Facilities between 0.1 and 0.2 mg/d in permitted flow received annual mass loading limits calculated assuming a 0.8 mg/L effluent phosphorus concentration at their permitted flow rate.[27] Smaller facilities retained the same wasteload allocations as specified in the 2002 TMDL.

With the wasteload allocations for the wastewater discharges determined as described above, EPA evaluated the load reductions needed from non-wastewater sources. To assist EPA in this process, the State of Vermont issued a Vermont Lake Champlain TMDL Phase 1 Implementation Plan that described the set of programmatic and policy commitments that the state would make to accomplish the Lake Champlain TMDL.[28] These commitments included new regulations and program enhancements in the areas of agriculture, stormwater, river management, wetlands, and forestry.

EPA applied the Lake Champlain BMP Scenario Tool to estimate the phosphorus load reductions that would result from full implementation of the Vermont plan.[29] EPA simulated management practices included in the Vermont TMDL implementation plan, or other practices judged by EPA to produce equivalent benefits, using the Scenario Tool to estimate the load reductions achievable from each source sector in each lake segment watershed.

EPA evaluated the effects of the load reductions expected from implementation of the Vermont plan on the in-lake phosphorus concentrations in each lake segment with the assistance of a spreadsheet-based lake modeling tool developed by the Vermont Department of Environmental Conservation.[30] The spreadsheet-based lake model incorporated the same input data and mass balance equations used in the

25. *Id*. at 28–29.
26. *Id.*
27. *Id.*
28. Letter from Peter Shumlin, Governor of Vt., to Gina McCarthy, Adm'r, U.S. Envtl. Prot. Agency and H. Curtis Spalding, Reg'l Adm'r Region. 1, U.S. Envtl. Prot. Agency (May 29, 2014) (on file with Vt. J. of Envtl. L.); AGENCY OF NAT. RES., VERMONT LAKE CHAMPLAIN TMDL PHASE I IMPLEMENTATION PLAN (2014).
29. PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 11, at 22.
30. *Id.*

calibrated Lake Champlain BATHTUB model, but allowed for greater flexibility and convenience when simulating multiple management alternatives.

The general approach used by EPA to assign TMDL allocations to each source sector was to first apply the load reductions estimated from the Scenario Tool for developed lands, back roads, forest lands, agricultural production areas, and stream channel sources. Load reduction amounts estimated by the Scenario Tool were subtracted from the 2001-2010 base loads to calculate the TMDL allocations for these sources. Load reductions applied to agricultural nonpoint sources were then increased as necessary in each lake segment watershed until the lake model predicted compliance with the in-lake phosphorus criteria in all lake segments, allowing for a five percent margin of safety in each lake segment.[31]

EPA applied some constraints and modifications in this process.[32] The EPA constrained the agricultural nonpoint source reductions applied in the TMDL in all watersheds within the maximum feasible reductions estimated from the Scenario Tool. A minimum agricultural nonpoint-source-load reduction of twenty percent was specified for all watersheds reflecting Vermont's intent to require some agricultural practices uniformly across the basin, except that no agricultural reductions were applied in the Burlington Bay watershed where agricultural-sources were minimal.[33] EPA applied equal percent agricultural nonpoint-source reductions in some adjacent watersheds that affected the same critical lake segment; for example, the South Lake A and B watersheds affected the South Lake A segment and the Otter Creek and Main Lake watersheds affected the Main Lake segment.[34] Reduction amounts required from forest and stream-channel sources were reduced in a few watersheds below the Scenario Tool estimates where agricultural reductions were sufficiently achievable, but more stringent reduction requirements for these source categories were applied in the South Lake B and Missisquoi Bay watersheds where the feasible agricultural reductions were not likely to be sufficient without additional forestry and river management actions.

V. FINAL TMDL RESULTS

EPA calculated the total loading capacities for each Vermont lake-segment watershed by subtracting the load reductions applied to source

31. *Id.* at 24.
32. *Id.*
33. *Id.* at 38.
34. *Id.*

sectors in each lake-segment watershed from the 2001-2010 base period loading rates, with allowance for a 5% margin of safety in each lake segment.[35] The total loading capacity in the 2016 TMDL for all Vermont watersheds was 418 metric tons per year (mt/yr), representing a 34% reduction from the total Vermont base load of 631 mt/yr.

EPA partitioned the total loading capacities into wasteload allocations, load allocations, and margins of safety for each Vermont lake-segment watershed as summarized in Table 1. The source categories within the wasteload allocations included wastewater discharges, the combined sewer overflow from the Burlington Main facility, stormwater runoff from developed land and roads, and discharges from agricultural production areas (barnyards and buildings). The source categories within the load allocations included nonpoint-source loads from agricultural land, forest land, and stream channel instability.

Vermont Lake Segment	2001-2010 Base Load	Total Loading Capacity	Wasteload Allocation	Load Allocation	Margin of Safety
South Lake B	51.1	29.9	9.0	19.4	1.5
South Lake A	26.5	11.8	2.2	8.9	0.6
Port Henry	7.0	3.1	0.6	2.3	0.2
Otter Creek	140.5	107.3	30.0	72.0	5.4
Main Lake	162.2	129.0	39.7	82.8	6.4
Shelburne Bay	10.2	9.0	3.8	4.8	0.5
Burlington Bay	4.5	3.1	2.9	0.0	0.2
Malletts Bay	56.4	46.4	17.9	26.2	2.3
Northeast Arm	17.8	15.6	3.8	11.1	0.8
St. Albans Bay	13.9	10.5	3.6	6.4	0.5
Missisquoi Bay	136.3	48.6	14.2	32.0	2.4
Isle LaMotte	4.1	3.6	0.9	2.5	0.2
TOTAL	**630.6**	**418.1**	**128.6**	**268.6**	**20.9**

Table 1: Summary of the 2016 Lake Champlain Phosphorus TMDL for Vermont lake segments.36 Phosphorus load amounts are in metric tons per year.

While the 2016 TMDL requires an overall Vermont load reduction of thirty-four percent, much greater percent reductions are required from some source categories in some lake segments (Table 2). For example, a total

35. *Id.* at 24.
36. *Id.* at 43.

load reduction of sixty-four percent is required for Missisquoi Bay.[37] Agricultural-nonpoint-source reductions of over sixty percent are required in the South Lake watersheds and an eighty-three percent agricultural reduction is required in Missisquoi Bay. Forest-load reductions of forty to fifty percent are required in the South Lake B and Missisquoi Bay watersheds.

Lake Segment	Total Overall	Wastewater[1]	Combined Sewer Overflow	Developed Land[2]	Agricultural Production Areas	Forest	Streams	Agricultural Nonpoint
South Lake B	41.4%	0.0%		21.1%	80.0%	40.0%	46.7%	62.9%
South Lake A	55.5%	0.0%		18.1%	80.0%	5.0%		62.9%
Port Henry	55.4%			7.6%	80.0%	5.0%		62.9%
Otter Creek	23.6%	0.0%		15.0%	80.0%	5.0%	40.1%	46.9%
Main Lake	20.5%	61.1%		20.2%	80.0%	5.0%	28.9%	46.9%
Shelburne Bay	11.6%	64.1%		20.2%	80.0%	5.0%	55.0%	20.0%
Burlington Bay	31.2%	66.7%	11.8%	24.2%	0.0%	0.0%		0.0%
Malletts Bay	17.6%	0.2%		20.5%	80.0%	5.0%	44.9%	28.6%
Northeast Arm	12.5%			7.2%	80.0%	5.0%		20.0%
St. Albans Bay	24.5%	59.4%		21.7%	80.0%	5.0%	55.0%	34.5%
Missisquoi Bay	64.3%	51.9%		34.2%	80.0%	50.0%	68.5%	82.8%
Isle LaMotte	11.7%	0.0%		8.9%	80.0%	5.0%		20.0%
TOTAL	**33.7%**	**42.1%**	**11.8%**	**20. 9%**	**80.0%**	**18.7%**	**45.4%**	**53.6%**

[1]Percent change from current permitted loads.

[2]Includes reductions needed to offset future growth.

Table 2. Percent load reductions relative to the 2001-2010 base loads required to achieve the total loading capacities in the 2016 Lake Champlain Phosphorus TMDL for Vermont lake segments.38

The new Vermont total loading capacity of 418 mt/yr is considerably higher than the total Vermont loading capacity of 268 mt/yr defined in the 2002 Lake Champlain TMDL.[39] This was a predicted consequence of using a new hydrologic base period representing wetter weather conditions

37. *Id.* at 44.
38. PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN, *supra* note 11.
39. LAKE CHAMPLAIN PHOSPHORUS TMDL, *supra* note 4, at 35.

relative to the 1991 base year used in the modeling for the 2002 TMDL.[40] Estimates of the total Vermont base load increased from 414 mt/yr in the 2002 TMDL to 631 mt/yr in the 2016 TMDL due to the different base periods used. The total load reduction required by Vermont to achieve the loading capacities also increased from 146 mt/yr in the 2002 TMDL to 212 mt/yr in the 2016 TMDL. However, on a percentage basis, the overall Vermont load reduction requirement of 34% in the 2016 TMDL is nearly identical to the reduction requirement of 35% indicated in the 2002 TMDL.

The Lake Champlain TMDL is important because it defines the loading targets and reduction amounts necessary for each phosphorus source to achieve water quality standards in the lake. The 2016 Lake Champlain TMDL included many years of additional data and several modeling refinements beyond those available for the 2002 TMDL. The loading targets defined in the 2016 TMDL can therefore be assumed to be more accurate and current than the loading capacities stated in the 2002 TMDL. However, both TMDLs produced essentially the same result as to the overall level of effort required by Vermont. Vermont's phosphorus load to Lake Champlain must be reduced by about one-third. Having scientifically-sound targets is important, but success will depend much more on the depth of the commitment by Vermont and by other federal, state, local, and private partner organizations working for a clean Lake Champlain to fund and implement all the actions necessary to achieve the TMDL as laid out in the Vermont Lake Champlain TMDL Implementation Plan[41] and in the Vermont Clean Water Act of 2015.[42]

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40. VT. AGENCY NAT. RES. & VT. AGENCY AGRIC., FOOD & MARKETS, PROGRESS IN ESTABLISHING AND IMPLEMENTING THE TOTAL MAXIMUM DAILY LOAD (TMDL) PLAN FOR LAKE CHAMPLAIN 9 (2008).

41. VERMONT LAKE CHAMPLAIN TMDL PHASE I IMPLEMENTATION PLAN, *supra* note 28.

42. H.35, 2015-2016 Leg. Sess. (Vt. 2015) (Act 64).

THE IMPORTANCE OF INTER-AGENCY COLLABORATION AND PUBLIC ENGAGEMENT IN THE DEVELOPMENT OF THE IMPLEMENTATION PLAN FOR THE NONPOINT SOURCE-FOCUSED VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL

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INTRODUCTION

A total maximum daily load ("TMDL") sets pollutant reduction targets from a range of sources to achieve state water quality standards of an

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impaired water body.[2] Although not required under the Clean Water Act ("CWA"), an implementation plan typically is submitted as part of the TMDL to describe the actions needed to meet pollutant reduction targets.

Phosphorus loading is arguably Lake Champlain's greatest threat, largely due to nonpoint sources—precipitation-driven runoff and erosion—from land use activities. In 2002, the U.S. Environmental Protection Agency ("EPA") approved a Lake Champlain Phosphorus TMDL prepared by Vermont and New York, but revoked its approval for the Vermont portion of the TMDL in 2011.[3] The new Vermont Lake Champlain Phosphorus TMDL requires further reductions across all source categories (referred to as "source sectors," such as agriculture, stormwater from developed lands, roads, and point sources) to meet pollution reduction targets.[4] A new state water quality statute, Act 64, requires the state to develop a new implementation plan for the TMDL.[5]

This article describes the public process used to develop the new implementation plan. That process involved three essential tasks: engaging stakeholders, collaborating among state agencies, and securing a political commitment. This article also describes how the plan is structured to meet the TMDL's required "reasonable assurances" that nonpoint-source pollution reductions would be achieved. As part of reasonable assurances, this article outlines an accountability framework used for tracking implementation and assessing progress to determine whether more actions are necessary to meet water quality standards.

I. BACKGROUND: RESTORING LAKE CHAMPLAIN AND THE ROLE OF THE FEDERAL CLEAN WATER ACT

A. The Lake Champlain TMDL and Its Implementation Plan

The following statements characterize the general public sentiment expressed during the process to develop a new restoration plan for the Vermont portion of Lake Champlain—the Vermont phosphorus Lake Champlain TMDL. According to the Friends of North Lake Champlain,

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2. 33 U.S.C. § 1313(d)(1)(C) (2012).

3. Letter from Linda Murphy, Dir. Office of Ecosystem Prot. to Christopher Recchia, Comm'r, Vt. Dep't of Environmental Conservation (Nov. 2002), https://www.epa.gov/sites/production/files/2015-09/documents/2002-lake-champlain-phosphorous-approval-tmdl.pdf [https://perma.cc/CDP3-ZGT4].

4. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 1 (2016), https://www.epa.gov/sites/production/files/2016-06/documents/phosphorus-tmdls-vermont-segments-lake-champlain-jun-17-2016.pdf [https://perma.cc/2W7X-TKAD] [hereinafter PHASE 1 PLAN 2015].

5. *Id.* at app. E

"non-point source pollution is the 10,000 leaks that drain into Lake Champlain. Individually, not making a significant impact, but collectively, they are creating one of the largest human and environmental tragedies of our time."[6] The Friends of Winooski stated "the debate is over as to whether and how much the phosphorus level in Lake Champlain must be reduced. Now, the question is how can we reach our shared water quality goal?"[7] Finally, comment letters to the State of Vermont suggested that, "we have the opportunity to reverse this now, before it's too late, if we can find the political will to do what needs to be done."[8]

Together, Section 303(d) of the CWA and the EPA Water Quality Planning and Management Regulations (40 C.F.R. part 130) direct states to develop TMDLs for "impaired" water bodies (rivers, streams, lakes, and ponds that fail to meet water quality standards due to a pollutant or degraded condition).[9] A TMDL is typically described as a pollutant "budget" that calculates a numeric target or maximum allowable amount (or load) of the pollutant the water body can assimilate while still meeting water quality standards.[10]

The TMDL must account for contributions from all sources of the problem pollutant and determine the allowable pollutant load each of the pollutant sources can safely discharge. Sources include discharges from pipes or other discrete conveyances known as "point sources"[11] and all other sources not defined as point sources, referred to as "nonpoint sources."[12] Nonpoint sources are diffuse discharges, such as precipitation or

6. Public Comment from Friends of Northern Lake Champlain to Kari Dolan, Dep't of Envtl. Conservation (Jan. 9, 2014).

7. Comment Letter from Friends of Winooski River on Draft State of Vermont Proposal for a Clean Lake Champlain (Jan. 13, 2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/cmnts/Friends%20of%20the%20Winooski%20River.pdf [https://perma.cc/D4YY-4PFT].

8. Comment Letter Toni Goddard on Draft State of Vermont Proposal for a Clean Lake Champlain (Jan. 22, 2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/cmnts/Comments%20from%20Toni%20Goddard.pdf [https://perma.cc/ECL5-LWDY].

9. *Impaired Waters and TMDLs: Statute and Regulations*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/tmdl/impaired-waters-and-tmdls-statute-and-regulations [https://perma.cc/VZK6-77MW] (last updated Jan. 19, 2016).

10. *Implementing Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDL)*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/tmdl [https://perma.cc/5NAL-MQLM] (last visited Apr. 3, 2016).

11. "Point sources" are "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture." 33 U.S.C. § 1362(14).

12. U.S. ENVTL. PROT. AGENCY, PROTECTING WATER QUALITY FROM AGRICULTURAL RUNOFF (2005). ("Nonpoint sources" of pollution are sources that do not meet the CWA's legal

snowmelt-driven stormwater runoff from agricultural lands, parking lots, roads, and other developed areas, and stream channel erosion due to traditional channelization practices (dredging, straightening, berming, and armoring) and increased stormwater runoff.[13]

Implementation plans put TMDLs in to action. They describe measures that will reduce pollutant loads enough to meet water quality standards.[14] While the federal CWA does not explicitly require implementation plans, they are key to meeting the TMDL's pollutant targets and are typically submitted as part of or in conjunction with the TMDL.[15] An implementation plan for Lake Champlain is required by state statute.[16] Act 64 requires: (1) an update to the Lake Champlain implementation plan; (2) a description of how the state's basin plans will be used to implement the Phase I plan; (3) a schedule for adopting the basin plans; and (4) specific elements in the basin plans for carrying out the TMDL.[17]

EPA approved the joint Vermont and New York Lake Champlain Phosphorus TMDL and its Implementation Plan in 2002.[18] Vermont's TMDL served as the framework for the state to guide implementation of actions to control phosphorus pollution loading into Lake Champlain from all sources.[19] Vermont's plan contained a suite of action items for all major phosphorus sources and helped to direct funding, staff levels, program development, and implementation priorities.[20] Subsequently, Vermont Governor Douglas announced a "Clean and Clear Action Plan" to accelerate implementation of the TMDL and restore the Lake.[21]

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definition of "point source." Nationally, nonpoint-source pollution is the leading cause of water quality degradation).

13. *What Is Nonpoint Source?*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/what-nonpoint-source [https://perma.cc/TEB2-UT2N] (last updated Jan. 5, 2016) ("The term 'nonpoint source' is defined to mean any source of water pollution that does not meet the legal definition of "point source." . . .).

14. *Effectively Implementing TMDLs*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/tmdl/effectively-implementing-tmdls [https://perma.cc/B2EK-CDS6] (last updated Dec. 1, 2015).

15. CLAUDIA COPELAND, CONG. RESEARCH SERV., R42752, CLEAN WATER ACT AND POLLUTANT TOTAL MAXIMUM DAILY LOADS AT SUMMARY (TMDLS) (2012).

16. VT. STAT. ANN. tit. 10, § 1386 (2015).

17. *Id.*

18. Letter from Linda M. Murphy, Dir., Office of Ecosystem Prot., Envtl. Prot. Agency Region 1, to Christopher Recchia, Comm'r, Vt. Dep't of Envtl. Conservation (Nov. 4, 2002), https://www.epa.gov/sites/production/files/2015-09/documents/2002-lake-champlain-phosphorous-approval-tmdl.pdf [https://perma.cc/H6NF-77ML].

19. PHASE I PLAN, *supra* note 4, at 1.

20. VT. AGENCY OF NAT. RES., REVISED IMPLEMENTATION PLAN: LAKE CHAMPLAIN PHOSPHOROUS TMDL 1 (2010).

21. Vt. Governor James H. Douglas, Clean and Clear Action Plan (Sept. 30, 2003), (transcript available at https://votesmart.org/public-statement/23255/clean-and-clear-water-action-plan-remarks-of-governor-james-h-douglas#) [https://perma.cc/Q736-BGFX].

In 2007, the Vermont General Assembly called for a programmatic audit of the Clean and Clear Action Plan.[22] The audit covered the period between July 2005 and June 2007 and reported no significant phosphorus pollutant reductions to Lake Champlain.[23] It also found that the TMDL Implementation Plan lacked specific objectives about how to achieve nonpoint source pollution reductions, making it difficult to track and review progress to improve program performance.[24]

That same year, Vermont Agency of Natural Resources ("ANR") established the Center for Clean and Clear to further enhance Vermont's efforts in restoring Lake Champlain.[25] A year later, ANR released a progress report that found the TMDL and its implementation plan to be "a sound and appropriate framework for the on-going implementation of phosphorus control measures."[26]

Still concerned about the lack of significant progress in restoring Lake Champlain, the Vermont General Assembly directed ANR to revise the implementation plan for the Vermont portion of the Lake Champlain TMDL by January 2010 and update the plan periodically thereafter.[27] ANR engaged in a stakeholder process in the summer of 2009 that resulted in the *Revised Implementation Plan: Lake Champlain Phosphorus TMDL*.[28]

B. Meeting Reasonable Assurance

Despite these efforts, EPA disapproved the Vermont portion of the Lake Champlain phosphorus TMDL in 2011 as a result of the lawsuit filed in federal court by the Conservation Law Foundation.[29] One of the primary reasons for EPA's disapproval was its finding that Vermont had not provided sufficient reasonable assurances that the plan would achieve reductions in nonpoint sources of phosphorus pollution (primarily

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22. Act 43 focused on stormwater management and the implementation of the Lake Champlain TMDL. VT. STAT. ANN. tit. 10, § 1264.

23. GREEN MOUNTAIN INSTITUTE FOR ENVIRONMENTAL DEMOCRACY, PERFORMANCE AUDIT OF VERMONT CLEAN AND CLEAR iii (2008).

24. *Id.* at iv.

25. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD & MKTS., VERMONT CLEAN AND CLEAR ACTION PLAN: 2010 ANNUAL REPORT 1 (2011).

26. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD, MKTS., PROGRESS IN ESTABLISHING AND IMPLEMENTING THE TOTAL MAXIMUM DAILY LOAD (TMDL) PLAN FOR LAKE CHAMPLAIN 2 (2008).

27. 2008 Vt. Acts & Resolves 126, 126–134.

28. VT. AGENCY OF NAT. RES., *supra* note 20.

29. Letter from H. Curtis Spalding, Reg'l Adm'r, Envtl. Prot. Agency Region 1, to Deborah Markowitz, Sec'y, Vt. Agency of Natural Res. 1 (Jan. 24, 2011), https://www.epa.gov/sites/production/files/2015-09/documents/2002-lake-champlain-tmdl-disapproval-decision.pdf [https://perma.cc/S2HD-ZB92].

agriculture and stormwater sources). "Nearly all elements of the plan depend on both additional funding and entities' willingness to participate or cooperate voluntarily with the intent of the program" and "the plan provides very little, if any, assurance that the recommended actions will occur, and provides no indication of the magnitude of phosphorus reductions expected from these actions."[30]

For a water body that is impaired by both point and nonpoint sources, as is the case with Lake Champlain, the level of pollution control at the point sources is based on the assumption that there will be controls on the nonpoint sources and that those nonpoint source pollutant load reductions will occur. Lake Champlain is one of these waters impaired by point and nonpoint sources.[31] Therefore, a TMDL for such waters must provide reasonable assurances that nonpoint-source control measures will achieve expected pollutant load reductions.[32]

Controlling nonpoint sources can be difficult compared to conventional ways to control pollution from point sources. Monitoring effluent from point sources is relatively easy, making it fairly straightforward for regulatory authorities to assign a quantitative effluent limit in a discharge permit.[33]

Nonpoint sources, however, are much harder to monitor and control. Nonpoint source pollution occurs from rainfall and snowmelt running over the landscape, requiring land-use best management practices ("BMPs") to control the pollution.[34] These nonpoint sources can be quite significant and damaging.[35] Thus, reasonable assurances are important because they address nonpoint source control needs. Moreover, reasonable assurances provide the public confidence that the TMDL is not based on overly optimistic or exaggerated assumptions regarding the amount of phosphorus-pollution load reductions that will occur from the implementation of nonpoint-source control measures.

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30. *Id.* at 11.

31. *Nutrient*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/water-quality/nutrients/ [https://perma.cc/TL6H-EN77] (last visited Apr. 25, 2016).

32. U.S. ENVTL. PROT. AGENCY, GUIDANCE FOR WATER QUALITY-BASED DECISIONS: THE TMDL PROCESS 15 (1991); Memorandum from Robert Perciasepe, Assistant Adm'r to Regional Adm'rs & Reg'l Water Div. Dirs. 5 (Aug. 8, 1997), https://www.epa.gov/sites/production/files/2015-10/documents/2003_10_21_tmdl_ratepace1997guid_0.pdf [https://perma.cc/5659-PLJB]; U.S. ENVTL. PROT. AGENCY, GUIDELINES FOR REVIEWING TMDLS UNDER EXISTING REGULATIONS ISSUED IN 1992 1, 4–5 (2002).

33. U.S. ENVTL. PROT. AGENCY, NATIONAL MANAGEMENT MEASURES TO CONTROL NONPOINT SOURCE POLLUTION FROM URBAN AREAS 0-7 (2005).

34. Daniel R. Mandelker, *Controlling Nonpoint Source Water Pollution: Can It Be Done?*, 65 CHI.-KENT L. REV. 479, 480–83 (1989).

35. OLIVER A. HOUCK, CLEAN WATER ACT TMDL PROGRAM: LAW POLICY AND IMPLEMENTATION 166 (1999).

EPA's disapproval of the initial plan resulted in the agency taking on the responsibility of establishing a new TMDL, as required by federal law.[36] The new TMDL, released in June of 2016, requires stronger reasonable assurances with specific and enforceable targets.[37] Vermont anticipates finalizing the implementation plan in 2016.[38]

EPA's task in developing the new TMDL involved setting new phosphorus pollution reduction targets to meet water quality standards.[39] The new targets must focus on sources contributing to the problem, most of which are nonpoint sources.[40] Virtually all of these nonpoint sources are under the direct authority of state government.[41]

The State of Vermont agreed to work cooperatively with EPA in the development of the new TMDL, recognizing it as an opportunity to incorporate flexibility in setting priorities and directing resources to achieve phosphorus load reduction in the most efficient and cost-effective manner possible.[42]

The Vermont Department of Environmental Conservation ("DEC") staff recognized that the reopening of the TMDL would provide an opportunity for Vermont to renew its commitment to restore Lake Champlain. DEC staff noted that: (1) the implementation plan is aligned with the state's delegated responsibility to maintain water quality; (2) nonpoint sources contributing to phosphorus loading are largely the result of land use activities that the state and local governments oversee; (3) the state already had in place a cooperative relationship among state agencies and engaged stakeholders that were involved in the development and implementation of the 2002 Vermont-specific Implementation Plan (and the process to amend that Plan in 2010); (4) a new TMDL implementation plan could be used to make enhanced policy commitments to achieve greater phosphorus load reductions, particularly at nonpoint sources; and (5) the

36. 40 C.F.R. § 130.7(d)(2).

37. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 4–6 (2016) [hereinafter 2016 PHOSPHORUS TMDL].

38. VT. STAT. ANN. tit. 10, § 1386 (2015).

39. 2016 PHOSPHORUS TMDL, *supra* note 39, at 4–6; 33 U.S.C. § 1313(d); 40 C.F.R. § 130.7 (2015).

40 PHASE I PLAN, *supra* note 4, at 1.

41. 33 U.S.C. §1329(a)(1).

42. 40 C.F.R. § 130.2(i). "If best management practices or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent;" Correspondence from David Mears, Comm'r to Stephen Perkins, U.S. Envtl. Prot. Agency (Oct. 23, 2013) (regarding the Draft set of preferred state policy alternatives pertaining to the Lake Champlain Phosphorus TMDL).

state could readily integrate the TMDL requirements into its existing watershed scale planning framework referred to as tactical basin planning.[43]

It is important to acknowledge that two major flood events in 2011 also had some influence on public opinion regarding the restoration of Lake Champlain.[44] The spring flood event in 2011 caused localized flooding in some communities and raised Lake Champlain to historic levels, causing damages to homes, property, and farmland.[45] A few months later, and seven months after EPA's disapproval of the Vermont portion of the Lake Champlain Phosphorus TMDL, Tropical Storm Irene struck.[46] Irene caused loss of life. The storm destroyed homes, displaced businesses, demolished roads and bridges, damaged farmlands, disrupted wastewater treatment, affected drinking water supplies across the state.[47] Irene caused spikes in water pollution loading into many of the state's waters, including Lake Champlain.[48] These events demonstrated to the public the impacts caused by precipitation-driven stormwater running off farms and developed lands. They helped to raise public concern about public health and water quality and renewed interest in actions that can achieve both improved water quality and greater resilience to future flooding.[49]

II. ROLE OF IMPLEMENTATION PLAN IN MEETING REASONABLE ASSURANCES

As described above, TMDLs that rely on pollution reductions from sources that are largely regulated by permits are relatively straight forward to implement. The reduction requirements are integrated into their permits. The challenge with TMDLs that require reductions from nonpoint sources is that EPA must find reasonable assurances that the necessary nonpoint source controls will occur.[50] Lake Champlain falls within this category of

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43. Author's personal knowledge, conversation with David Mears, Comm'r, Dep't of Envtl. Conservation.

44. PHASE I PLAN, *supra* note 4, at 52.

45 STEPHANIE S. CASTLE, LAKE CHAMPLAIN BASIN, FLOOD RESILIENCE IN THE LAKE CHAMPLAIN BASIN AND UPPER RICHELIEU RIVER 5 (2013).

46. *Id.*

47. SACHA PEALER, LESSONS FROM IRENE: BUILDING RESILIENCY AS WE REBUILD 1, 3, 5 (2012); David K. Mears & Sarah McKearnan, *Rivers and Resilience: Lessons Learned from Tropical Storm Irene*, 14 VT. J. ENVTL. L. 177, 178 (2013).

48. LAKE CHAMPLAIN PHOSPHOROUS PLAN: NEW YORK 11, http://www.dec.ny.gov/docs/water_pdf/lcbprp2014draft.pdf [https://perma.cc/Y259-4L9U] (last updated June 17, 2014).

49. VT. AGENCY OF NAT. RES., RESILIENCE: A REPORT ON THE HEALTH OF VERMONT'S ENVIRONMENT 11 (2011).

50. Revisions to the Water Quality Planning and Management Regulation, 65 Fed. Reg. 43,586, 43,668 (July 13, 2000).

TMDL's. Therefore, success in achieving a clean Lake Champlain fundamentally means greater control of precipitation-driven nonpoint sources and improvements in natural infrastructure, such as floodplains and river corridors, that could help attenuate the erosive forces of floodwaters and improve water quality.[51]

Nonpoint sources of pollution, particularly agricultural and stormwater runoff, and stream channel erosion, are the largest contributors of nutrient and sediment pollution into Vermont's waters.[52] About ninety-seven percent of the phosphorus load to Lake Champlain comes from these sources.[53] Restoring Lake Champlain means that Vermont needs to dramatically increase its efforts to control nonpoint sources of pollution.

Providing reasonable assurances that control on nonpoint pollution sources will achieve expected pollutant load reductions will need: (1) a comprehensive implementation plan that contains enhanced state programs to target the greatest pollution sources, particularly nonpoint sources, with increased funding levels to support implementation;[54] (2) modeling tools to quantify the reductions from measures described in the implementation plan; and (3) an accountability framework that will serve as a backstop to ensure a high likelihood that implementation according to the plan will take place.[55]

The challenge is how to create an implementation plan that contains adequate and effective measures and is acceptable by the very sources that are causing or contributing to the pollution problem.

III. THE PUBLIC PROCESS

Getting buy-in from the public to support the Lake Champlain TMDL required public policy makers to convince the public, political leaders, and stakeholders themselves that a clean Lake Champlain is a worthy investment. Creating a political will to invest enough to improve the lake's

51. *Restoring Lake Champlain*, AGENCY OF NAT. RES. (2015), http://dec.vermont.gov/watershed/cwi/restoring [https://perma.cc/HN7D-T2ZL].

52. "Stream channel erosion" refers to the stream bed and bank erosion brought about by loss of floodplain and wetland functions. Stream channel dredging, straightening, berming, and armoring, coupled with the impacts from a greater amount of stormwater runoff from stormwater flow or drainage practices, have resulted in poor, highly erosive (often referred to as "disequilibrium") stream channel conditions.

53. 2016 PHOSPHORUS TMDL, *supra* note 39, at 16.

54. PHASE I PLAN, *supra* note 4, at 1–3.

55. Letter from Stephen S. Perkins, Dir., Office of Ecosystem Prot., U.S. Envtl. Prot. Agency, Region 1, to David Mears, Comm'r, Vt. Dep't of Envtl. Conservation, and Chuck Ross, Sec'y, Vt. Agency of Agric., Food & Mkts (Jan. 17, 2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/Phase_1_Plan_Appendices_August%20 2015_draft.pdf [https://perma.cc/V6V8-HRLD] [hereinafter Jan. 17 Letter from Stephen S. Perkins].

health and water quality statewide was not easy. Even the term "TMDL" is difficult to understand, making it hard to engage the public and secure their support.

Secondly, controlling nonpoint sources fundamentally means changing or making adjustments to our land uses. Changing land uses requires education. All polluted runoff sources (farmers, municipal road crew and highway departments, commercial business owners with large parking lots, developers at construction sites, and residential homeowners) need to learn about the problems with nonpoint source pollution, and understand why they may be contributing to the problem, how to take action, and what resources are available to help with implementation.[56] The added challenges are that the right actions are not always easy to implement and can be costly. It will also take time before the benefits are realized in the lake's water quality.[57]

The process Vermont used to build interest and support involved three essential tasks:

- Task #1: Engaging stakeholders, including the business community, farm associations, local governments, environmental advocacy groups, watershed groups, and the public early in the process;
- Task #2: Bringing together state agencies to work collaboratively throughout the development of the implementation plan; and
- Task #3: Building a political commitment at the state level to support the goals of the TMDL.

A. Task 1: Engaging Stakeholders

Much of the Lake Champlain TMDL's focus is on nonpoint-source pollution reductions that affect many activities on the landscape. Thus, a robust public process, involving all source categories, is vital to the TMDL process. That process must engage stakeholders and the public and show responsiveness on the part of public agencies to the concerns of the public.[58]

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56. STATE OF VT., VERMONT'S CLEAN WATER INITIATIVE 24 (2014), http://legislature.vermont.gov/assets/Legislative-Reports/303279.pdf [https://perma.cc/VKB2-3TCH].

57. Mandelker, *supra* note 34, at 480–83.

58. FINAL REPORT OF THE AGRICULTURAL WORKING GROUP 3, http://legislature.vermont.gov/assets/Documents/2014/WorkGroups/House%20Agriculture/Bills/H.586/Witness%20Testimony/H.586~Laura%20DiPietro~Final%20Report%20of%20the%20Agricultural%20Working%20Group~2-25-2014.pdf [https://perma.cc/4HCW-6AP7].

Vermont recognized the need for a new, bold, and extensive approach to engage municipalities, farmers, and the public in a renewed commitment to restore Lake Champlain.[59] The state set about creating and implementing an outreach plan to use across all source categories.[60] That outreach plan included listening sessions, small stakeholder meetings, farmer working group meetings, technical discussions, and public meetings to periodically report on progress in the development of the TMDL.[61]

Vermont first initiated an extensive public outreach process with a series of fifteen informal listening sessions around the Champlain Basin in the fall of 2011.[62] These sessions were intentionally organized early in the process, before the completion of the modeling to estimate pollution load reduction needs and before identifying pollution reduction strategies to pursue.[63] The intent of these listening sessions, jointly sponsored by EPA, were to raise awareness about EPA's disapproval of the TMDL and next steps, hear about people's concerns, listen to suggestions about strategies to restore Lake Champlain, and, most importantly, invite on-going and far-reaching participation across all sectors in the process.[64]

The state discovered an extremely high level of frustration about the condition of Lake Champlain and tremendous support for a renewed effort to turn the lake around. Some of the more common messages raised during the listening sessions that helped to move the discussion forward were: "Do not invest in any more studies"; "We need action"; "Safeguarding clean water is everyone's business"; "We all have a role in reducing water pollution"; "Municipalities will support the TMDL if actions are science-based, reasonable, cost-effective, and doable"; "Investments should target the biggest sources"; and "Stop 'pointing fingers' and focus on problem-solving."[65]

EPA began developing new phosphorus loading models based on updated water quality and stream flow data.[66] EPA engaged a technical working group made up of state and federal agency staff to assist in the

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59. SARAH COHEN, COLLABORATIVE APPROACHES TO ENVTL. DECISION-MAKING: A STATE AGENCY'S GUIDE TO EFFECTIVE DIALOGUE AND STAKEHOLDER ENGAGEMENT 32.

60. *Id.*

61. *Id.*

62. *Id.*

63. *Id.*

64. *Id.*

65. *Id.*

66. 2016 PHOSPHORUS TMDL, *supra* note 39, at 4–6; *Lake Champlain Phosphorus TMDL: A Commitment to Clean Water*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/tmdl/lake-champlain-phosphorus-tmdl-commitment-clean-water [https://perma.cc/D6EF-NXHD] (last visited Apr. 3, 2016).

development and assessment of the modeling data and tools for evaluating the performance of pollution control practices.[67]

The state held another eight public meetings in the summer of 2013.[68] These meetings were small, sector-specific stakeholder meetings intended to provide technical updates on the TMDL and foster a more thorough discussion about pollution control needs and strategies within each sector.[69] Topic themes included: stormwater management on developed lands in large municipalities; municipal wastewater infrastructure, municipal road-related stormwater management; stormwater management on private (e.g., commercial, industrial) properties; regional planning; roles of watershed organizations; and regional and statewide environmental advocacy interests.[70]

DEC and the Vermont Agency of Agriculture Food and Markets ("VAAFM") ran the Agricultural Working Group, a concurrent stakeholder process solely focused on agricultural community.[71] The state retained facilitation services from the Environmental Mediation Center ("EMC") and the Consensus Building Institute ("CBI") with support from EPA via the Conflict Prevention and Resolution Center, Natural Resources Conservation Service ("NRCS"), and the private philanthropic organizations Green Mountain Coffee Roasters and the High Meadows Fund.[72]

Agricultural Working Group members included dairy farmers, livestock farmers, and crop farmers from small, medium, and large farms and agricultural service providers and other stakeholders.[73] The Agricultural Working Group sponsored 15 focus group sessions with nearly 400 people participating to discuss the efficacy of conservation practices, ideas to achieve greater water quality improvements, resource needs, and federal and state programs.[74] The sessions spread across 13 different watersheds in the state, most of which were in watersheds within the Lake Champlain Basin.[75] Upon completing those focus group meetings, the work group met seven times to develop recommendations to reduce phosphorus pollution from the agricultural sector.[76]

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67. 2016 PHOSPHORUS TMDL, *supra* note 39, at 5.
68. Author's personal knowledge.
69. *Id.*
70. *Id.*
71. FINAL REPORT OF THE AGRICULTURAL WORKING GROUP, *supra* note 58, at 4.
72. *Id.*
73. *Id.*
74. *Id.*
75. *Id.*
76. *Id.*

In November of 2013, Vermont released the outline of an implementation plan entitled *The State of Vermont Proposal for a Clean Lake Champlain, Draft for Discussion* for public comment.[77] The proposed set of policy commitments to be applied basin-wide outlined how Vermont could meet reasonable assurances. The Agricultural Working Group's recommendations were incorporated into this proposal were as draft policy commitments for all other major sources of phosphorus to Lake Champlain including public and private developed lands and municipal and state road networks.[78] It also included additional draft commitments to restore natural infrastructure (floodplains, river corridors, wetlands, buffers, and forest management) and a proposal for a new clean water improvement fund.[79]

The state, in partnership with EPA, held six public meetings in December of 2013.[80] The Lake Champlain Basin Program ("LCBP") facilitated the meetings.[81] The state then worked with the regional planning commissions to hold an additional thirteen public meetings across Vermont to discuss clean water needs outside the Lake Champlain Basin.[82]

Well over 500 people attended the Lake Champlain Basin public meetings and the presentations focused on activities that work effectively at reducing nutrient pollution.[83] The state received well over 100 comments, including formal comments from EPA.[84] Most of the comments expressed general support for the TMDL, although there were concerns about cost and the potential impacts to farming.[85]

Some of the comments expressed during the December public meetings truly helped to establish the public discourse that became fundamental to securing support for the TMDL from the public, stakeholders, the Governor, and legislators. That support ultimately led to the passage of Act 64—the state legislation that provided the legislative authority and funding

77. VT. DEP'T OF ENVTL. CONSERVATION & VT. AGENCY OF AGRIC., FOOD & MKTS., STATE OF VERMONT PROPOSAL FOR A CLEAN LAKE CHAMPLAIN: DRAFT FOR DISCUSSION (2013).

78. *Id.* at 3.

79. *Id.* at 26.

80. News Release, EPA and Vermont Announce Public Meetings to Discuss Lake Champlain Cleanup Efforts, U.S. Envtl. Prot. Agency (Nov. 26, 2013), https://yosemite.epa.gov/opa/admpress.nsf/6427a6b7538955c585257359003f0230/c0b11825666aec3785257c230070ff8d!OpenDocument [https://perma.cc/5XJS-A9RM].

81. *Id.*

82. DEP'T OF ENVTL. CONSERVATION, UPDATED 2013-2036 TIMELINE FOR COMPLETING THE VERMONT LAKE CHAMPLAIN RESTORATION PLAN, http://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2016-01-11%20Updated%20Timeline.pdf [https://perma.cc/A4ML-FWH7] (last visited May 2, 2016).

83. PHASE I PLAN, *supra* note 4, at 2.

84. Letter from Stephen S. Perkins, *supra* note 55.

85. DEP'T OF ENVTL. CONSERVATION & VT. AGENCY OF AGRIC., FOOD & MKTS., SUMMARY OF PUBLIC COMMENT (2014).

to begin to implement the TMDL and water quality restoration priorities statewide.[86] Those key messages were:

- "Be part of the solution." Vermonters love Lake Champlain and the streams that flow into it. Everyone has a responsibility to do their part to protect the health of sports fishery, the recreation and tourism benefits these waters provide, the lake's value to local businesses and property values, public health and safety, and the clarity the ecology;
- "All in." Moving away from finger-pointing and working together to find and implement solutions is how we need to imagine a new way of living on the land that supports agriculture, our businesses, and communities and protects our lakes and streams;
- "Clean water is good for the economy." Tourism and recreation, property values, and even business recruitment depend on a clean Lake Champlain;
- "Phosphorus control actions often provide additional benefits beyond clean water." Better management of soil, manure, and fertilizers can reduce costs to farmers and improve the health of the soil. Maintaining gravel roads can save towns money over the long haul by correcting chronic erosion problems along ditches and at culverts. Restoring floodplains can reduce damage to property from future flooding and support fish and wildlife habitat.[87]

Eventually, the policy commitments evolved into the *Draft Vermont Lake Champlain Phosphorus TMDL Phase I Implementation Plan*, released to EPA and presented to the public at a press event in May of 2014[88] (it was later updated with the passage of Act 64 in July of 2015).[89] Six months later, the state and EPA hosted four more public meetings in November of 2014 to discuss progress in drafting the TMDL and describe examples of success stories from implementing pollution reduction management practices across all sectors.[90]

EPA released the draft TMDL in August of 2015, held three more public meetings with the state, and announced a thirty-day public comment period on the draft TMDL (which was later extended to a sixty-day

86. PHASE I PLAN, *supra* note 4, at 4.
87. *Id.*
88. *Id.*
89. *Id.*
90. UPDATED 2013-2036 TIMELINE FOR COMPLETING THE VERMONT LAKE CHAMPLAIN RESTORATION PLAN, *supra* note 82.

comment period).[91] EPA released the final, approved TMDL in June of 2016.[92] In August of 2016, within three months of the release of the EPA-approved TMDL, Vermont will hold another set of three public meetings and public comment period before releasing the final Phase I implementation plan anticipated for September of 2016.[93]

B. Task 2: Collaborating Among State Agencies

Collaborating among state agencies in the implementation of the Lake Champlain TMDL is essential, because state oversight and management of the various source categories extends across multiple state agencies. While DEC is the designated lead agency to manage the quality of Vermont's waters, VAAFM was delegated the authority to manage agricultural nonpoint-source pollution control.[94] The Vermont Agency of Transportation ("VTrans") uses its grant programs and voluntary Road and Bridge Standards to incentivize municipalities to use road BMPs.[95] The Forests, Parks and Recreation Department ("VFPR"), albeit a department of ANR along with DEC, promotes the use of forest-management related practices to prevent polluted runoff from entering surface waters.[96] DEC also relied on these agencies and departments to engage their own constituencies in understanding and participating in the TMDL process.

Another reason for a state-wide, multi-agency solution is to work together to avoid the cost-prohibitive consequences if Vermont fails to secure nonpoint source reductions. The consequences of failing to meet the

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91. *EPA Extends Public Comment Period on Phosphorus Limits for Vermont Segments of Lake Champlain*, U.S. ENVTL. PROTECTION AGENCY (Sept. 9, 2015), https://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/f65d724324cb414b85257ebb006f107d!OpenDocument [https://perma.cc/L6SN-FPBQ].

92. Press Release, U.S. Envtl. Prot. Agency, EPA Releases Final Phosphorus Limits for Vermont Segments of Lake Champlain (June 17, 2016), https://www.epa.gov/newsreleases/epa-releases-final-phosphorus-limits-vermont-segments-lake-champlain [https://perma.cc/B3KN-98CS].

93. VT. STAT. ANN. tit. 10, § 1386.

94. Memorandum of Understanding between Vt. Agency of Nat. Res. & the Vt. Dep't of Agric., Food & Mkts. Concerning Agricultural Nonpoint Source Pollution Reduction Program (Apr. 16, 1993), http://legislature.vermont.gov/assets/Documents/2014/WorkGroups/House%20Fish%20and%20Wildlife/Bills/H.586/Witness%20Testimony/H.586~Jim%20Leland~Memorandum%20of%20Understanding%20Between%20ANR%20and%20Agency%20of%20Agriculture%C2%A6%20Non%20point%20source%20pollution%20reduction~1-21-2014.pdf [https://perma.cc/TBA9-3TML].

95. CHRIS COLE, DEPUTY SEC'Y, TRANSPORTATION AND WATER QUALITY (2015), http://legislature.vermont.gov/assets/Documents/2016/WorkGroups/House%20Fish%20and%20Wildlife/Bills/H.35/Witness%20Testimony/H.35~Chris%20Cole~Transportation%20and%20Water%20Quality~1-29-2015.pdf [https://perma.cc/5D7P-UEZZ].

96. *Acceptable Management Practices*, VT. DEPT. OF FORESTS, PARKS & REC., http://fpr.vermont.gov/forest/vermonts_forests/amps [https://perma.cc/2BET-9D4R] (last visited Apr. 4, 2016).

early policy and program-based milestones necessary to support implementation or failing to achieve targeted nonpoint source reductions, both of which as described in the TMDLs' accountability framework, are significant.[97] EPA may "[r]evise the TMDLs to reallocate additional load reductions from nonpoint to point sources, such as wastewater treatment plants."[98] Vermont runs the risk that wastewater treatment plants in the basin may be targeted for greater phosphorus reductions, which could result in upgrading facilities to the limit of technology.[99] The State would also need to expand the use of offsets and expand permit programs to directly regulate more phosphorus pollutant sources.[100] Perhaps the most egregious consequence of focusing on reductions at the point sources, particularly wastewater treatment plants (a small source relative to the nonpoint source control needs), would be the failure to secure enough phosphorous reductions to achieve a clean Lake Champlain.[101] Other consequences may "expand NPDES permit coverage to unregulated sources," and "increase and target federal enforcement and compliance assurance."[102]

The state agencies and EPA met regularly for many months. EPA explained early in the process their expectation that the Phase 1 Implementation Plan would need to be: (1) broad enough in scope to include all major pollutant sources, including those sources beyond DEC's existing authorities; (2) enforceable to demonstrate that the pollutant controls will take place; and (3) measurable in order for EPA to demonstrate that the TMDL can meet water quality standards over time and to enable the state to track its progress in reducing pollutant loading. Specifically, EPA expected the Phase 1 Implementation Plan to describe:

> each policy or program element involved to meet the TMDL's pollution load reductions; how the phosphorus reduction associated with elements may be estimated using the phosphorus estimation tool called the "TMDL scenario tool"; the policy mechanisms to ensure the element will occur; the time period—date and year—when the element will take effect; dates for activities or "milestones" of partial implementation of the elements; resources

97. 2016 PHOSPHORUS TMDL, *supra* note 39, at 58–59.
98. *Id.* at 57, 59.
99. *Id.* at 54.
100. Letter from Stephen S. Perkins, *supra* note 55.
101. E-mail from Stephen Perkins, Dir., Office of Ecosystem Prot., U.S. Envtl. Prot. Agency, Region 1 to David Mears, Comm'r, Vt. Dep't of Envtl. Conservation (Nov. 1, 2013) (on file with Vt. J. Envtl. L.)
102. 2016 PHOSPHORUS TMDL, *supra* note 39, at 57, 59

> needed to support the element; and, anticipated sources of any new funding needed to support implementation.[103]

Fortunately, state agencies were already meeting on a regular basis to discuss a wide range of cross-agency topics. The inter-agency coordination that resulted from the State's recovery efforts following the catastrophic floods of 2011[104] created the foundation to support enhanced communications about the TMDL. Senior management staff from ANR and VTrans met twice per month. ANR and VAAFM met once per month. The Lake Champlain TMDL became a permanent agenda item for these meetings. Senior management of DEC, VAAFM, VTrans, and VFPR jointly participated at public meetings and testified collectively at the General Assembly.[105] Their staff worked as a team to evaluate public comments and develop the Phase I Plan.

C. Task 3: Securing a Political Commitment to Achieve a Clean Lake Champlain

On January 8, 2015, Governor Peter Shumlin walked through a crowd of protesters to give his inaugural address to the State's General Assembly. Protesters were calling for greater affordability of health care and were angry over his decision to abandon action to build the first-in-the-nation, single-payer universal health care system.[106] Although this was not the entrance that anyone would have expected, the Governor did invoke a standing ovation when he unveiled the restoration of Lake Champlain as a top agenda item:[107]

> We love our rivers and lakes, from Lake Memphremagog to the Battenkill, from the Lamoille River to Lake Bomoseen, from Otter Creek to the river I grew up on, the Connecticut. And we all revere

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103. *See* Letter from Stephen S. Perkins *supra* note 55 (detailing some of EPA's expectations).

104. Mears & McKearnan, *supra* note 47, at 190.

105. Draft Press Release, U.S. Envtl. Prot. Agency & Vt. Dep't of Envtl. Conservation, Announcing the First Round of TMDL Small Group Meetings (Sept. 13, 2011) (on file with Vt. J. Envtl. L.).

106. Paul Heintz, *Twenty-Nine Arrested After Protest Disrupts Shumlin Inauguration*, SEVEN DAYS (Jan. 9, 2015), http://www.sevendaysvt.com/OffMessage/archives/2015/01/08/massive-protest-disrupts-shumlin-inauguration [https://perma.cc/N9UH-MJH3].

107. Steph Machado, *Amid Protesters, Gov. Shumlin Focuses on Environmental Issues in Inauguration Speech*, MYCHAMPLAINVALLEY.COM (Jan. 8, 2015), http://www.mychamplainvalley.com/news/vermont/amid-protesters-gov-shumlin-focuses-on-environmental-issues-in-inauguration-speech [https://perma.cc/QC9Q-VC48].

> our crown jewel, Lake Champlain, which supports hundreds of millions of dollars in economic activity every year. [108]

The Governor acknowledged the challenges in meeting the public's call for cleaner water: "We know everything we hold precious is under threat from climate change and pollution. . . . We are rapidly losing the battle for clean water."[109] He then followed up with a resounding commitment to do something about it: "We must all take our share of responsibility and work together . . . to get the job done. . . . I need your support to ensure that the State of Vermont does its part, and . . . to launch a new era of clean water in Vermont."[110] The Governor also announced a Clean Water Fund to support clean water needs, stating that "[w]e must all take our share of responsibility and work together . . . to get the job done . . . . I need your support to ensure that the State of Vermont does its part, and . . . to launch a new era of clean water in Vermont."[111]

How did we arrive at this level of political support? How did the conversation change from concerns of how costly the restoration of Lake Champlain has been to acknowledging that we have not done enough to reduce the sources of phosphorus? We went from reporting on the numerous good-faith efforts made in recent years across all source sectors to realizing the many water quality problems that remain.

What changed is that the call for a cleaner Lake Champlain got louder. This was partly due to the leadership of state government to seize the opportunity and use the TMDL process to achieve water quality improvements for Vermont communities statewide. Also notable was the collaboration across state agencies to engage their constituencies and stakeholders and convince them to do their part.

The fundamental reason was from the groundswell of public opinion for cleaner water, thanks to the numerous voices of municipalities, business groups, grassroots organizations, and farmer groups. Nearly all of the voices were speaking in unison to demand clean water, calling for an "all in" approach to Lake Champlain and clean water statewide. The call was to stop the finger-pointing and encourage everyone to take on some responsibility to improve water quality. Advocates circulated petitions,

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108. Peter Shumlin, Governor, Inaugural Address (Jan. 8, 2015), http://www.vpr.net/apps/interactive-transcript-gov-peter-shumlins-third-inaugural-address/ [https://perma.cc/U2BK-8HFP].

109. *Id.*

110. *Id.*

111. *Id.*

contacted their representatives, used newsletters, and wrote action plans demanding clean water.

Another important voice supporting the TMDL came from the business community. The Agency of Commerce and Community Development and businesses across the state recognized the importance of clean water to local economies and to the recreation and tourism economy that depends on a clean environment.[112] Perhaps a pivotal moment was when Tom Torti, president of the Lake Champlain Regional Chamber of Commerce, remarked, "It's time for the business community and the taxpayers of Vermont to stand up and say 'we also have an affirmative obligation to fund this going forward. These are all of our waters.'"[113]

D. Key Strategies of the Implementation Plan

As described above, the TMDL implementation plan is the road map to describe how to achieve the reductions in pollutant loading from each of the source categories. The implementation plan for the new Lake Champlain TMDL is based on two phases.[114] The Phase I Implementation Plan involved the development of a basin-wide implementation plan to lay out the policy commitments related to nonpoint-source phosphorus pollutant reductions.[115] That plan was built on the draft set of policy commitments that was released in November of 2013[116] and the public comments received on that document. EPA is using the Phase I Plan to meet reasonable assurances.[117]

Engaging people who live and work in the watersheds that make up the basin is a critical part of the restoration process. Now that EPA finalized the TMDL, the state will develop "Phase II" plans—watershed-scale implementation plans for each segment of Lake Champlain.[118] The state will rely on its tactical basin planning process to develop and implement these Phase II plans and seek reductions in pollutant loading at critical

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112. *See* Patricia Moulton & Deb Markowitz, *Moulton & Markowitz: The Many Benefits of Clean Water*, VTDIGGER (Apr. 17, 2015, 6:55 PM), http://vtdigger.org/2015/04/17/moulton-markowitz-the-many-benefits-of-clean-water/ [https://perma.cc/99CZ-AZQ7] (containing commentary from Patricia Moulton, the Secretary of the Vermont Agency of Commerce and Community Development, about the economic importance of clean water in Lake Champlain).

113. John Herrick, *Vermonters Should Be "All In" on Water Quality*, VTDIGGER (Feb. 18, 2015), http://vtdigger.org/2015/02/18/vermonters-water-quality/ [https://perma.cc/5WA3-JD5F].

114. PHASE I PLAN, *supra* note 4, at 1.

115. *Id.*

116. VT. DEP'T. OF ENVTL. CONSERVATION, *supra* note 77.

117. Letter from Stephen S. Perkins, *supra* note 55.

118. PHASE I PLAN, *supra* note 4, at 1.

sources within all pollutant source categories.[119] The process fosters collaboration among local and regional partners, municipalities, farmers, businesses, federal and state agencies, and other interested parties. It keeps people engaged and identifies local concerns. Phase II plans target and implement point and nonpoint pollutant control measures and practices and includes implementation dates for those corrective actions.[120]

E. The New Implementation Plan

The Phase I Implementation Plan was the outcome of a significant amount of stakeholder engagement, a comprehensive evaluation of policy options,[121] and agency collaboration. The state anticipates releasing the final draft of the Phase I Implementation Plan by early August of 2016, holding a public comment and three more public meetings and adopting it as the final plan by September of 2016.[122] The plan targets the principal sources of phosphorus, including the agricultural sector, developed-lands sector (including state and municipal roads), the point-source sector, river channel and floodplain sources, and forest management sources.

In the agricultural sector the plan calls for an update to the Required Agricultural Practices (water quality practices) for all farms. The new standards will include: (1) stream and ditch setbacks; (2) livestock exclusion; (3) nutrient management planning, including enhanced practices at flood-prone lands and other critical source areas; and (4) improved compliance and enforcement, including small farm certification.[123]

In the developed-lands sector, the plan issues the following stormwater control measures: (1) a new state general permit to reduce stormwater discharges from existing developed lands where impervious surfaces exceed three acres and currently are not regulated; (2) an update to the existing municipal general permit, referred to as the "Municipal Separate Storm Sewer System" ("MS4") permit, consistent with the requirements of the new Lake Champlain TMDL; (3) a new state highway-stormwater general permit to reduce erosion and stormwater discharges from the state

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119. INT'L JOINT COMM'N, INTERNATIONAL MISSISQUOI BAY STUDY BOARD: MISSISQUOI BAY CRITICAL SOURCE AREA STUDY 23 (2012) (the term, "critical sources" or "critical source areas," refer to those areas on the landscape that have a high likelihood of delivering nonpoint pollution, relative to other areas; targeting these areas for corrective action improves the cost-effectiveness in achieving required pollution reductions).

120. PHASE I PLAN, *supra* note 4, at 3, 113.

121. JONATHAN R. WINSTEN, POLICY OPTIONS FOR REDUCING PHOSPHORUS LOADING IN LAKE CHAMPLAIN 1 (2004); VT. DEP'T OF ENVTL. CONSERVATION, WATER QUALITY REMEDIATION, IMPLEMENTATION AND FUNDING REPORT 98 (2013).

122. Author's personal knowledge.

123. PHASE I PLAN, *supra* note 4, at 73.

highway network; (4) a new municipal-road stormwater general permit to reduce erosion and stormwater discharges from municipal roads; and (5) an update to the stormwater manual, the state's technical guidance for new development projects that requires a state stormwater permit.[124]

In the point-source sector, which includes wastewater treatment, the plan applies more stringent concentration limits for effluent from some waste water treatment facility ("WWTF") in targeted segments of the Lake Champlain watershed when upgrades are required.[125] The plan also increases floodplain and river-corridor protection for both flood resilience and water quality benefits using: (1) new floodplain rules, mapping, and municipal support; (2) stream alteration permits; (3) new codes and standards for stream crossings; (4) an update to the Emergency Relief and Assistance Fund rule; and (5) and Standard River Management Procedures for state disaster response.[126]

In regards to forest management, the plan requires an update of the acceptable forest management practices to reduce impacts from logging roads and skid trails.[127] In addition, the Phase II plan will use the Tactical Basin Planning process to target highest-priority actions in each watershed.[128] Finally, the Phase I plan will establish a new Clean Water Fund to provide greater support in BMP implementation.[129]

IV. ACCOUNTABILITY FRAMEWORK

An "accountability framework" is a new strategy, modeled after the Chesapeake Bay TMDL, to ensure that the commitments made in the Phase I Plan and implementation actions described in the Phase II plans will occur.[130] This framework contains expectations within successive two-year milestone periods.[131] The first milestone period, for years 2015 to 2017, focuses on the establishment of new programs and permits described in the Phase I plan and the implementation and enforcement of programs already in place.[132] EPA expects to issue an interim report card by early 2017 on the

124. *Id.* at 84–90.
125. *Id.* at 32.
126. *Id.* at 53–56.
127. *Id.* at 97.
128. *Id.* at 109.
129. *Id.* at 126.
130. CHESAPEAKE BAY TMDL, SECTION 7. REASONABLE ASSURANCE AND ACCOUNTABILITY FRAMEWORK 7-2 (2010).
131. Lake Champlain TMDLs Public Outreach Meetings (Aug. 2015) (on file with VT. J. OF ENVTL L.) [hereinafter Pubic Outreach Meetings].
132. UPDATED 2013-2036 TIMELINE FOR COMPLETING THE VERMONT LAKE CHAMPLAIN RESTORATION PLAN, *supra* note 82.

state's progress through the end of 2016 and will make a final determination by early 2018 whether the state has met expectations for the first milestone period.[133]

The second milestone period, post-2017, involves monitoring progress in implementing the TMDL over the twenty-year implementation schedule.[134] EPA anticipates monitoring progress at the watershed scale, tied to the five-year Phase II planning cycles and keyed to the plan's implementation tables.[135] EPA envisions a check-in point halfway through the five-year Phase II planning cycle and a major evaluation of progress at the end of the five-year cycle.[136]

The framework specifies contingencies if progress is delayed. Those contingencies target a particular watershed or are applied more broadly if more systemic problems arise. DEC acknowledges the role of an accountability framework as a transparent and equitable way to achieve reasonable assurances that pollution-load reduction targets will be met across all sectors.

V. ELEMENTS OF THE ACCOUNTABILITY FRAMEWORK AND CONTINGENCIES TO ENSURE PROGRESS

The accountability framework for the Lake Champlain TMDL consists of numerous program elements, with completion dates specified, many of which are described in the Phase I Plan,[137] such as: update agricultural and forestry rules in 2016; issue new stormwater permits by 2017 and seek authority and funding for implementation of the Phase I Plan by 2015; and develop and implement Phase II plans for each of the watersheds in the basin, updated every five years to 2036.[138]

The framework further establishes milestones to demonstrate near-term commitments and progress over time, including developing and using a tracking and accounting system to track programmatic progress and BMP implementation by 2016. There are also milestones in place for EPA action

133. *Id.*

134. *Id.*

135. *Tactical Basin Planning: Managing Waters Along a Gradient of Condition and Recommended Changes to Current Basin Planning Framework*, DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/sites/dec/files/documents/WSMD_swms_Chapter_4_Approach_to_TacticalBasinPlanning_Rev2_V5.pdf [https://perma.cc/E7CB-WXJX] (last visited Apr. 4, 2015) (implementation tables are part of the Phase II tactical basin plans that identify geographically and programmatically specific actions to meet the plan's priorities).

136. Public Outreach Meetings, *supra* note 136; 2016 PHOSPHORUS TMDL, *supra* note 39, at 55–59.

137. PHASE I PLAN 2015, *supra* note 4, at app. B.

138. 2016 PHOSPHORUS TMDL, *supra* note 39, at 56–58.

if Vermont fails to complete a Phase I Implementation Plan that meets reasonable assurances or to fulfill phosphorous reductions described in the Phase II plans.

EPA will determine an appropriate response that will continue to support implementation of the TMDL if Vermont fails to: (1) complete a Phase I Implementation Plan that meets EPA's expectations in meeting reasonable assurances; or (2) fulfill phosphorus reduction needs described in the Phase II plans. Some of the responses that EPA would consider are to:[139] (1) assign reductions to point sources, making them more stringent (this change may result in requiring upgrades at wastewater-treatment-plant discharges to limits of technology and offsets); (2) expand CWA discharge permit coverage to include more stormwater and/or agricultural sources; and (3) increase regulatory oversight of discharge permits proposed and issued.[140]

To assist the state in meeting its commitments described in the Phase I plan, the State of Vermont is developing a comprehensive tracking and reporting system. This system will track, evaluate, and report on its progress under the TMDL, leveraging EPA's tracking and accounting system it has developed for monitoring progress.[141]

The system will track the level of state investment, measurable outcomes from the investment, environmental performance (such as phosphorus reductions estimated from BMP activities), and social investment.[142] This tracking system will enable the state to document the location of and phosphorus reduction by BMPs that are supported by public investment.[143] Social indicators will show the degree of investment in educational and technical assistance programs necessary to raise awareness and increase BMP adoption rates. Vermont will evaluate its progress in meeting the goals of the implementation plan and report to EPA and the Vermont General Assembly on a periodic basis.

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139. Letter from Stephen S. Perkins, *supra* note 55.

140. Letter from Stephen S. Perkins, Dir., Office of Ecosystems Prot., to David Mears, Comm'r, Vt. Dep't of Envtl. Conservation & Chuck Ross, Sec'y, Vt. Agency of Agric., Food & Mrkts. (Feb. 13, 2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/SupplementalDEC_AAFM_letter_02-13-14.pdf [https://perma.cc/LC8C-GBB7]; 2016 PHOSPHORUS TMDL, *supra* note 39, at 56–57.

141. PHASE I PLAN 2015, *supra* note 4, at 107.

142. *Id.*

143. *Id.*

CONCLUSION: THE ROAD TO RECOVERY

A detailed look at past efforts to restore Lake Champlain identified a number of "lessons" that were constraining Vermont's progress in achieving meaningful phosphorus load reductions into Lake Champlain: (1) lack of leadership; (2) fragmentation of agency responsibilities; (3) competing messages from special interest groups; (4) how crises galvanize public concern but rarely lead to long-term commitments; and (5) attitudes both inside and outside bureaucracies.[144]

The reopening of the TMDL provided the State of Vermont a unique opportunity to use adaptive management in evaluating progress. To create a new Phase I Implementation Plan that "would do right by the Lake," state agency staff took deliberate steps to learn from past and present management decisions, adjust management programs and implementation strategies, and involve partners and stakeholders throughout the process.

The outcome is notable. Vermont, thus far, has successfully addressed those earlier lessons that heretofore had constrained prior efforts. We now have political leadership, new authorities to sustain long-term commitments, and a Clean Water Initiative to promote inter-agency cooperation. The strong support from both the Governor and both houses of the General Assembly resulted in the passage of Act 64,[145] referred to as the with the House approval by a vote of 133 to 11 and Senate approval by a vote of 27 to 2.[146] The Act provided the state with the authority and capacity it needs and a new Clean Water Fund. The state launched a Clean Water Initiative[147] that builds on existing inter-agency cooperation to meet the state's legal obligations under the federal CWA and Act 64.[148]

The state and EPA have launched a new chapter in the restoration of Lake Champlain. That chapter contains new policies and authorities, stronger enforcement measures, and a greater emphasis on transparency and public engagement.

A few important gaps remain that may affect the pace of restoration efforts; most immediate is the need for long-term funding to support a long-term commitment to implement the TMDL plans. An important step

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144. Gail Osherenko, Note, *Understanding the Failure to Reduce Phosphorous Loading in Lake Champlain: Lessons for Governance,* 15 VT. J. ENVTL. L. 323, 324 (2014), http://vjel.vermontlaw.edu/files/2014/01/Issue-2_Osherenko.pdf [https://perma.cc/LU6F-7YF8].

145. 2015 Vt. Acts & Resolves 975, 1016–1018 (codified as amended at VT. STAT. ANN. tit. 10, § 1386 (2015)).

146. Rebecca Ellis, Presentation on Vermont's Clean Water Act (Nov. 2015).

147. STATE OF VT., *supra* note 56.

148. There are four inter-agency working groups as part of the Clean Water Initiative: Finance and Reporting, Communications, Agriculture, and Transportation.

towards closing that gap will be the release by the State Office of the Treasury report on long-term financing strategies to meet statewide water quality improvement needs, required by Act 64 and due in 2017.[149]

Nonetheless, the new Phase I Implementation Plan, which incorporates the wisdom, experience, and interests of political leaders, municipalities, interested parties, and government staff, is helping the state head in the right direction toward achieving a cleaner Lake Champlain. Time will tell; the first reporting milestone of the accountability framework is at the end of 2016, with EPA's issuance of a report card on Vermont's progress due early next year. Stay tuned.

149. VT. STAT. ANN. tit. 10, § 1386.

THE VERMONT CLEAN WATER ACT: WATER QUALITY PROTECTION, LAND USE, AND THE LEGACY OF TROPICAL STORM IRENE

***Trey Martin*[1]**

INTRODUCTION: ACT 64 OF 2015 AND THE VERMONT CLEAN WATER INITIATIVE

Vermont Act 64 of 2015 ("Act 64" or "Vermont Clean Water Act")[2] was passed with broad support and signed into law with much fanfare.[3] Act 64 resulted from a major effort across state government, coordinated by the Vermont Agency of Natural Resources ("ANR" or the "Agency") Department of Environmental Conservation ("DEC"). It is intended to provide legal tools, authority and capacity to comply with federal regulatory requirements to remediate significant phosphorus impairment in Lake Champlain,[4] and more generally to address impaired waters across the

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2. 2015 Vt. Acts & Resolves 975.

3. *See, e.g.*, Press Release, Governor Peter Shumlin, Governor Peter Shumlin Signs Clean Water Bill (June 17, 2015), http://governor.vermont.gov/node/2389 [https://perma.cc/H2GE-86LU].

4 On June 17, 2016, the U.S. Environmental Protection Agency ("EPA") adopted a Total Maximum Daily Load and Phase I Implementation Plan to address phosphorus impairment in Lake Champlain. For more information about the history of the State of Vermont and EPA efforts to regulate and remediate phosphorus impairment in Lake Champlain, please see *Restoring Lake Champlain*, AGENCY OF NAT. RESOURCES, http://dec.vermont.gov/watershed/cwi/restoring [https://perma.cc/HL4L-

state.[5] Passed in anticipation of EPA action to adopt a new Lake Champlain Total Maximum Daily Load ("TMDL"), Act 64 supports the State of Vermont's regulatory obligations established under section 303(d) of the federal Clean Water Act ("CWA").[6] It reaches beyond the "point source" pollution control scheme established by Congress under the CWA and expands state authority to address surface water pollution, particularly polluted stormwater runoff.[7] In the CWA, Congress obligates states to take the steps necessary to restore impaired waters.[8] In the case of Lake Champlain restoration, Vermont's Act 64 promotes a set of policies—regulatory, fiscal, and planning—intended to protect, maintain, enhance, and restore Lake Champlain and all of Vermont's surface waters as part of a statewide, programmatic Clean Water Initiative.[9]

The Vermont General Assembly, executive branch agencies, stakeholders, and advocates have worked together for decades to protect the state's natural resources, including major lake ecosystems like Lake Champlain, from the most adverse impacts of land use and development. Vermont is of course celebrated for policies that conserve and protect waters, forests, and still wild places. Those same policies also protect the health of Vermont's tourism and working-lands economy. Moreover, original patterns of development—small towns and villages clustered around significant lakes, ponds, rivers, and streams and surrounded by working farms and forests—have been protective of natural resources generally. But now many major water resources are impaired in Vermont and Vermonters have clamored for better protections.[10]

5KE4]; *Lake Champlain Phosphorus TMDL: A Commitment to Clean Water*, ENVTL. PROT. AGENCY, http://www.epa.gov/tmdl/lake-champlain-phosphorous-tmdl-commitment-clean-water [https://perma.cc/29VJ-UB5F] (last updated Dec. 1, 2015).

5. *See generally* 2015 Vt. Acts & Resolves 975 ("Despite the State and federal mandates to maintain and prevent degradation of State waters, multiple lakes, rivers, and streams in all regions of the State are impaired, at risk of impairment, or subject to water quality stressors.").

6. *See* Federal Water Pollution Control Act, 33 U.S.C. § 1313(d) (2012) ("Each State shall establish for the waters identified . . . the total maximum daily load, for those pollutants . . . [a]t a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety."); *see also* Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *supra* p. 666.

7. *See generally Polluted Runoff: Nonpoint Source Pollution*, ENVTL. PROT. AGENCY, http://www.epa.gov/polluted-runoff-nonpoint-source-pollution [https://perma.cc/75CC-AYZM] (last updated Feb. 22, 2016) (describing the difference between point source and nonpoint source pollution).

8. *See generally Implementing Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)*, ENVTL. PROT. AGENCY, https://www.epa.gov/tmdl [https://perma.cc/9N8K-KNTA] (last updated Feb. 10, 2016).

9. *See* 2015 Vt. Acts & Resolves 976 (describing the purpose of the bill); *see also Clean Water Initiative*, VT. DEP'T OF ENVTL. CONSERVATION, http://cleanwater.vermont.gov/ [https://perma.cc/VC2J-E67P] (describing the Vermont's Clean Water Initiative).

10. *See* VT. DEP'T OF ENVTL. CONSERVATION, STATE OF VERMONT 2014 WATER QUALITY INTEGRATED ASSESSMENT REPORT 4 (2014),

As an important step in the journey toward clean water across the state, ANR called for a new Clean Water Initiative in 2015.[11] That initiative consists of: (i) internal reorganization and new resources DEC's Watershed Management Division, within the Agency of Agriculture, Food and Markets ("AAFM"), and the Agency of Transportation ("VTrans") to ensure dedicated program capacity to implement the Lake Champlain TMDL and the statewide goals of Act 64;[12] (ii) regulatory targets established under state and federal law to reduce pollution to water resources in almost every corner of Vermont;[13] (iii) tactical basin planning to identify the greatest needs and strategic investments in pollution abatement at the sub-watershed level;[14] and (iv) a new, dedicated Clean Water Fund and requirement for annual programmatic investments in pollution abatement projects and strategic conservation.[15]

Against this comprehensive approach, the challenge facing Vermont and the Clean Water Initiative is primarily diffuse and precipitation-driven, nonpoint source nutrient pollution in our largest watersheds. This includes phosphorus impairment in Lakes Champlain and Memphremagog and nitrogen pollution in the Connecticut River, flowing all the way into Long Island Sound.[16] Identifying, funding, and implementing best management practices ("BMPs") across a rural landscape requires a categorical rethinking of land use practices. Even though controlling point-source discharges is an important part of the equation in many watersheds, Vermont has asserted that the state cannot simply ratchet down the

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http://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_305b%20WQ%20Report_2014.pdf [https://perma.cc/Z7AS-S2U5] (describing the impaired or altered waters in Vermont); *see also* 2015 Vt. Acts & Resolves 975 (describing Vermont's waters as "vital assets," noting the extent of impairment and costs of impairment, and stating the purpose to "manage and plan for the use of state waters and development in proximity to State waters"); *see also* STEVE SCHEINERT ET AL., RESEARCH ON ADAPTATION TO CLIMATE CHANGE IN THE LAKE CHAMPLAIN BASIN AND VERMONT'S WATERWAYS, REPORT: VALUE OF WATER QUALITY AND PUBLIC WILLINGNESS TO PAY FOR WATER QUALITY POLICY AND PROJECT IMPLEMENTATION 1–3 (2014), http://epscor.w3.uvm.edu/2/pdfFiles/pubs/wtp_report_v7-1_final.pdf [https://perma.cc/YF3V-SMLH] ("Vermont residents are deeply concerned about water quality, more so than any other surveyed policy issue.").

11. *See generally* VT. AGENCY OF NAT. RES., VERMONT'S CLEAN WATER INITIATIVE 3–4 (2014), http://legislature.vermont.gov/assets/Legislative-Reports/303279.pdf [https://perma.cc/3X6U-72R8].

12. 2015 Vt. Acts & Resolves 1023; *see Watershed Management Division*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/contacts [https://perma.cc/T2V8-RQCW] (last visited Apr. 7, 2016) (reflecting nine new, dedicated positions already working full time under the Clean Water Initiative).

13. *See generally* STATE OF VERMONT 2014 WATER QUALITY INTEGRATED ASSESSMENT REPORT, *supra* note 10 (discussing various water pollution programs throughout Vermont).

14. Neil C. Kamman & Ethan Swift, *Tactical Basin Planning as the Vehicle for Implementation of the Vermont Clean Water Act*, *infra* p. 710.

15. *See* 2015 Vt. Acts & Resolves 1018 (establishing the Clean Water Fund).

16. STATE OF VERMONT 2014 WATER QUALITY INTEGRATED ASSESSMENT REPORT, *supra* note 10, at 41.

phosphorus or nitrogen concentrations in discharges from industrial facilities or sewage treatment plants.[17] Pursuant to the Vermont Clean Water Initiative and the Vermont Lake Champlain Phosphorus TMDL Phase I Implementation Plan ("Phase I Plan"), agricultural fields will be buffered more significantly, cover crops sewn, and manure spreading practices changed.[18] State and municipal roads will be retrofitted with stormwater controls including better ditches and right-sized culverts.[19] Developed lands will require improved practices, such as stormwater retention ponds, vegetated swales, and other green stormwater infrastructure.[20] Natural infrastructure like floodplains, wetlands, and forests will be conserved and protected as perhaps the state's best defense against stormwater pollution.[21] This is a particularly important strategy as Vermont's climate changes and the intensity and frequency of rainfall and snowmelt events increase.[22] The Lake Champlain TMDL and the Phase I Plan, which serve as templates for surface water pollution control statewide, describe all of this planning and the future actions to implement the CWA in great detail. More broadly, the initiative is a commitment by the state's General Assembly and executive branch agencies to improve the care with which Vermonters live on the land, as needed to improve water quality.

In one sense, Act 64 is important because of the significant new and expanded regulatory authority, programmatic capacity, and funding it provides for the state to meet its obligations under the federally required Lake Champlain TMDL and future TMDLs for Lake Memphremagog and the Connecticut River. The requirement under federal law to address nutrient and sediment pollution impairment in Lake Champlain was not the only, or even primary, motivation for Vermont state officials, legislators, stakeholders, and advocates. Over the past several decades, Vermont has increasingly taken an intensive and holistic look at the connectedness among development, economic growth, land use, and water quality.[23] Precedents for state action to address the goals of the CWA through state

17. *See* Letter from Peter Shumlin, Vt. Governor, to Gina McCarthy, Adm'r, Envtl. Prot. Agency & Curt Spalding, Regional Adm'r, Envtl. Prot. Agency, Region 1 (May 29, 2014), (of file with Vt. J. Envtl. L.).

18. *See* STATE OF VT., VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL PHASE I IMPLEMENTATION PLAN 69, 75 (2015), http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/Ph%201_plan_Version_4.pdf [https://perma.cc/DF5N-ATRU].

19. *Id.* at 85–86.

20. *Id.* at 84, 90–92.

21. *Id.* at 92.

22. *Id.* at 128.

23. William G. Howland, *The Lake Champlain Basin Program: Its History and Role*, *supra* p. 588; *see generally* Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts*, *supra* p. 615 (providing an overview of the history of Vermont's response to surface water clean-up).

regulation and land use requirements extend back decades. But perhaps the most dramatic recent lesson about the important connection between how we live on the landscape, and the impact of our choices on water resources, came about as a result of Tropical Storm Irene in August, 2011.

I. LESSONS LEARNED FROM TROPICAL STORM IRENE[24]

On August 28, 2011, Tropical Storm Irene passed through Vermont, dumping up to 11 inches of rain, flooding creeks and rivers, and impacting almost every community in the state.[25] Six people died in the storm and more than 3,000 structures were damaged or destroyed, along with 500 miles of state roads and 200 bridges.[26] Communities were cut off when those road systems went down, dozens of water supply systems were compromised, private wells submerged by floodwaters were contaminated, sewage treatment facilities discharged more than ten million gallons of raw or partially treated sewage, and numerous residential septic systems failed as a result of the storm.[27] The damage to infrastructure was estimated at more than $700 million—almost two-thirds of the state's annual general fund budget.[28]

The damage to the natural environment was equally extreme. Steady, heavy rains fell on ever more saturated soils, overwhelming Vermont's stream and river systems and causing inundation flooding and also fluvial erosion and landslides.[29] Nearly ten thousand acres of forest land were impacted by floodwaters that undermined root systems and debris that damaged tree stems. Floodwaters acted as vectors to move invasive plants and seeds that will inhibit healthy forest generation for decades to come.[30]

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24. *See generally* David K. Mears & Sarah McKearnan, *Rivers and Resilience: Lessons Learned from Tropical Storm Irene*, 14 VT. J. ENVT. L. 177 (2013) (discussing the value of watershed management policies in protecting communities and preserving the natural environment).

25. Wilson Ring, *Vermont Marks Two Years Since Flooding, Damage*, WEATHER CHANNEL (Aug. 28, 2013), https://weather.com/news/news/vt-marks-2-years-irenes-flooding-damage-20130828 [https://perma.cc/583H-9PUF].

26. Nancy Shulins, *After Irene, Vermont Shows Us What Climate Resilience Looks Like*, GRIST (Nov. 2, 2014), http://grist.org/climate-energy/after-irene-vermont-shows-us-what-climate-resilience-looks-like/ [https://perma.cc/3VBZ-UVK2].

27. SACHA PEALER, VT. AGENCY OF NAT. RES., LESSONS FROM IRENE: BUILDING RESILIENCY AS WE REBUILD 3–4 (2012), http://anr.vermont.gov/sites/anr/files/specialtopics/climate/documents/factsheets/Irene_Facts.pdf [https://perma.cc/A43Q-ZZY8].

28. *See* Ring, *supra* note 25.

29. GEORGE SPRINGSTON & KRISTEN UNDERWOOD, IMPACTS OF TROPICAL STORM IRENE ON STREAMS IN VERMONT 13, http://vcgi.vermont.gov/sites/vcgi/files/event_archive/IreneGeomorphRevised02142012small.pdf [https://perma.cc/6SQ5-KPJN].

30. *See* PEALER, *supra* note 27, at 4.

Hundreds of oil and chemical spills were reported around the state, contaminating flood waters, sediment, and soils.[31]

Water resources were especially impacted by the flooding, which hit ten of Vermont's seventeen major river basins and caused sometimes catastrophic channel enlargement, deposition, and relocation.[32] The floodwaters scoured rivers and streams, stressing fish and macroinvertebrate populations and degrading aquatic habitat.[33] Sediment deposition and increased algae growth disrupted in-stream habitat and chemical contaminants distributed by floodwaters harmed aquatic and terrestrial species.[34] In-stream work to channelize and dredge streams in support of recovery efforts also had a negative impact on the quality and diversity of aquatic habitats according to scientists and environmental activists.[35] Lake Champlain tributaries delivered sediment and nutrient loads to the lake and high winds pushed high waters into waves that eroded shorelines and damaged structures.[36] The clarity of water was impacted by the heavy load sediment and nutrients, and phosphorus levels were recorded at higher than average levels, promoting the conditions in which algal blooms and cyanobacteria thrive.[37] Indeed, aerial photos taken of Lake Champlain after Tropical Storm Irene graphically depict the impact of sediment pollution: huge plumes of chocolate brown, muddy water at the mouth of every major tributary.[38]

This devastation forced scientists, policy makers, and legislators to examine the impact of our built landscape on the natural environment and identify opportunities for protection of natural infrastructure like floodplains, river corridors, and wetlands that help to absorb the impact of flooding and protect our roads, bridges, homes, and businesses.[39] Indeed,

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31. Brian Mann, *Post-Irene Cleanup May Damage Environment*, NAT'L PUB. RADIO (Sept. 14, 2011), http://www.npr.org/2011/09/14/140461854/post-irene-cleanup-may-damage-environment [https://perma.cc/6VGF-2TV5].

32. *See* PEALER, *supra* note 27, at 5.

33. Vermont PBS, *Vermont Trout River Interview with Kim Greenwood*, YOUTUBE (Apr. 23, 2012), https://www.youtube.com/watch?v=NrnY8gHa054#t=295 [https://perma.cc/B4TC-PMBC].

34. PEALER, *supra* note 27, at 6.

35. Allison Teague, *ANR Renews Commitment to Pre-Irene Enforcement of River Protections*, VT DIGGER (Nov. 27, 2011, 8:20 PM), http://vtdigger.org/2011/11/27/anr-renews-commitment-to-pre-irene-enforcement-of-river-protections/ [https://perma.cc/2XED-KX3F].

36. *2011 Flooding*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/water-quality/flooding/2011-flooding/ [https://perma.cc/C2R8-4XN7] (last visited Apr. 6, 2016).

37. LAKE CHAMPLAIN BASIN PROGRAM, FLOOD RESILIENCE IN THE LAKE CHAMPLAIN BASIN AND UPPER RICHILIEU RIVER 16 (2013), http://www.lcbp.org/wp-content/uploads/2013/04/FloodReport2013_en.pdf [https://perma.cc/QVE4-Z47A].

38. *Photo Gallery: Tropical Storm Irene*, LAKE CHAMPLAIN BASIN PROGRAM (Jan. 31, 2013), http://www.lcbp.org/2013/01/photo-gallery-tropical-storm-irene-2011-2/ [https://perma.cc/43GR-73PA].

39. PEALER, *supra* note 27, at 6–7.

many policy makers concluded in the wake of Irene that "the goals of protecting our communities and preserving our natural environment are closely intertwined and interdependent."[40] A perfect example of this phenomenon was the function of floodplains, wetlands, and forest swamps along the Otter Creek that absorbed flood waters during the storm and saved the town of Middlebury from potentially devastating inundation flooding and erosion.[41] The Otter Creek story was, unfortunately, not the rule. In too many Vermont towns and watersheds, Irene illustrated the risks of development without regard to protection of "natural watershed storage" capable of capturing water, sediment, and woody material during heavy rainfall events and the resulting devastation demanded a strong response.[42] Almost as soon as the flood waters began to recede, the Vermont General Assembly, Shumlin Administration, and municipal and private stakeholders worked together to bolster existing flood resilience policies, create new laws and policies, and prepare for the inevitable next storm.

The link between land use policy and surface water quality is complex and legislative action in Vermont has not been confined to flood resilience policy alone. In the four years following Tropical Storm Irene, the Vermont General Assembly passed three critical pieces of legislation aimed at improving surface water quality through land use regulation at the municipal and state level: Vermont Act No. 138 of 2012 ("Act 138"), Vermont Act No. 172 of 2014 ("Act 172" or "Shoreland Protection Act"), and the Vermont Clean Water Act.[43] Taken together, these three acts represent a major step forward in the history of Vermont's efforts to ensure that land use, development, and economic growth do not come at the expense of ensuring that the waters of Vermont meet the fishable, swimmable, and drinkable standards for surface waters established forty years ago in the CWA.[44] In broad brush strokes, the three acts:

- resulted in new protection for river corridors, flood plains, and flood hazard areas;[45]
- established statewide minimum standards for cutting and managing vegetation and creating new impervious surface

40. Mears & McKearnan, *supra* note 24, at 178.

41. *Id.* at 187.

42. Mike Kline, *Giving Our Rivers Room To Move: A New Strategy and Contribution to Protecting Vermont's Communities and Ensuring Clean Water*, *infra* p. 735; *see generally*, Springston & Underwood, *supra* note 29 (illustrating rainfall totals, inundation damage, and erosion damage throughout Vermont).

43. S. 202, 2011-2012 Leg. Sess. (Vt. 2012); H. 526, 2013-2014 Leg. Sess. (Vt. 2012); H. 35, 2015-2016 Leg. Sess. (Vt. 2015).

44. 33 U.S.C. § 1251(a).

45. *See generally* 2012 Vt. Acts & Resolves 425 (updating the statute to provide more assistance in the case of floods and to have more management of flood hazard areas).

within 250 feet of all lakes and ponds with a surface area greater than ten acres;[46] and

- mandated that the ANR, VTrans, and VAAFM take significant new regulatory actions to control polluted stormwater runoff from developed lands, agricultural and silvicultural operations, and state and local roads.[47]

In each case, Vermont legislators, officials, and stakeholders around the state looked at the human impact on the landscape and the corresponding impact on water resources and pledged to take action to curb or more tightly regulate those human impacts.

Tropical Storm Irene was not the only causal event leading to this concentrated and focused set of legislative and administrative actions between 2012 and 2015. Other precedents are important to consider, including state land use regulations established under Act 250 of 1970, which for nearly forty years has required commercial scale development to avoid impacts to the natural environment (e.g., rivers, streams, lakes, and ponds, and wetlands).[48] During the decade before Irene, Vermont's stormwater statute was enhanced in multiple legislative acts in order to support implementation of the original Lake Champlain TMDL.[49] Two major bills were proposed in order to regulate land use in the buffers of lakes, ponds, rivers, and streams.[50] Then Act 110 of 2010 required ANR to establish a river corridor management program in order to provide guidance to municipalities for regulation of development in river corridors.[51] Those actions were an important prelude for the three major pieces of water quality legislation enacted in the years following Tropical Storm Irene. The rest of this article will explore each of those three acts, providing a summary of the altered state of Vermont's land use regulations as they

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46. 2014 Vt. Acts & Resolves 775.

47. *See generally* 2015 Vt. Acts & Resolves 976 ("It is the purpose of this act to . . . engage all municipalities, agricultural operations, businesses, and other interested parties as part of the State's efforts to improve the quality of the waters of the State.").

48. *See generally* 1970 Vt. Acts & Resolves 237 (providing the language for the act, passed in 1970, aiming to balance commercial development with environmental harm).

49. *See* 2004 Vt. Acts & Resolves 541 (directing DEC to adopt by rule a stormwater program to regulate stormwater runoff from impervious surface in a manner that would mitigate to the greatest extent its effects on receiving waters in addition to the program for management of stormwater under the CWA NPDES program); *see id.* at 209–10 (showing amendments to the stormwater statute).

50. *See* H.B. 297, 2007–2008 Sess. (Vt. 2007) (a bill requiring a fifteen-foot vegetative buffer along public waters and that the Natural Resources Board regulate buffer zones); *see* H.B. 323. 2009–2010 Leg. Sess. (Vt. 2010) (a bill establishing fifty-foot buffer zones around navigable waters). Although neither bill was enacted into law, environmental leaders within the Vermont General Assembly, ANR staff, and water quality advocates began building the case for shoreland protection during the years before Tropical Storm Irene.

51. *See generally* 2010 Vt. Acts & Resolves 217–18 (amending several sections of title 10 of the Vermont Statutes Annotated related to conservation and development).

apply to surface water quality before concluding with a look forward to the most important unresolved issues facing the state in the quest to protect Vermont's water resources.

II. ACT 138 OF 2012

Act 138 was signed into law by Vermont Governor Peter Shumlin on May 15, 2012,[52] only nine months after Tropical Storm Irene pounded Vermont, following a tough legislative process during which the tension between land use regulation and water quality was at the fore.[53] During the session, nine bills were taken up, dozens of hearings and joint hearings were held, and testimony was taken from myriad witnesses from the Shumlin administration, municipalities, advocates, experts, and stakeholders.[54] On one hand, immediate recovery costs and needs was the primary focus of discussions about Irene during the 2012 legislative session.[55] But Vermont policymakers also looked beyond recovery to flood resiliency, examining vulnerabilities and asking what land use best practices would be necessary to mitigate damage during future flood events.[56]

Initially referred to as the "Rivers and Lakes Bill" by DEC river scientists,[57] Act 138 established new regulations to promote and enhance the function of natural floodplains and to decrease reliance on engineered structures to protect against flood hazards.[58] Act 138 also clarified what river management practices are acceptable and under what circumstances the state can act to minimize river erosion hazards during flood events.[59] This innovative law also established new requirements for towns to identify

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52. S. 202, 2011–2012 Leg. Sess. (Vt. 2012).

53. Howard Weiss-Tisman, *Lawmakers Try to Address Post-Irene Lessons*, BRATTLEBORO REFORMER (Aug. 25, 2012, 3:00 AM), http://www.reformer.com/irene/ci_21397569/lawmakers-try-address-post-irene-lessons [https://perma.cc/HH3D-5TW3].

54. Based on author's personal knowledge.

55. Based on author's personal knowledge.

56. *See, e.g.*, *Welcome to Flood Ready Vermont*, FLOOD READY VT., http://floodready.vermont.gov [https://perma.cc/P7U7-K2K8] (last visited Apr. 7, 2016) (discussing Vermont's efforts to make communities more flood resilient); VT. AGENCY OF NAT. RES., RESILIENCE: A REPORT ON THE HEALTH OF THE VERMONT ENVIRONMENT 8 (2011), http://anr.vermont.gov/sites/anr/files/aboutus/documents/Resilience%202011.pdf [https://perma.cc/PS9W-MZC7] (discussing techniques for Vermont to reduce flood damage).

57. VT. DEP'T OF ENVTL. CONSERVATION, SUMMARY OF "RIVERS BILL" COMPONENTS IN ACT 138 (2012)

58. *See* 2012 Vt. Acts & Resolves 425, 427 (describing amendments to the statute of flood hazard areas to better manage flooding in Vermont).

59. *Id.* at 429.

and protect river corridors.[60] River scientists at DEC explained the bill's primary objectives related to riparian management as follows:

- to "increase municipal participation, awareness, and protection of floodplain assets"[61] by allowing DEC to delegate review of floodplain development proposals to regional planners and municipal officials implementing standards consistent with the National Flood Insurance Program (NFIP);
- to ensure ongoing compliance with NFIP requirements by requiring DEC regulation of floodplain encroachments otherwise exempt from municipal regulation (i.e., encroachments resulting from agriculture, silviculture, or energy generation), including regulations more stringent than NFIP minimum standards under a new General Permit;
- to reduce the risk to public and private property from flooding by giving authority to DEC for new stream alteration standards, standards for conducting emergency operations after a flood, and standards for excavation and movement of in-stream fill;
- to better protect river corridors, flood plains, and buffers by giving authority to DEC to adopt new rules and procedures to delineate fluvial erosion hazard areas within riparian corridors and to regulate development that would increase the risk within those areas; and
- to ensure coordinated flood resiliency efforts at every level of government by including other requirements for outreach, communication, and education within state government, regional planning commissions, and municipalities.[62]

Environmental advocacy groups like the Vermont League of Conservation Voters supported the underlying legislative effort and praised the result.[63] State Representative David Deen, the Chair of the Vermont House Committee for Fish, Wildlife and Water Resources, summarized the spirit driving this comprehensive river protection legislation: "People were whistling past the graveyard relative to the potential of rivers flooding and impacting communities," Deen said. "Obviously after Irene we were not able to look the other way anymore."[64]

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60. *Id.* at 435; SUMMARY OF "RIVERS BILL" COMPONENTS OF ACT 138, *supra* note 57, at 2.
61. SUMMARY OF "RIVERS BILL" COMPONENTS IN ACT 138, *supra* note 57, at 1.
62. *Id.* at 1–3.
63. VT. LEAGUE OF CONSERVATION VOTERS, VERMONT ENVIRONMENTAL SCORECARD 4 (2012), http://vermontconservationvoters.org/wp-content/uploads/2013/12/2012_VT_LCV_Scorecardpdfreduced2.pdf [https://perma.cc/BTZ4-TDQD].
64. Weiss-Tisman, *supra* note 53; 2012 Vt. Acts & Resolves 441–42.

In addition to the important flood resiliency aspects of the law, another important legacy of Act 138 was the mandate to DEC to report on priorities, costs, and revenue options needed to protect surface waters in Vermont.[65] This mandate played upon the important theme that public support and funding for water quality protection efforts is critical and that failure to provide that support will have long-term negative impacts not only on human and ecosystem health, but also on Vermont's economy and its use of state resources.[66] Section 19 of Act 138 found that new actions are necessary to preserve, protect, and restore Vermont's surface waters and that regulation of development in floodplains, river corridors, shorelands and wetlands is necessary to promote flood resiliency; it required DEC to estimate the overall funding needs, priorities for action, and mechanisms to administer new programs to abate pollution from agricultural and developed lands in Vermont.[67] As will be discussed in more detail below, the report mandate also directed DEC to make recommendations for restoring and protecting shorelands of lakes and ponds, including whether new statewide standards for development would be necessary to protect the functions and values of Vermont's lakes and ponds.[68]

As the flood waters of Tropical Storm Irene receded, Vermont began a multi-year conversation about the connections among land use, development, surface water quality, and flood resiliency. As directed, DEC prepared a comprehensive report in response to the mandate of Act 138, summarizing investments and actions taken to date, providing an overview of the challenge of nonpoint source pollution control, and describing a menu of investments and programs to address statewide clean water challenges.[69] The report was delivered in multiple legislative committees and joint committees as witnesses from the Shumlin administration, advocacy groups, and other stakeholders worked with legislators to determine what actions would be necessary to remediate Vermont's surface waters and how those efforts should be funded.

The report mandate in Act 138 was intended to generate legislative proposals for programs and funding related to clean water, but DEC's report did not provide specific recommendations and the Shumlin administration, legislative leaders, advocates, and stakeholders did not initially agree on a path forward for surface water pollution control and

65. 2012 Vt. Acts & Resolves 441.
66. *Id.*
67. *Id.* at 443.
68. *Id.*
69. *See* VT. AGENCY OF NAT. RES., WATER QUALITY REMEDIATION, IMPLEMENTATION AND FUNDING REPORT 5–6 (2013), http://legislature.vermont.gov/assets/Documents/Reports/286133.PDF [https://perma.cc/6WJG-V4JU].

funding.[70] Legislative leaders and clean water advocates worked on several pieces of legislation, but no substantive bills were passed during the biennium from 2013 to 2014, in large part because the Shumlin administration advocated postponing action until DEC could develop a draft implementation plan for the new TMDL it was working to develop with EPA.[71]

DEC did, however, recommend options for regulating development and land use in the shorelands of lakes and ponds greater than ten acres in size in a separately submitted report at the beginning of the 2013 legislative session, launching a two-year legislative campaign that ended when Governor Shumlin signed the "Shoreland Protection Act" into law on June 5, 2014.[72]

III. ACT 172 OF 2014: THE SHORELAND PROTECTION ACT

In response to the mandate in Act 138 for recommendations regarding regulation of shoreland development, DEC's Lakes and Ponds Program delivered a report to the General Assembly at the beginning of the 2013 legislative session that detailed the value of the state's lakes and ponds, the health of shorelands around those resources, and recommendations for greater protection through state regulations.[73] As detailed in that report, DEC research scientists working with EPA had documented that over eighty percent of lakes and ponds larger than twenty acres in Vermont had compromised shoreland health as a result of development pressure and largely unregulated land use practices.[74] More importantly, the report provided strong evidence that compromised shoreland health negatively impacts water quality in the near shore area of lakes and ponds, results in

70. *See* 2014 Acts & Resolves 274 (memorializing ongoing requests for administration recommendations to address surface water pollution in Vermont).

71. *See* H.586: Witnesses, VT. GEN. ASSEMBLY, http://legislature.vermont.gov/bill/status/2014/H.586#witnesses (last visited June 27, 2016) (providing links to one example of proposed legislation before Act 64 and DEC testimony regarding status of TMDL negotiations with EPA); *see also* Kari Dolan, *The Importance of Inter-Agency Collaboration and Public Engagement in the Development of the Implementation Plan for the Nonpoint Source-Focused Vermont Lake Champlain Phosphorus TMDL*, *supra* p. 663 (discussing the disapproval of the 2002 TMDL and Vermont's efforts with EPA to develop a comprehensive management plan in the style of the Chesapeake Bay TMDL); Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts*, *supra* pp. 625–28 (explaining the transition from the 2002 Lake Champlain TMDL to the updated TMDL).

72. H. 526, 2013–2014 Leg. Sess. (Vt. 2012).

73. *See generally* AMY PICOTTE ET AL., VT. AGENCY OF NAT. RES., LAKE SHORELAND PROTECTION AND RESTORATION MANAGEMENT OPTIONS (2013), http://legislature.vermont.gov/assets/Documents/Reports/285836.PDF [https://perma.cc/C3ZX-CNNE] (presenting options and recommendations for strengthening Vermont shoreland management).

74. *See id.* at 21 (explaining that even the twenty percent of towns that have shoreland zoning rules "often have a difficult time enforcing them").

unstable shoreline banks more susceptible to erosion and degradation, and leads to loss of critical habitat for fish, insects, amphibians, birds, and mammals.[75] Additionally, the report detailed the economic functions and values that healthy lakes and ponds have in Vermont: supporting recreation and tourism, hunting, fishing, wildlife watching, swimming, and property values and tax base.[76] Given the threat to these important resources, the DEC Lakes and Ponds Program recommended in the report that the General Assembly enact comprehensive, statewide standards to regulate development and land use in shorelands of Vermont's lakes and ponds.[77]

Although the Agency's report on shoreland protection was initially overshadowed by the Act 138 report on funding needs for surface water quality, shoreland protection emerged in the 2013 session as a leading environmental issue. During the spring of 2013, the Vermont House Committee on Fish, Wildlife and Water Resources worked for six weeks on two separate bills, taking testimony from numerous witnesses, including administration officials, environmental advocates, property rights advocates, and scores of individual citizens who testified at an evening public hearing on the proposed legislation.[78] Not surprisingly, the debate over which land use restrictions would be necessary to protect important shoreland resources was marked by strong support from environmental advocates, scientists, and the Shumlin administration on one hand, and strong opposition from municipalities, property owners, and property rights advocates on the other.[79] Signaling an understanding that reasonable restrictions on land use and development were important to protect water resources, on March, 27, 2013, the Vermont House of Representatives voted 105 to 42 in favor of House Bill 526 ("H.526").

The Vermont Senate Committee for Natural Resources and Energy began taking testimony on H.526, but action was postponed in light of widespread opposition from property rights advocates.[80] After a summer of hearings between sessions of the 2013-2014 biennium, H.526 ultimately did pass and was signed into law as Act 172, with significant revisions to the

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75. *Id.* at 3–4.

76. *Id.* at 5–6.

77. *Id.* at 16.

78. *See H.526 (Act 172): Witnesses*, VT. GEN. ASSEMBLY, http://legislature.vermont.gov/bill/status/2014/H.526?#witnesses (last visited Apr. 7, 2016) (providing related documents and witness testimony).

79. *See id.* (based on the personal knowledge of the author).

80. *See H.B. 526*, *supra* note 78 (showing a number of Committee for Natural Resources and Energy hearings and based in part of author's personal knowledge); *see* Letter from Lake Bomoseen Association Member to Vt. Legislators (Mar. 26, 2013), http://lakebomoseen.mylaketown.com/uploads/tinymce/lakebomoseen/h223letter.pdf [https://perma.cc/Y79L-ZDBL] (expressing opposition to Vermont's H.526).

bill to address concerns expressed by citizens and advocacy groups during the extended process.[81]

The principal result of Act 172 was to establish a new permitting program within DEC to regulate the creation of new impervious surface or cleared areas within 250 feet of lakes and ponds greater than 10 acres in surface area.[82] Under the act, permits may only be issued for creation of impervious surface or cleared area on slopes of less than 20%, where no more than 20% of the area within 250 feet of the mean high water level is impervious and where no more than 40% of that area is cleared, except where an applicant can demonstrate that the use of BMPs is functionally equivalent to the statutory limits.[83] Under all circumstances, cutting of trees or removal of vegetation within the first 100 feet of the mean high water level must be managed consistent with management standards intended to promote a healthy mix of grasses, shrubs, and trees.[84] The act also makes accommodation for existing (as of July 2014), non-conforming lots, with the goal of ensuring that no landowners would lose their right to develop, use, and enjoy these lots; it also makes allowance for public recreational areas and contains exemptions for certain activities that do not require a DEC permit.[85] Finally, the Shoreland Protection Act allows DEC to delegate permitting authority to municipalities with zoning restrictions functionally equivalent to the statewide standards so long as the municipality is able to demonstrate programmatic capacity to administer a permitting program and enforce those standards.[86]

In the findings of the Shoreland Protection Act, the Vermont General Assembly acknowledges the "multiple pressures" on Vermont's water, despite ongoing efforts to regulate stormwater, wastewater, and agricultural runoff, and asserts the necessity of required BMPs in the lands adjacent to lakes and ponds.[87] Act 172 however was not intended, and does not purport, to offer solutions to major nutrient impairment in Vermont's surface waters. Indeed, although the Phase I Implementation for the Lake Champlain TMDL does include a section on shoreland protection, it is just one component of a much broader plan focused on many different sources of

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81. H. 526, 2013–2014 Leg. Sess. (Vt. 2012); VT. GEN. ASSEMB., ACT NO. 172 (H. 526): ACT SUMMARY (2014), http://legislature.vermont.gov/assets/Documents/2014/Docs/ACTS/ACT172/Act172%20Act%20Summary.pdf [https://perma.cc/T7YD-SNH2]; 2013 Vt. Acts & Resolves 410–12.
82. 2014 Vt. Acts & Resolves 777.
83. *Id.* at 782.
84. *Id.* at 778–79.
85. *Id.* at 78.
86. *Id.* at 773–74.
87. *Id.*

phosphorus pollution.[88] Nonetheless, the Shoreland Protection Act was a significant step forward in the journey towards the Vermont Water Quality Act.

First, the legislative process, spanning fifteen months and including multiple public hearings and countless hours of committee testimony, provided Shumlin officials the opportunity to educate legislators and the public about water quality and to preview the next set of legislative conversations that would ultimately result in the Vermont Clean Water Act.[89] Next, the legislative process that resulted in Act 172, if sometimes messy and controversial, was robust and productive: multiple committees took testimony on the bill in both bodies of the General Assembly, citizens around the state engaged on the pros and cons of shoreland protection, the final outcome was debated on the floors of both chambers and, in the end, Act 172 passed with overwhelming support.[90] The final disposition of the act showed that Vermont officials, legislators, advocates, and stakeholders could work through complex issues in a manner that protected the environment and respected property rights. Although Act 172 reflects a number of key compromises, it underscores two basic premises: (1) that restrictions on the ways in which we build on and use the land are a necessary part of water quality protection; and (2) that individual landowners are responsible to work with state officials, scientists, and regulators to ensure that their use of private land does not impose a burden on the state's commonly owned water resources.[91]

In the Shoreland Protection Act, those twin premises are reflected most importantly in the vegetation management standards that mandate specific requirements for landowner management of shoreland vegetation and the statutory scheme that requires DEC's Lakes and Ponds Program to provide education, outreach, and assistance to those landowners in addition to permitting allowable activities.[92] The result of this coordination is that each mile of lake and pond shoreland in Vermont will be managed over time to achieve a natural buffer between developed lands and waters, ensuring infiltration of stormwater runoff, a mix of vegetation providing strong root structure and bank stability and ideal habitat for birds, mammals, amphibians, and fish.[93]

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88. STATE OF VERMONT, *supra* note 18, at 60–61.
89. *H.526*, *supra* note 78.
90. *See id.*
91. *See* H. 526, 2013–2014 Leg. Sess. (Vt. 2014) (requiring permits for certain land development with the goal of preserving Vermont's water resources).
92. *See* 2014 Vt. Acts & Resolves 784.
93. *Id.* at 774.

IV. ACT 64 OF 2015: THE VERMONT CLEAN WATER ACT

In spite of significant progress following Tropical Storm Irene to establish new protective regulations for lakes and ponds, river corridors, and floodplains, the State of Vermont continued to face pressure from EPA, clean-water advocates, and stakeholders around Vermont to take strong action to protect Lake Champlain and to fund the effort required to do so.[94] The State had already submitted to EPA a Phase I Implementation Plan for the Lake Champlain TMDL outlining actions across all sectors necessary to control phosphorus pollution sources across the enormous watershed, including actions for which new state authority or resources would be necessary to successfully complete the mission.[95] State and federal officials had also presented their plans in a series of public meetings across the Lake Champlain Basin during the months leading up to the 2015 Legislative Session.[96] In addition, the Vermont General Assembly had mandated in Act 97 of 2014 that ANR deliver a report outlining programmatic costs, investments, and potential revenue sources needed to support implementation of the impending TMDL and to address surface water impairments across Vermont.[97]

Widespread algal blooms were reported again in Lake Champlain during the warmest months of the summer and fall—not just in the most polluted bays and inlets, but also in the waters off Burlington's beaches.[98] The table was set for action and Governor Shumlin put the pieces in motion during his Inaugural Address and State of the State.[99] In this speech, he outlined legislative actions needed to address stormwater pollution from developed lands, roads, and farms and provide resources to communities, farmers, and loggers to fund required actions and hold all sectors, especially

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94. *Vermont Outlines Plan to Address Lake Champlain Cleanup*, LAKE CHAMPLAIN LIFE, http://lakechamplainlife.com/latest-tool-in-vermonts-lake-champlain-cleanup/ [https://perma.cc/HD47-VCLK] (last visited Apr. 11, 2016).

95. STATE OF VERMONT, *supra* note 18, at 1–3; *Restoring Lake Champlain*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/cwi/restoring [https://perma.cc/U834-DMZ6] (last visited Apr. 11, 2016).

96. *See* U.S. ENVTL. PROT. AGENCY, REGION 1, PUBLIC OUTREACH MEETINGS: LAKE CHAMPLAIN TOTAL MAXIMUM DAILY LOAD (2015), https://www.epa.gov/sites/production/files/2015-09/documents/aug-2015-public-meeting-presentation.pdf [https://perma.cc/5KYU-7GQQ] (providing an example of the public outreach meetings conducted by officials).

97. 2014 Acts & Resolves 274.

98. Sam Heller, *Two Burlington Beaches Closed by Suspected Algae Blooms*, VT DIGGER (July 13, 2015, 3:07 PM), http://vtdigger.org/2015/07/13/two-burlington-beaches-closed-by-suspected-algae-blooms/ [https://perma.cc/2A2W-6F55]; *Blue-Green Algae in Lake Champlain*, LAKE CHAMPLAIN COMMITTEE, http://www.lakechamplaincommittee.org/lcc-at-work/algae-in-lake/#c4033 [https://perma.cc/2T9R-4DUU] (last visited Apr. 1, 2016) (listing the sites at which algal blooms were reported in the summer and fall of 2015).

99. Governor Peter Shumlin, Third Inaugural Address to Vt. Gen. Assembly (Jan. 8, 2015), https://vimeo.com/116440740 [https://perma.cc/7J4L-9EVN].

agriculture, responsible for failure to comply with water quality laws and regulations.[100] Governor Shumlin announced his administration's intention to support new capital and general fund support for implementation of clean water planning and pollution abatement projects in addition to advocating for creation of a dedicated clean water fund that would serve as a clearing house for state investments and private donations.[101] Referring to the "heartbreaking" algal blooms and pea-green waters of Lake Champlain, the Governor stated that declining water quality is the "greatest threat to our local environment" and underscored that protecting the Lake is "critical to protecting our economy."[102]

Thus, the race was on to enact comprehensive clean water legislation and dedicate new funding for the clean-up effort. Administration officials and legislative leaders worked to craft and introduce a single bill—House Bill 35—that would: provide new authority to ANR and VAAFM to regulate polluted runoff from roads, developed lands, farming operations, and farm fields; institute new penalties for actors failing their obligations under existing and new laws and regulations; and propose a dedicated Clean Water Fund and public process for directing investments in clean water.[103] Eleven different legislative committees held hearings on the bill over the course of four months of process, dozens of witnesses provided testimony, and in the end, H.35 passed with broad bipartisan support in both the Vermont House of Representatives and the Vermont Senate.[104] When Governor Shumlin gathered legislative and municipal leaders, environmental advocates, and other stakeholders together on the shores of Lake Champlain to sign H.35 into law on June 16, 2015, he summarized the spirit that inspired that collaboration:

> This bill is not only about cleaning up Vermont's waterways and Lake Champlain, it is about protecting our economy and a natural habitat that binds Vermonters tightly to our state and inspires others to put roots down here . . . . In short, this bill is about protecting what makes Vermont so special. Cleaning up our waterways won't happen overnight, but this bill puts us on a path

100. *News Release of Gov. Peter Shumlin's Inaugural Address*, VT DIGGER (Jan. 8, 2015), http://vtdigger.org/2015/01/08/text-gov-peter-shumlins-inaugural-address/ [https://perma.cc/5PQ3-AJPS].

101. Governor Peter Shumlin, *supra* note 99.

102. *Id.*

103. *See* H. 35, 2015–2016 Leg. Sess. (Vt. 2015).

104. H. 35, 2015–2016 Leg. Sess. (Vt. 2015) (based, in part, on author's personal knowledge).

> to ensure that future generations of Vermonters grow up to enjoy the natural beauty that has defined this state since the beginning.[105]

As stated at the outset of this article, the Vermont Clean Water Act is noteworthy because of the important new and expanded regulatory authority, programmatic capacity, and funding it provides for the State of Vermont to control nutrient and sediment pollution in the Lake Champlain Basin and to address water quality challenges across the state. Act 64 is also significant because it illustrates the principle Justice Brandeis wrote about so eloquently almost 100 years ago in his famous dissent to the *New State Ice* case that states may serve in a cooperative federal system as laboratories "and try novel social and economic experiments" to solve localized problems incisively where the broad strokes of national policy are inadequate.[106] The context of *New State Ice* is wholly distinct from the questions that states face in attempting to address surface water impairment resulting from polluted stormwater runoff (rather than point source pollution traditionally regulated under the CWA), but the need for states to take novel and creative approaches is still real.[107] The reach of the CWA is limited, local solutions are necessary, [108] and Act 64 provides those solutions. At once, it provides support for and complements Vermont's federally delegated clean water programs, finding state law solutions to address the sources of phosphorus and sediment pollution that are beyond the reach of the traditional federal CWA programs: back roads, agricultural fields, and river corridors.[109] Like Act 138 and Act 172 before it, the Vermont Clean Water Act is predicated on the connection between the ways in which we live and develop the land on one hand and water quality on the other.

This connection is reflected in category after category addressed by the bill:

- In the agricultural sector, Act 64 requires VAAFM to engage in rulemaking to revise its "accepted agricultural practices" as "required agricultural practices" in order to establish new water quality management practices and reporting

105. Press Release, Governor Peter Shumlin, *supra* note 3.

106. New State Ice Co. v. Liebmann, 285 U.S. 262, 311 (1932) (Brandeis, J., dissenting).

107. David K. Mears & Rebecca Blackmon, *Lessons for Lake Champlain from Chesapeake Bay: Returning Both Waters to the "Land of Living"*, *infra* pp. 580–83 (discussing how the court in the Chesapeake Bay litigation did not find EPA's interpretation of section 303(d) to infringe on traditional state powers, thus allowing states to use their land use powers in implementing TMDLs).

108. *Id.*

109. *See* Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts*, *supra* pp. 624–28 (explaining the disapproval of the first Lake Champlain TMDL and efforts to develop new state authority).

requirements for small farms, nutrient storage and management, buffers, and livestock exclusion.[110] It requires VAAFM and ANR to collaborate on enforcement, anti-degradation policy, and prevention of discharges to state waters; it establishes new certification for custom applicators of manure; and it enacts new penalties for farm operations failing to comply with required agricultural practices, including suspension of tax benefits under Vermont's "Current Use Program."[111]

- Act 64 generally revises ANR's statutory authority to regulate stormwater, including clarification of existing state and federal authority, exemptions, and rulemaking authority to establish watershed priorities in the tactical basin planning process.[112] It establishes new rulemaking authority to regulate runoff from municipal roads and to require redevelopment and retrofits to existing developed lots with more than three acres of impervious surface.[113] Act 64 directs ANR to report on whether to lower from one acre to one-half acre the threshold for requirement of a state stormwater operating permit for new construction.[114] Finally, it requires ANR's Commissioner of Forests, Parks and Recreation to revise and readopt "Acceptable Management Practices for Maintaining Water Quality on Logging Jobs."[115]
- In addition to land use requirements, Act 64 also establishes new positions within DEC and VAAFM to carry out the Clean Water Initiative.[116] Likewise, it establishes a new Clean Water Fund with dedicated revenue to support compliance related projects undertaken by municipalities, agricultural operations, and watershed groups.[117] Finally, it eliminates a safe harbor provision in state law that had allowed waste water treatment facilities not to comply with effluent concentration standards where state funding was not available to finance upgrades.[118]

110. 2015 Vt. Acts & Resolves 989.
111. *See id.* (describing enforcement procedures).
112. *Id.* at 1,008.
113. *Id* at 1,010.
114. *Id.* at 1,014.
115. *Id.* at 1,031–32.
116. *Id.* at 1,030
117. *Id.* at 1,018.
118. *Id.* at 1,030.

CONCLUSION: UNRESOLVED ISSUES

Like most legislative efforts of its size and scope, the Vermont Clean Water Act is far from perfect. Act 64 however represents a significant step forward for clean water in Vermont and provides robust new authority to address nutrient and sediment pollution from agricultural and silvicultural operations, roads, and developed lands through standards for land use and development across the Vermont landscape. Moreover, it establishes new capacity within state government to plan, support, and regulate within the Clean Water Initiative. Finally, the new Clean Water Fund creates a mechanism and requirement for annual investment in pollution abatement projects around the state.

Notably, Act 64 does not establish a permanent revenue source for the Clean Water Fund, but provides for a surcharge on Vermont's property transfer tax that sunsets after three years.[119] Moreover, that surcharge is expected to raise only a little more than five million dollars each year, well short of previous estimates of total annual need provided by DEC, clean water advocates, and municipal officials.[120] While "total need" can be an elusive concept, it is clear that implementation and compliance costs for municipalities, agricultural operations, and private landowners will significantly surpass current costs and levels of investment and state support will be necessary to ensure that the comprehensive effort moves continuously forward. The Vermont Clean Water Act, therefore, directs the Vermont Treasurer, working with the Shumlin administration, to report back by January 2017 with recommended sources for permanently funding and financing the Clean Water Initiative.[121] The cost of clean water—especially for investments across a watershed as large as Lake Champlain—is Vermont's next challenge.

Other major challenges loom ahead. Analogous to the cost that regulated entities and landowners will bear under the Clean Water Initiative, the state agencies tasked with implementing new regulations must be able to sustain the capacity and momentum currently developed in the face of constant budget pressures and strong reactions from the regulated community when new regulations are implemented and costs assumed. State officials have embraced new measures and practices to

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119. *Id.* at 1,022.

120. *See* DANIEL DICKERSON, VT. LEGISLATIVE JOINT FISCAL OFFICE, H.35 AN ACT RELATING TO IMPROVING THE QUALITY OF STATE WATERS (2015), http://legislature.vermont.gov/assets/Documents/2016/WorkGroups/House%20Fish%20and%20Wildlife/Bills/H.35/Witness%20Testimony/H.35~Dan%20Dickerson~Fiscal%20Note~3-31-2015.pdf [https://perma.cc/LA3S-BR54] (providing revenue estimates for fees established in Act 64); *see also* WATER QUALITY REMEDIATION, IMPLEMENTATION AND FUNDING REPORT, *supra* note 69, at 67.

121. 2015 Vt. Acts & Resolves 1,022.

streamline business processes, increase accountability, and protect open government in the years after Tropical Storm Irene. But increased demands on state agencies related to clean water must be balanced with other environmental challenges like: promoting clean energy generation and clean transportation alternatives; protecting forest health and integrity; and protecting critical habitat, travel corridors, and natural areas for native species threatened by climate change and sprawling development—not to mention other challenges, such as healthcare, treatment of mental illness and addiction, and education funding. This article memorializes the spirit of collaboration that marked debate and passage of Act 64, but that spirit must be sustained over decades and in spite of those other pressures and competing needs.

Finally, the Clean Water Initiative depends upon the ability of the state and EPA to adapt to the inevitable development of new information and ideas throughout the implementation period. The monitoring data, studies, models, and assumptions supporting the Lake Champlain TMDL Phase I Implementation Plan and the Clean Water Initiative are comprehensive and cutting edge.[122] Nonetheless, as Professor Owen notes in his article, *After the TMDLs*, there is no proof that the complex, systemic changes necessary to successfully meet the goals underlying TMDLs in the CWA can be delivered by the legal tools available under federal law.[123] The Lake Champlain TMDL Phase I Implementation Plan and the Clean Water Initiative attempt to account for future population growth and development and the unpredictable impact on Vermont of global climate change, but the "problem of nonpoint pollution [results from] a complex set of climatological, ecological, and social factors."[124] The future holds an inevitable loss of forest lands, floodplains, and wetlands, increased stormwater volume from new development, increased rainfall amounts and more severe storms, and the long term challenge of stabilizing Vermont's river systems. Finally, targets for regulation must also account legacy pollution in our receiving waters—the problems in Lakes Champlain and Memphremagog, the Connecticut River, and throughout Vermont are the result of hundreds of years of human activity on the landscape.[125] The work

122. Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts, supra* pp. 626–28 (discussing Vermont's commitment to implementing a strong TMDL); Neil C. Kamman & Ethan Swift, *Tactical Basin Planning as the Vehicle for Implementation of the Vermont Clean Water Act*, *infra* p. 710 (discussing the role of tactical basin planning in implementing Act 64 and the new TMDL).

123. Dave Owen, *After the TMDLs*, *supra* pp. 864–67.

124. *See* Christopher Koliba et al., *The Lake Champlain Basin as a Complex Adaptive System: Insights from the Research on Adaption to Climate Change (RACC) Project*, *supra* p. 563.

125. Eric Smeltzer, *History of Vermont's Lake Champlain Phosphorus Reduction Efforts, supra* p. 617.

from the last decade represents a thoughtful and comprehensive first step. But the State of Vermont, EPA, and stakeholders must be flexible and adaptive during the twenty-year implementation of the Lake Champlain TMDL and in the ongoing work of the Clean Water Initiative. Only through a collective ethic of protection, a dogged habit of collecting and responding to data, and a determination to face yet-unknown challenges can the goal of transforming our land use and restoring our surface waters be achieved.

TACTICAL BASIN PLANNING AS THE VEHICLE FOR IMPLEMENTATION OF THE VERMONT CLEAN WATER ACT

***Neil C. Kamman*[1] *and Ethan Swift*[2]**

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INTRODUCTION[3]

A comprehensive and transparent planning process is necessary to achieve full implementation of the Lake Champlain TMDL over the long-term and to stage and document interim progress and improvement.[4] In Vermont, the state relies on the tactical basin planning process for this purpose. Tactical basin planning is a watershed management planning process by which water quality monitoring and pollution source assessment information is integrated with modeling or other land-based prioritization factors to identify necessary actions to protect, maintain, enhance, and restore surface waters.[5]

Basin planning is not a new concept in Vermont or elsewhere in the United States. Many states have their own forms of watershed-based pollution control planning and the U.S. Environmental Protection Agency ("EPA") promotes specific guidance on the development of such plans to address impaired waters.[6] In this article, Vermont's unique approach to

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3. The planning work that is described in this article is the product of many talented individuals. Karen Bates, DEC's longest-serving watershed planner was involved in the very first efforts to develop and implement the Guidelines and her work continues to this day. Steven Syz, Tom Willard, and Wallace McLean, with the guiding vision of Canute Dalmasse, were the true architects of the initial Watershed Initiative and Canute is missed by many. The current or prior contributions of Jim Ryan, Marie Levesque-Caduto, Benjamin Copans, Ryan McCall, Josh Gorman, Catherine Kashanski, Tim Clear, and Danielle Owczarski to the basin planning process and its on-the-ground outcomes must not be understated. The effectiveness of these individuals is of course a reflection of the many DEC staff, watershed partners, and advocates, far too numerous to mention here. The authors also thank Mike Kline for his long-term knowledge, patience, and guidance in the development of the surface water management strategy and tactical planning process. Above all, we thank Pete LaFlamme, Director of Watershed Management in Vermont, for his steadfast support of science-based watershed planning to protect, maintain, enhance, and restore surface waters.

4. *See generally* David K. Mears & Trey Martin, *Foreword: Restoring and Maintaining the Ecological Integrity of Lake Champlain*, *supra* p. 470.

5. VT. DEP'T OF ENVTL. CONSERVATION, VERMONT SURFACE WATER MANAGEMENT STRATEGY, CHAPTER 4 TACTICAL BASIN PLANNING (2011), http://dec.vermont.gov/sites/dec/files/documents/WSMD_swms_Chapter_4_Approach_to_TacticalBasinPlanning_Rev2_V5.pdf [https://perma.cc/6JBW-BHHE] [hereinafter TACTICAL BASIN PLANNING].

6. U.S. ENVTL. PROT. AGENCY, HANDBOOK FOR DEVELOPING WATERSHED PLANS TO RESTORE AND PROTECT OUR WATERS (2008), https://www.epa.gov/sites/production/files/2015-

large-scale watershed planning, called the "tactical basin planning process" ("TBPP"), is described in terms of its role in implementing the Lake Champlain or other large watershed TMDLs and several aspects of the Vermont Clean Water Act ("Act 64"). The TBPP delivers a nationally unique approach to watershed management planning. The content of this article describes the foundations of the TBPP and key evolution points from Vermont's earliest attempts to plan implementation of the Federal Clean Water Act ("CWA") requirements when they were newly minted in the 1970s. This evolution culminated recently in a set of incremental improvements that reflect important and necessary technological and scientific advancements to basin planning to support Vermont's implementation of the Lake Champlain TMDL. Setting the stage for these advancements, we review the legal basis of basin planning with an emphasis on Federal and Vermont Statutes, and describe the general development approach for any given plan. In the close of this article, we described the technological advances representing the next stages of TBPP evolution, which are being undertaken as of this writing by the Department of Environmental Conservation ("DEC") Watershed Management Division. These changes will yield a planning process poised to integrate and deliver prioritized pollution control or mitigation actions for all Vermont surface waters, especially for Lake Champlain.

I. TACTICAL BASIN PLANNING IS REQUIRED BY STATE AND FEDERAL STATUTE

Section 303(e) of the CWA requires that states engage in water quality planning.[7] Title 40 C.F.R. part 130, in part, directs state agencies to prepare basin plans, focus on priority issues and geographic areas, identify priority point and nonpoint water quality problems, consider alternatives, and recommend control solutions and funding sources.[8] In the Vermont statute, basin and watershed planning requirements are found in a number of statutory and regulatory provisions, including, but not limited, to 10 V.S.A. sections 1251, 1253, and 1258, 24 V.S.A. section 3438, and section 1-02.D of the Vermont Water Quality Standards ("VWQS").

09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf [https://perma.cc/PW7B-4NPB].

7. 33 U.S.C. § 1313 (2012).

8. 40 C.F.R. pt. 130.

A. 40 C.F.R. Part 130[9]

In part 130 of the CWA regulations, EPA provides a framework for how states may develop Water Quality Management ("WQM") plans in accordance with sections 208 and 303(e) of the Clean Water Act and certified and approved updates of those plans.[10] The first efforts to develop basin plans in Vermont in the 1970s followed on the enactment of these CWA provisions and provided the first accounting of point source discharges to all rivers of the state. This planning work was focused specifically on identifying, prioritizing, and upgrading wastewater treatment and the execution of those plans yielded improvements to individual rivers and streams. A review of Vermont's federally-required biennial reporting under section 305(b) provides an impressive view into the investments made in wastewater and point source pollution control.[11]

B. 10 V.S.A. Section 1253(d)

The Vermont General Assembly promulgated legislation in 1998, amended in 2015 by Act 64, which requires the Agency of Natural Resources ("ANR") to revise all fifteen basin plans on a five-year cycle.[12] Moreover, ANR is also tasked to prepare an overall management plan, envisioned by 40 C.F.R. part 130.5 as the "continuous planning process," to ensure that the water quality standards are met in all state waters.[13] In Vermont, this continuous planning process is published under the title of the "Vermont Surface Water Management Strategy" ("SWMS").[14] Concurrent with the CWA, ANR must ensure that basin plans take inventory of the existing and potential causes and sources of pollution that may impair surface waters.[15] New provisions of 10 V.S.A. section 1253(d) stipulate that basin plans shall consider approved municipal and regional

9. AGENCY OF NAT. RESOURCES, VERMONT WATER QUALITY STANDARDS ENVIRONMENTAL PROTECTION RULE CHAPTER 29(A) (2014), http://dec.vermont.gov/sites/dec/files/documents/WSMD_WaterQualityStandards_2014.pdf [https://perma.cc/3LW6-EYU7] [hereinafter VERMONT WATER QUALITY STANDARDS CHAPTER 29(A)].

10. 40 C.F.R. pt. 130.

11. *Assessment and Listing*, VT. DEP'T OF ENVTL. CONSERVATION, http:// http://dec.vermont.gov/watershed/map/assessment#Assessment [https://perma.cc/69ZT-F94Z] (last visited Apr. 12, 2016).

12. VT. STAT. ANN. tit. 10, § 1253(d)(1) (as amended by Act 64) (2015).

13. 40 C.F.R. § 130.5.

14. *Vermont Surface Water Management Strategy*, VT. DEP'T. ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/map/strategy [https://perma.cc/2EAS-588H] (last visited Apr. 26, 2016).

15. *Id.*

plans adopted under title 24.[16] Chapter 17 in title 24 and this coordination between ANR and Regional Planning Commissions ("RPCs") to ensure tactical basin and regional plan consistency is described later in this article.

C. Vermont Water Quality Standards

Basin planning is an ongoing process. It is designed to be compatible with the VWQS and is in-fact guided by those rules. The term "basin" refers to the fifteen major river basin planning units that cover the Vermont. DEC now employs a tactical planning process as described by the SWMS to streamline the production of tactical basin plans.[17] The TBPP empowers people with information and tools and provides focus for activities to protect and restore water quality that reflect appropriate levels of stakeholder input.

D. Water Quality Assessment

Every two years, the general water quality conditions of the state are documented pursuant to section 305(b)[18] of the CWA and specific lakes, ponds, rivers, and streams across Vermont with documented water-quality-standards violations are identified and listed as impaired in the CWA section 303(d) listing process.[19] In conjunction with this federal listing process, ANR also identifies and separately lists other priority waters that need further assessment or are altered by flow regulation or exotic aquatic species.[20] These priority listings guide the development of pollution source control strategies, TMDLs, restoration actions, and assessment actions, all of which are integrated by the tactical basin plans. The WQS section 1-02.D requires that basin plans:

- inventory the existing and potential causes and sources of pollution that may impair waters;[21]

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16. VT. STAT. ANN. tit. 10, § 1253(d); VT. STAT. ANN. tit. 24, § 4348 (2015).

17. *Vermont Surface Water Management Strategy*, *supra* note 14.

18. *National Water Quality Inventory Report to Congress*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/waterdata/national-water-quality-inventory-report-congress [https://perma.cc/D2TF-AJBT] (last updated Sept. 30, 2015) (citing to the listing of each water quality report).

19. VT. DEP'T OF ENVTL. CONSERVATION, VERMONT SURFACE WATER ASSESSMENT AND LISTING METHODOLOGY 27 (2016), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/WSMD_assessmethod_2016.pdf [https://perma.cc/PH5C-ZVKY].

20. *Id.*

21. VERMONT WATER QUALITY STANDARDS CHAPTER 29(A), *supra* note 9.

- establish a strategy to improve or restore waters and to ensure full support of uses;[22]
- identify strategies, where necessary, by which to allocate levels of pollution between various sources and between individual discharges; [23] and
- to the extent appropriate, contain specific recommendations by the Secretary that include, but are not limited to:
  - the identification of all known existing uses and salmonid spawning or nursery areas important to the establishment or maintenance of such fisheries; [24]
  - reference to conditions appropriate for specific waters; [25]
  - any recommended changes in classification and designation of waters; [26] and
  - schedules and funding for remediation, stormwater management, riparian zone management, and other measures or strategies pertaining to the enhancement and maintenance of the quality of waters within a basin.[27]

II. THE TACTICAL BASIN PLANNING PROCESS EVOLVES OVER TIME

These enabling statutes and rules, as of 1998, allowed for the development of the first coordinated basin-planning framework for Vermont's surface waters. In 1998, this was known as the Watershed Planning Initiative, Guidelines for Watershed Planning (referred to subsequently as the "Guidelines" approach).[28] This framework established that the state-led water quality planning process would focus annually on priority issues and geographic areas and on the development of water quality controls leading to implementation measures.[29] In doing so, the original 2002–2008 water quality management basin plans (herein referred to as "traditional" basin plans) were used to direct implementation at the strategic level by drawing upon general water quality assessments to identify priority point and nonpoint water quality problems, considering alternative solutions, and recommending control measures, including the

22. *Id.*
23. *Id.* at 10–11.
24. *Id.*
25. *Id.*
26. *Id.*
27. *Id.*
28. VT. DEP'T OF ENVTL. CONSERVATION, VERMONT WATERSHED INITIATIVE, GUIDELINES FOR WATERSHED PLANNING (2003, rev. 2007), http://www.vtwaterquality.org/planning/docs/pl_planningguidelines.pdf.
29. *Id.* at 22.

financial and institutional measures recommended for implementing identified solutions.[30] The State and partner organizations worked collaboratively and with enthusiasm to develop the initial traditional basin plans, including the White River,[31] Poultney-Mettowee,[32] West-Williams-Saxtons,[33] Lamoille,[34] and Waits-Wells-Ompompanoosuc.[35] The last traditional basin plan issued in draft form was the North Lake Champlain Direct Drainages watershed management plan.[36]

Over the course of the ten years since the inception of the original Guidelines approach, six traditional basin plans were approved. While these plans culminated important public processes involving many stakeholders, many of these plans were deficient with respect to geographic precision and progress in executing the overall process was hampered by a number of challenges, as described by annual legislative reports required by 10 V.S.A. section 1253(d). Inherent to these challenges were certain key and well-intentioned components of the Guidelines, which ultimately exhibited top-heavy characteristics.

The Guidelines approach featured an emphasis on general water quality education as a precursor to obtaining stakeholder input and plan development.[37] This was critical at the time as the citizenry in general and watershed agents in particular were not nearly as educated about water quality issues as they are now. Further, in many watersheds, a contingent of stakeholders needed to be developed "from whole cloth." A significant challenge to the Guidelines process was that it took far more time than initially anticipated to carry out an inclusive, educational process involving

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30. *Id.* at 16.

31. VT. AGENCY OF NAT. RES., WHITE RIVER BASIN PLAN (2002), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_wrbplan.pdf [https://perma.cc/SKD4-A753].

32. VT. DEP'T OF ENVTL. CONSERVATION, POULTNEY-METTOWEE BASIN PLAN (2005), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_basin2.final-plan.3-07.pdf [https://perma.cc/C5EZ-83VT].

33. VT. AGENCY OF NAT. RES., BASIN 11 MANAGEMENT PLAIN: WEST RIVER, WILLIAMS RIVER, AND SAXTONS RIVER (2008), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_basin11%20Plan.6-08.pdf [https://perma.cc/FJ7W-TFDA].

34. VT. AGENCY OF NAT. RES., LAMOILLE RIVER BASIN WATER QUALITY MANAGEMENT PLAN (2009), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_basin7.finalplan.pdf [https://perma.cc/R34P-UGXQ].

35. VT. AGENCY OF NAT. RES., BASIN 14 "LITTLE RIVERS" WATER QUALITY MANAGEMENT PLAN (2008), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_basin14.final_plan.6-30-08.pdf [https://perma.cc/LKX8-8L4H].

36. VT. AGENCY OF NAT. RES., DRAFT WATERSHED MANAGEMENT PLAN FOR THE NORTHERN LAKE CHAMPLAIN DIRECT DRAINAGES (2009), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/pl_basin5.Finalplan.pdf [https://perma.cc/MEH2-U4JZ].

37. TACTICAL BAIN PLANNING, *supra* note 5.

the many stakeholders to develop a watershed management plan with which *all* of the public could identify. This grassroots effort in some river basins started from square one where no watershed organizations existed; though in fairness, there were mature organizations in other watersheds. In those instances where capacity was lacking, DEC Watershed Coordinators formed diverse and inclusive watershed councils and conducted numerous public forums and panel discussions in order to provide the council and other interested persons with the technical information necessary to formulate strategies and develop the information needed to draft a basin plan. Yet, the watershed councils of several basin-planning processes, which were comprised of well-intentioned and intelligent citizens, never truly became the agents of implementation. Accordingly, DEC's Watershed Coordinators were educating one stakeholder group who formulated the plan while working with another to implement the plan. This resulted in inefficiency and a lack of common goals. Further, due to the coarse geographic specificity of traditional basin plan strategies, the determination of what specific actions to undertake to fulfill a basin plan often occurred in subsequent, more sector-specific planning efforts, such as river corridor[38] or stormwater master planning, [39] better backroads capitol inventories,[40] or thru the use of more contemporary water quality monitoring data.

The reader should not take from this discussion a diminishment in value of the Guidelines era of basin planning in Vermont. The significant benefit of the Guidelines approach, and truly the brilliance behind its development, was to educate a generation of watershed stewards and advocates. In some cases, those stewards did ultimately form the basis for watershed implementation or advocacy organizations, which ultimately have grown in capabilities to be strong partners for identifying and executing pollution control projects. Examples of organizations that expanded capacity coincident with the implementation of watershed-specific guidelines planning efforts include, but are not limited to, the White River Partnership, the Memphremagog Watershed Association, the Southeast Vermont Watershed Association (which was deeply involved in initial efforts to conduct basin planning in Southeastern VT), the Lewis Creek Association,

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38. *River Corridor Protection*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/protection [https://perma.cc/UCG9-4HMQ] (last visited May 2, 2016).

39. VT. AGENCY OF NAT. RES., VERMONT STORMWATER MASTER PLANNING GUIDELINES (2013), http://dec.vermont.gov/sites/dec/files/wsm/erp/docs/SWMPFinal6-23-16.pdf [https://perma.cc/T6VA-NH8E].

40. *Better Roads*, VT. DEP'T OF TRANSP., http://vtransengineering.vermont.gov/bureaus/mab/better-back-roads [https://perma.cc/4MFF-2ZQX] (last visited Apr. 12, 2016).

and numerous natural resource conservation districts.[41] Nonetheless, the development of capacity for watershed implementation did not always track with the basin-specific planning processes carried forth under the Guidelines years. With increasing need to provide more complete technical information in the development of basin plans, and in order to expend well-documented and efficiently-spent remediation funds from the Clean Water Initiative Program,[42] ANR recognized the need to change the Guidelines process to become more information-rich and data driven.

The tactical planning process recognizes the importance of an educated citizenry and stakeholder base, but capitalizes on the education conferred by the Guidelines approach by reversing the order of the planning and education components of that approach. Plans are now developed by first focusing on how state or partner programs are targeted to priority areas as identified by water quality monitoring or sector-specific assessment information.[43] These results are then communicated to incrementally broader stakeholder groups prior to issuance of a draft tactical plan. This transition was envisioned and set into motion with the development of the SWMS in 2009 and 2010. As the SWMS approached completion, and as DEC's Watershed Management Division realigned its programs around the SWMS's guiding principles, the TBPP itself evolved. Reflecting staff and stakeholder input on how planning could better be accomplished, tactical planning was revised. Specifically, the process changed from one that provided generalized information and then solicited feedback on prospective problems to one that watershed stakeholders, the regulated community, and citizens could learn through a tactical basin plan and the development process exactly where water quality issues exist, why and how they were so-identified and prioritized, and how they would be addressed through watershed stressor management.[44]

The benefits of the evolved, geographically-explicit, and data-driven TBPP, include:

- more direct focus on surface water resources, tailored to basin-specific stressors and conditions that are germane to that basin and sub-basins;

41. TACTICAL BAIN PLANNING, *supra* note 5.

42. During the period of 2004 to 2010, the current DEC Clean Water Initiative Program was known as the ANR's Clean and Clear Program. Clean and Clear, developed by Governor James Douglas, was the precursor for the Ecosystem Restoration Program, which itself was renamed the Clean Water Initiative Program in 2015, in recognition of the goals and provisions of Act 64.

43. TACTICAL BAIN PLANNING, *supra* note 5.

44. *Id.*

- coordination among programs and agencies, thereby making technical assistance and available funding a more efficient and predictable process;
- improved capabilities to address complex environmental issues that cross agencies' jurisdictions;
- improved basis for management decisions as better coordination of monitoring is established and more information is gathered on a specific basin;
- encouragement of consistency and continuity as an initial framework prepared and applied to all basins and sub-basins in a systematic and sequential (rotational) fashion;
- opportunities for enhanced data sharing as agencies and organizations improve communication and coordination;
- encouragement of innovative solutions with input from the various stakeholders and partners;
- geographically explicit/targeted implementation actions identified and funded through a comprehensive and robust prioritization process; and
- tracking and accountability.

The two-year period, during which the TBPP was developed, saw the issuance of five additional "hybrid" basin plans, which were initially developed using the Guidelines approach. Owing to long-plan development processes reflective of the more intensive Guidelines approach, these plans were modified prior to publication to provide some additional geographic specificity reflective of modern tactical basin plans. These plans were the Ottauquechee/Black,[45] Memphremagog,[46] Winooski,[47] Otter Creek,[48] and Missisquoi.[49]

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45. VT. AGENCY OF NAT. RES., BASIN 10 WATER QUALITY MANAGEMENT PLAN: OTTAUQUECHEE & BLACK RIVER (2012), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_basin10final.pdf [https://perma.cc/MJ2B-CV9N].

46. VT. AGENCY OF NAT. RES., BASIN 17 WATER QUALITY MANAGEMENT PLAN (2012), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_basin17final.pdf [https://perma.cc/536W-MEK3].

47. VT. AGENCY OF NAT. RES., WINOOSKI RIVER BASIN WATER QUALITY MANAGEMENT PLAN (2012), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_basin8final.pdf [https://perma.cc/H6AM-W5K6].

48. VT. AGENCY OF NAT. RES., OTTER CREEK BASIN WATER QUALITY MANAGEMENT PLAN (2012), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_ottercreekplan.pdf [https://perma.cc/W9SP-MM9Z].

49. VT. AGENCY OF NAT. RES., MISSISQUOI BAY BASIN WATER QUALITY MANAGEMENT PLAN (2013), http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_Basin06Plan.pdf [https://perma.cc/59H6-XZNP].

III. MODERN TACTICAL BASIN PLANS FEATURE CONSISTENT PROCESS, SPECIFIC CONTENT, AND ARE RELIANT ON PARTNERSHIPS

In Vermont, there are fifteen planning basins, six of which occur in the Lake Champlain Basin (Figure 1). These are the Missisquoi, Lamoille, North Lake Champlain Direct Drainages, Winooski, Otter Creek, and South Lake Champlain Basins. These plans are renewed and re-authorized on a five-year rotating cycle as is described by the SWMS.[50]

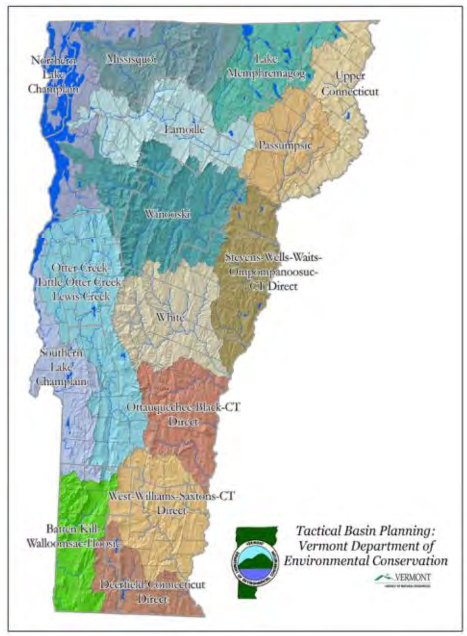

Figure 1. Tactical basin planning watersheds in Vermont.

The watershed-specific findings of tactical basin plans may vary by planning basin but the content is consistently expressed across the basins, such that the reader can access and obtain similar information for any basin of interest. For example, the highest-priority subwatersheds for phosphorus pollution and abatement are all shown in the same location of any given plan.[51] The outline is as follows.

An executive summary presents an overview of known stressors, issues, and proposed actions in the plan for its five-year lifespan.[52] The top ten actions are listed along with a summary of waterbody re-classification opportunities to achieve higher levels of water quality protection.[53]

In a given basin plan, the introduction presents a brief basin description, purpose of the plan, planning process, the partners involved in the process to develop the plan's recommendations, and the expected outcomes over the five-year implementation horizon.

The section titled "Chapter 2. Water Quality in the Basin" presents a textual and graphical characterization of the basin, which relies on water quality monitoring and sector-specific assessments to substantiate why the

50. TACTICAL BASIN PLANNING, *supra* note 5.
51. *Id.*
52. *Id.*
53. *Id.*

subsequent prioritized implementation actions are as stated.[54] Key items include: surface waters exhibiting very good or excellent biological, geomorphic, and chemical fisheries; impaired, stressed, and altered waters; waterbody-specific TMDLs; and the status of direct discharges—municipal or industrial wastewater. Also shown are priority watersheds for focused monitoring and assessment, priority subwatersheds for targeted implementation, and individual surface waters identified for protection through reclassification or designation. This section of the plan is derived by a thorough analysis of several types of assessments. These include water quality monitoring data, stream geomorphic, bridge, and culvert assessments, stormwater infrastructure mapping and illicit discharge identifications, stormwater master plans, road erosion risk assessments, and available municipal road network capitol inventories.

In "Chapter 3. Establishing Management and Protection Goals for Surface Waters," each tactical plan outlines opportunities for augmented protections for surface waters.[55] This plan chapter lists those waters identified through the planning process that present opportunities for outstanding resource water designations,[56] waterbody reclassifications,[57] or wetland reclassifications.[58]

The most important component of any tactical plan is the implementation table in chapter four of every tactical basin plan, which presents individual plan actions that reflect priority protection and restoration actions that have been identified from sector specific assessments and subjected to stakeholder review.[59] These are typically projects or geographically explicit strategies.

Each implementation table documents projects that have been identified, the stressor that will be addressed by implementing the project, involved partners, prospective funding sources, and a statement of prioritization. This is one area of the tactical plan that is currently seeing rapid evolution and improvement.

The process and timing by which tactical basin plans are developed is described in detail in chapter four of the SWMS. The public and stakeholder involvement in the TBPP comes in various stages and is structured to ensure that all relevant partners have had input to the plan before it is released for citizen review and comment prior to signature by

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54. WINOOSKI RIVER BASIN WATER QUALITY MANAGEMENT PLAN, *supra* note 47, at 5.
55. *Id.* at 13.
56. *Id.* at 55.
57. *Id.* at 8.
58. 12-004-056 VT. CODE R. § 4 (2016).
59. TACTICAL BASIN PLANNING, *supra* note 5.

the ANR Secretary. The TBPP has been structured such that the following steps are undertaken to develop a plan:

1) Internal Plan Development—all available data and assessments are reviewed internally under the direction of the Watershed Management Division's Watershed Coordinators. During this stage, all relevant DEC and ANR programs are consulted to determine the priorities of each program for water quality management. Also during this stage, Watershed Coordinators are interacting with staff of the agencies of Agriculture Food and Markets, Transportation, and Conservation and Community Development and federal partners such as the U.S. Department of Agriculture's Natural Resources Conservation Service ("NRCS") and the Forest Service ("USFS") to obtain additional State priorities. At this stage, RPCs begin the identification of municipal priorities and integrate the priorities identified in RPC-led hazard mitigation[60] or transportation[61] into the tactical plans that have opportunity to improve surface water conditions or specific regional plan priorities.[62]
2) Partner Organization Outreach—during this stage, the initial priorities derived above are brought forth to watershed-based organizations, which play an important role in planning and implementation as described in more detail below.[63] This is an incremental process whereby the Watershed Coordinator will expand the growing prioritized implementation table of the draft basin plan based on partner input. At the close of this process, it is expected that all stakeholders in the watershed will have contributed their knowledge and priorities to the developing draft tactical basin plan.
3) Prioritization—using a new prioritization approach that stages projects according to pre-set criteria describing project readiness and importance, the Watershed Coordinator will work with RPC planners to prioritize actions in the implementation table of the plan.[64] The RPC represents the many municipalities

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60. *Local Hazard Mitigation Plan*, VT. DEP'T OF PUB. SAFETY, http://demhs.vermont.gov/plans/local-hazard [https://perma.cc/9V3M-X4XW] (last visited Apr. 12, 2016).

61. *Regional Planning*, VT. AGENCY OF TRANSP., http://vtransplanning.vermont.gov/planning/regional [https://perma.cc/EQ3D-J87C] (last visited July 7, 2016).

62. VT. STAT. ANN. tit. 24, § 4341.

63. TACTICAL BASIN PLANNING, *supra* note 5.

64. *Id.*

that may be identified as responsible parties in the execution of priority projects in a tactical basin plan.

IV. PARTNERSHIPS ARE KEY TO DEVELOPING AND IMPLEMENTING TACTICAL BASIN PLANS

The efforts necessary to implement the TMDL span a wide range of land uses and phosphorus source sectors. A growing interaction with agencies in state and federal government is implicit in the development of tactical plans and the establishment of their priorities. Major state funding agencies, including agencies of Agriculture, Food and Markets ("VAAFM"), Transportation, Conservation and Community Development, and USFS and NRCS, are key partners whom are involved in developing, then adopting within their own work plans, tactical plan priorities. Examples from NRCS include recent (2016-2017) targeted planning and practice interventions for the Rock and Pike Rivers and St. Albans Bay watersheds and also the direct drainages to South Lake Champlain.[65] In addition, USFS has been involved in developing watershed protection and habitat restoration priorities in several southern Vermont tactical plan areas.[66] The Agency of Transportation is a regular partner in the planning process, directing stormwater quality remediation efforts at the localized level for all of their projects.

This focus among agencies is critical. Yet without additional, more localized partnerships with watershed organizations, advocates and concerned citizens progress toward attainment of the Lake Champlain TMDL, or cleanup of other waters, cannot be assured. The combination of capacity development supported by the guidelines and funding support during the "goldrush" years of river assessments produced a wide cadre of qualified local scientists and planners with significant capacity for watershed improvement. The TBPP works with many stakeholders to ensure that relevant parties understand and agree with the priorities of each tactical basin plan. Several key partnerships are described, though the list presented is decidedly incomplete.

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65. News Release, U.S. Dep't of Agric., USDA to Invest $45 Million to Improve Water Quality in Lake Champlain (Aug. 28, 2014), http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/releases/?cid=STELPRDB1260116 [https://perma.cc/X96B-B3NM].

66. TACTICAL BASIN PLANNING, *supra* note 5.

A. Regional Planning Commissions

Act 64 has set forth a new relationship between DEC and the RPCs to fulfill the specific roles and responsibilities toward development of tactical basin plans. Through this cooperative process, the Vermont Association of Planning and Development Agencies ("VAPDA") and DEC have agreed to a series of activities that each RPC shall undertake in support of tactical planning for all watersheds in the state, which is codified by Act 64.[67] This new organizational alignment recognizes that significant municipal outreach is now needed to expand understanding of Act 64 authorities, develop tactical basin plans, and ultimately to track the implementation of the projects and best management practice ("BMP") installations highlighted in tactical plans that are carried out by municipalities or other partners. The roles and responsibilities articulated in Act 64 for RPCs specifically recognize the strengths of the RPCs in supporting municipal activities aimed at water quality protection and restoration. As of this writing, all Vermont RPCs are actively engaged in the process of Act 64 outreach and tactical basin plan development in one manner or another.

B. The Vermont Association of Conservation Districts

The Vermont Association of Conservation Districts ("VACD") is both a local and state-wide partner in efforts to improve the water quality of Vermont's lakes, rivers, and streams, and supports the goals of protecting, maintaining, enhancing, and restoring the biological, chemical, and physical integrity of the state's surface waters.[68] Act 64 also identifies the Natural Resources Conservation Council (the governing body of conservation districts) as statutory partners to the TBPP and VACD facilitates this work in a number of ways. At the local level, Vermont's fourteen natural resource conservation districts host and sponsor many educational and informational events while promoting watershed-wide awareness and action to address water quality issues.[69] At the state level, VACD technical programs—including staff and district consultations—work with both state and federal partners to initiate, develop, and implement a variety of targeted on-farm conservation projects within priority watersheds. Natural resource conservation districts are principal partners in the implementation of tactical basin plans.

67. VT. STAT. ANN. tit. 10, § 1253(d)(1).

68. *Who We Are*, VT. ASS'N OF CONSERVATION DISTRICTS, http://www.vacd.org/who-we-are [https://perma.cc/4TVU-4J2V] (last visited July 7, 2016).

69. TACTICAL BASIN PLANNING, supra note 5.

VACD has recently entered into a coordinated effort with DEC, NRCS, and VAAFM to develop a common framework for identifying and assessing agricultural water quality resource concerns specific to statewide initiatives and to implement the priorities of each tactical basin plan. This is exemplified by the recently awarded Regional Conservation Partnership Programs ("RCPP") for the Lake Champlain and Connecticut River watersheds, which have recently brought millions of federal funds to address agricultural and forest-sector pollution sources in Vermont.[70] VACD has provided necessary outreach at the local level to inform and educate landowners about the funding opportunities provided by the RCPP to address the most critical areas of concern.[71] In this regard, prioritized practice implementation, coupled with innovative environmental stewardship programs, will implement proven BMPs and creative methods to enhance the long-term sustainability of farms and further contribute to nutrient reduction and co-benefits such as flood and climate resilience. This work is focused on high priority critical source areas in each tactical basin plan and priority sub-basins.

VACD, through each conservation district, has also evolved to include planning and project implementation efforts to address stormwater management, river corridor assessment and planning, and water quality monitoring. Annually, VACD implements a statewide "Trees for Streams" program which implements dozens of acres of riparian buffer plantings, which reflects the priority river corridor restoration opportunities identified in tactical basin plan as well as the goals of the RCPP.[72]

C. Watershed Organizations

Several watershed organizations in Vermont have evolved from initially focusing on single-issue or topic-specific initiatives to multi-dimensional, holistic organizations. Since these groups are too numerous to list here, the examples provided simply reflect the diversity and strength of these organizations as partners in the tactical planning process. One such

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70. *Regional Conservation Partnership Program*, U.S. DEP'T OF AGRIC., http://www.nrcs.usda.gov/wps/portal/nrcs/main/vt/programs/farmbill/rcpp/ [https://perma.cc/MR6E-3PRS] (last visited Apr. 12, 2016); *Three Connecticut Projects Selected for RCPP Funding*, U.S. DEP'T OF AGRIC., http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/programs/farmbill/rcpp/?cid=nrcseprd376207 [https://perma.cc/293M-49XG] (last visited Apr. 12, 2016).

71. WINOOSKI RIVER BASIN WATER QUALITY MANAGEMENT PLAN, *supra* note 47, at 10.

72. VT. DEP'T OF ENVTL. CONSERVATION, PROJECT 10: TREES FOR STREAMS-RIPARIAN BUFFER PLANTINGS, STATEWIDE, ANNUAL REPORT ON THE VERMONT CLEAN WATER INITIATIVE PROGRAM 36 (2016), http://legislature.vermont.gov/assets/Legislative-Reports/2016-Clean-Water-Initiative-Program-Annual-Report.pdf [https://perma.cc/P5BC-H2ZS].

example is the Lewis Creek Association ("LCA").[73] Originally formed as the Lewis Creek Conservation Committee, LCA formed around the concept of defining and establishing a "greenway" along the Lewis Creek main stem and eventually its tributaries.[74] Following on one successful riparian land conservation project, principal members of the Hinesburg Land Trust envisioned a broader mission for conservation throughout the watershed, which eventually led to the establishment of LCA and its multi-dimensional mission.[75] LCA also took on a data-driven, science-based approach to watershed activism and was instrumental in the piloting of the first iteration of the DEC River Management Program's Stream Geomorphic Assessment protocols. Similar organizations now are active in many areas of Vermont, conducting assessments or follow-up implementation projects, and their assessment results comprise critical elements of tactical basin plans.[76]

Many watershed associations in the state have evolved from primarily water quality generalists to astute citizen scientists and have contributed greatly to the state's long-term database of water quality monitoring and assessment data in this effort. Such is the case with the Addison County River Watch Collaborative ("ACRWC"), formed in late 1997 to unite ongoing stream-monitoring efforts by citizens in the Addison County region.[77] Prior to the efforts of these volunteer water quality monitoring organizations, there was a lack of long-term water quality monitoring baseline data regarding the health of surface waters in Vermont. ACRWC is one of a number of citizen-based water monitoring groups in Vermont who now support part time staff and undertake robust water quality monitoring activities as an integral component of their outreach and education efforts.[78] In partnering with the Addison County Regional Planning Commission, ACRWC established effective online and one-on-one means of sharing this data with towns in Addison County.[79] Through the TBPP, this model has been shared among other watershed groups in Vermont and adopted in most of the Lake Champlain watersheds.

As watershed organizations continue to mature, they encounter an increasing challenge to convey information that is compelling, coherent,

73. *History*, LEWIS CREEK ASSOC., http://www.lewiscreek.org/history [https://perma.cc/P6WD-UTED] (last visited Apr. 12, 2016).

74. *Id.*

75. *Id.*

76. *Id.*

77. *Addison County River Watch Collaborative*, ADDISON CTY. REG'L PLANNING COMM'N, http://acrpc.org/programs-services/natural-resources/acrwc/ [https://perma.cc/ANR3-CD9Z] (last visited Apr. 12, 2016).

78. *Background*, ADDISON CTY. REG'L PLANNING COMM'N, http://acrpc.org/background/ [https://perma.cc/585Z-UD92] (last visited Apr. 12, 2016).

79. *Id.*

and interpretable. As groups seek to provide updated monitoring results to the communities they serve, it remains an ongoing challenge to "tell the water quality story" that engages and motivates the public to take ownership and responsibility for local and municipal actions. By coordinating their efforts through the TBPP, these groups have contributed to a long-term database of information that continues to inform Vermont's assessment, listing, and reporting requirements.[80] This has proven to be an invaluable contribution to tactical plans and to the implementation of municipal actions outlined by those plans.

Many watershed organizations (one example being the Friends of the Winooski River) also interact with towns for planning and zoning assistance regarding water resource issues.[81] Translating data into communicable actions requires an understanding of policies and regulations that can affect change and influence behavior. Taking this information and using it to influence local and state policy requires an inherent understanding of state and local government in Vermont, the gaps, and where municipalities have the ability to become more proactive.

D. Watersheds United Vermont: The Synergy of Coordination

Watersheds United Vermont ("WUV") is a statewide network of local groups dedicated to the health of their home watersheds.[82] WUV was formed within the last three years, resulting from the dedicated work of several key water quality professionals from statewide and watershed-specific associations, the consulting sector, and the state. WUV grew in response to the obvious need for a more organized framework to enhance communication and general coordination. The mission of WUV is to empower community-based watershed groups in all parts of the state to protect and restore Vermont's waters.[83] Members include informal neighbor groups who join together for water quality monitoring, more mature associations that conduct river cleanups and public education, and professionally staffed organizations that carry out major restoration projects.[84] Member groups collaborate effectively and efficiently with diverse partners to improve the state's water quality and the resilience of

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80. *Vermont Integrated Watershed Information System*, VT. DEP'T OF ENVTL. CONSERVATION, https://anrweb.vt.gov/DEC/IWIS/ [https://perma.cc/R97B-PUKM] (last visited Apr. 12, 2016).

81. WINOOSKI RIVER BASIN WATER QUALITY MANAGEMENT PLAN, *supra* note 47, at 18.

82. WATERSHEDS UNITED VT., http://www.watershedsunitedvt.org/ [https://perma.cc/E93Y-WV3T] (last visited Apr. 12, 2016).

83. *Id.*

84. *Id.*

Vermont's rivers and streams. The organization of this umbrella group recognizes a long-standing need to provide information sharing and enhanced coordination. This organization serves an important role as conduit for communicating updates on tactical basin planning, emerging priorities, and funding opportunities and as a feedback mechanism for tactical basin planning, water quality policies, and program efficiencies. WUV maintains a comprehensive list of watershed associations that are active in Vermont,[85] most of which participate in the TBPP.

E. Peer-to-Peer Networks for Agricultural Water Quality Coordination

In response to the growing attention and awareness around the Lake Champlain TMDL, other TMDLs, Act 64, and tactical basin planning priorities, a number of peer-to-peer networks have evolved to address their increasing roles and responsibilities to ensure that agricultural activities are conducted in a sustainable fashion to meet water quality goals and objectives. Groups like the Franklin County-based Farmers Watershed Alliance[86] and the Champlain Valley Farmers Coalition[87] are committed to providing a network of support for members to meet the requirements of the TMDLs and Act 64 while remaining viable farming operations. These groups foster enhanced coordination with state agencies and other watershed partner organizations, such as Friends of North Lake Champlain, to provide for technical assistance and funding opportunities to bring farming operations in compliance with agricultural and water quality standards. Through the TBPP, DEC Watershed Coordinators work with these networks to maintain awareness of agricultural water quality outreach and remediation efforts and assist in directing remediation actions to the highest priority subwatersheds.

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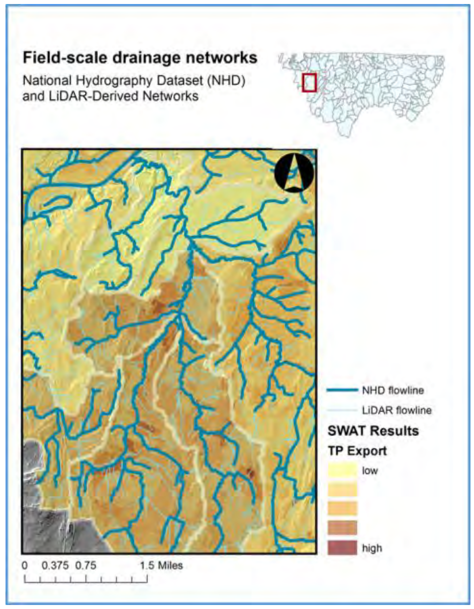
85. *Id*.

86. *Request for Proposal*, FARMER'S WATERSHED ALL. (2015), http://farmerswatershedalliance.com/ [https://perma.cc/HS6K-JRQU].

87. CHAMPLAIN VALLEY FARMERS COAL., http://www.champlainvalleyfarmercoalition.com/ [https://perma.cc/G42R-3TZA] (last visited Apr. 12, 2016).

V. TACTICAL BASIN PLANS ESTABLISH REGULATORY PRIORITIES FOR ACHIEVEMENT OF TMDLS

Achievement of the Lake Champlain TMDL will not rely solely on execution of individual projects as identified by tactical plan implementation tables. Achieving the TMDL will require that BMPs be installed in locations not currently identified by available assessments.[88] The Lake Champlain TMDL accountability framework envisions that the programs and management approaches spelled out by Act 64 and the BMPs envisioned by the Lake Champlain Scenario Tool[89] need to be deployed onto the landscape in such a manner as to incrementally pursue achievement of the respective TMDL load and land-based wasteload allocations at the watershed scale. These explicit, Phase-II watershed-specific plans comprise the blueprints by which the TMDL is to be accomplished. The Lake Champlain TMDL and the Lake Champlain Phase I Plan[90] identify tactical basin planning as the vehicle by which Phase II rosters of BMPs, identified projects, and regulatory measures will be identified. Further, Act 64 specifically tasks certain new



One use of the of the Missisquoi Basin "SWAT" model shows the intersection of high levels of nutrient export, superimposed upon extremely high-resolution water conveyance features derived from LiDAR data. Note the precision with which high-nutrient runoff potential areas can be integrated with conveyances that may connect to watercourses.

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88. VT. DEP'T OF ENVTL. CONSERVATION, LAKE CHAMPLAIN TMDL PHASE I IMPLEMENTATION PLAN 23 (2015), https://www.epa.gov/sites/production/files/2015-09/documents/vt-lake-champlain-tmdl-phase1-ip.pdf [https://perma.cc/K2YY-TZB6].

89. TETRATECH, INC., & U.S. ENVTL. PROT. AGENCY, LAKE CHAMPLAIN TMDL SCENARIO TOOL: REQUIREMENTS AND DESIGN (2015), https://www.epa.gov/sites/production/files/2015-09/documents/lake-champlain-bmp-scenario-tool-report.pdf [https://perma.cc/E6XN-R2FV]; *National Water Quality Inventory Report to Congress*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/waterdata/national-water-quality-inventory-report-congress [https://perma.cc/67SP-EEQD] (last updated Sept. 30, 2015).

90. LAKE CHAMPLAIN TMDL PHASE I IMPLEMENTATION PLAN, *supra* note 88.

permit programs to articulate, in state law, how tactical planning will be used to inform promulgation of permit coverage.[91] Tactical plans themselves are not regulatory instruments; however, their development and public approval process is intended to notify all interested parties as to the breadth of activities necessary to achieve the Lake Champlain TMDL, improve water quality generally, and spotlight the regulatory programs and project activities that are staged for promulgation over the subsequent five-year plan lifecycle to pursue the longer-term goal of full implementation.[92]

This work requires a significant investment of water quality modeling capacity into the TBPP. As described in the Lake Champlain Phase I TMDL Implementation Plan, tactical basin plans, beginning with those issued in 2016, will feature several technological improvements to support this work.

High-resolution topographic data will be used to model how water moves over the landscape. This information will be combined with predicted nutrient loadings from the Lake Champlain Soil Water Assessment Tool ("SWAT") model,[93] other models, and other watershed characteristics—slope, soil type, etc.—to prioritize BMP selection and placement. This will allow the Watershed Management Division to apply and refine the broad recommendations from the Lake Champlain TMDL Scenario Tool into geographically explicit prescriptions in order to meet the load allocations of the TMDL.[94] The nutrient loading reductions at the project-level can then be predicted to account and track progress toward achievement of the allocations as practices are put into place.[95] These modeling approaches will improve tactical basin plans and assist the promulgation of the new permit programs or performance standards put in place by Act 64. TBPP modeling efforts assist certain permit programs and standards: the Municipal Roads General Permit, the "Three-acre" Developed Lands Permit, the Transportation General Permit, the Required

91. VT. STAT. ANN. tit. 10, § 1264(e) (as amended by Act 64 § 31).

92. *Id.* § 1264(b)(18).

93. TETRATECH, INC., & U.S. ENVTL. PROT. AGENCY, LAKE CHAMPLAIN BASIN SWAT MODEL CONFIGURATION, CALIBRATION AND VALIDATION (2015), https://www.epa.gov/sites/production/files/2015-09/documents/swat-model-configuration-calibration-validation.pdf [https://perma.cc/269R-N3V4].

94. VT. DEP'T OF ENVTL. CONSERVATION, PROGRESS REPORT ON RIVER BASIN WATER QUALITY MANAGEMENT PLANNING DURING 2015 7 (2016), http://legislature.vermont.gov/assets/Legislative-Reports/2016-Basin-Planning-Legislative-Report-1-15-16Final.pdf [https://perma.cc/VW8C-RGXZ].

95. *Id.*

Agricultural Practices, and the Accepted Management Practices for Forestry.[96]

VI. EVOLUTION OF PROJECT IDENTIFICATION, STAGING, FUNDING, AND PUBLIC DISPLAY OF TACTICAL BASIN PLANS

A recent evolution of the TBPP relied upon lean[97] business process evaluation tools promoted by the State of Vermont to examine and improve approaches by which remediation projects are identified, prioritized, and funded. The most important outcome to this evaluation was development of integrated criteria allowing prospective projects to be prioritized for implementation within tactical basin plans then funded using available federal and state funds. The development of these "Stage Gate"[98] criteria to be applied to tactical basin plan implementation tables is premised on the idea that any given project is completed through a series of discrete phases: inception, scoping and feasibility, design, and construction. For any given project phase or stage, there have been developed predictable criteria, or "gates," that should be satisfied to move a project forward to the next stage. This approach ensures that incrementally higher-cost investments necessary to move a project through the stages are made on the most important projects first and that projects which do not merit additional investment are identified at the earliest possible point in time.

This type of business practice will engender public confidence in the management of water quality remediation funding, but only when the process is transparently executed and easily monitored. As such, the Watershed Management Division is developing a comprehensive database tracking system that supports the management of tactical basin plan implementation tables and Lake Champlain TMDL Phase II actions. This system is being developed to allow public access to view the breadth of projects to be undertaken, their stage, criteria-based prioritization, and status. The development and deployment of this database should be considered a foundational shift in the capabilities of the TBPP. The database will track the lifespan of projects from proposal to design,

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96. *Municipal Roads Program*, VT. DEP'T ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/stormwater/permit-information-applications-fees/municipal-roads-program#Development of Permit [https://perma.cc/6YVB-VMFH] (last visited July 10, 2016).

97. VT. DEP'T OF ENVTL. CONSERVATION, STRATEGIC PLAN 2013-2015 5 http://dec.vermont.gov/sites/dec/files/co/documents/DECStrategicPlan2013-2015.pdf [https://perma.cc/S4RG-H8L7] (last visited July 7, 2016).

98. STAGE GATE INT'L, http://www.stage-gate.com/resources_stage-gate.php [https://perma.cc/U5NN-AB5J] (last visited Apr. 12, 2016) (providing one consulting firm's description of an industry-standard process for managing innovation costs).

implementation to operation and management, and eventually termination. The database will also help facilitate reporting to the legislature, EPA, and the public. The first application of stage-gate criteria is being implemented within the new database for the 2016 Missisquoi and Lamoille tactical plans and the 2017 South Lake Champlain and Ottauquechee tactical plans. The same database will be used to track and account for the full suite of clean water projects statewide to meet the reporting requirements of Act 64 and support the accountability needs of the Lake Champlain TMDL.

With this level of modernization, the TBPP is poised to further evolve into a "within-basin Continuing Planning Process," involving stakeholders and organizations who can carry out the process by ensuring and tracking high-priority implementation actions. Each tactical plan will establish a schedule that ensures a rotational cycle of monitoring, assessing, planning, and implementing recommendations contained in that plan. Each newly developed assessment that is called for in an implementation table will yield a suite of prospective projects to be added into the tracking system during the lifecycle of the tactical plan. Thus, each tactical planning process will yield a continually-evolving implementation table that shows steady progress toward attaining priority actions. With this type of technology underlying each tactical basin plan, the five-year updates become a simple process of taking stock of progress, elevating unfulfilled projects to higher priority, introducing new strategies or projects, and identifying new reclassification or designation opportunities. The modern tactical planning process will provide Vermont citizens a transparent and readily accessed one-stop resource to understand the breadth and status of pollution control activities being undertaken in Vermont as a result of the newly enacted Vermont Clean Water Act.

GIVING OUR RIVERS ROOM TO MOVE: A NEW STRATEGY AND CONTRIBUTION TO PROTECTING VERMONT'S COMMUNITIES AND ENSURING CLEAN WATER

***By Mike Kline*[1]**

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I. STREAMBANK AND CHANNEL EROSION—DEFINING THE PROBLEM

A. The Loss of Watershed Storage

Lake Champlain and the Green Mountains share an intertwined geologic history that continues today and is highly relevant to discussions about how to protect the quality of Lake Champlain. The Green Mountains have been scraped, carved, and eroded by wind, water, and glacier.[2] Large glacial lakes have come and gone, lands have rebounded from the massive weight of the glaciers, and rivers have cut down, reforming the steep and narrow valleys they once occupied.[3] These fluvial geomorphic[4] processes continue today.[5] The Vermont bedrock, surficial geology, and soil maps explain the complex origins of alluvial (i.e., river-borne) materials that deliver phosphorus as they are eroded down-valley to Lake Champlain.[6] Efforts to restore the lake by reducing sediment and nutrient pollution loads must take these processes into account.

Because natural rivers are dynamic flowages of water, sediment, and wood debris, they are constantly eroding and depositing.[7] Watershed total

2. MIKE WINSLOW, LAKE CHAMPLAIN COMM., GLACIERS & THE CHAMPLAIN WATERSHED 15 (2016), http://www.lcmm.org/navigating/QuadCurriculum_Glaciers.pdf [https://perma.cc/R9TD-D3Y7].

3. Mike Winslow, *A Natural and Human History of Lake Champlain*, *supra* pp. 489–91.

4. Fluvial geomorphology is the science explaining how the forces and processes of flowing water, sediment, and woody debris create the different surface features and landforms of a watershed—from the small stream to the large river setting over long periods of time. Rivers are understood in their natural setting and how they respond to human-induced changes in a watershed. VT. AGENCY OF NAT. RES., STREAM GEOMORPHIC ASSESSMENT 2 (2016), http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/geomorphic-assessment [https://perma.cc/XJM2-QYA7].

5. Mike Kline & Barry Cahoon, *Protecting River Corridors in Vermont*, 46 J. AM. WATER RESOURCES ASS'N 230 (2010).

6. MIKE KLINE, VERMONT AGENCY OF NAT. RESOURCES: RIVER CORRIDOR PLANNING GUIDE 2 (2010), http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_rivercorridorguide.pdf [https://perma.cc/PR58-D7MF].

7. MARK P. SMITH ET AL., THE ACTIVE RIVER AREA: A CONSERVATION FRAMEWORK FOR PROTECTING RIVERS AND STREAMS 1 (2008),

maximum daily load ("TMDL") models addressing the ill-effects of human-caused eutrophication will factor a natural background level of watershed erosion that will always be delivering nutrients to the receiving waterbody during precipitation events.[8] None of Vermont's larger basins are in a condition, however, to obtain an empirical signal of the watershed "base-load" of eroded sediments at the mouths of the rivers because human hands have increased erosion in unstable rivers from the smallest headwater streams to the largest river reaches in Vermont.[9]

What is measured instead is the loss of natural watershed storage, or the loss of those landscape features where water, sediment, and woody material would be captured and held during storm events. Storage occurs when the depth and velocity of floodwater is reduced and its suspended sediments are precipitated and held to the land surface by physical, chemical, or biological means.[10] Beaver ponds, wetlands, floodplains, and naturally-vegetated riparian lands are natural features and their existence and contribution to watershed storage has been significantly depleted in Vermont over the past 200 year.[11] It should be noted, however, that these features do not permanently store the nutrient they capture, i.e., natural base-level erosion would still occur, but at a lower rate than that which is measured today. As will be discussed below in more detail, we have learned that by investing in the protection of these natural features, we restore river systems closer to a state of equilibrium, which results in significant water quality benefits.

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http://www.floods.org/PDF/ASFPM_TNC_Active_River_%20Area.pdf [https://perma.cc/S7BW-DQ7S].

8. KATHRYN MORSE & DIANE MUNROE, PHOSPHORUS LOADING IN LAKE CHAMPLAIN i (2011), http://www.middlebury.edu/media/view/276855/original/final_compiled_small.pdf [https://perma.cc/Y5KJ-Y4U7].

9. *Vermont Stream Geomorphic Assessment Data and River Corridor Plans: Vermont Rivers Program Data Management System (DMS)*, VT. AGENCY OF NAT. RES., https://anrweb.vt.gov/DEC/SGA/Default.aspx [https://perma.cc/N4B4-NSCE].

10. *What Is a Watershed?*, U.S. GEOLOGICAL SURVEY, http://water.usgs.gov/edu/watershed.html [https://perma.cc/2CNQ-5ME6] (last visited Apr. 16, 2016).

11. *Vermont Stream Geomorphic Assessment Data and River Corridor Plans*, *supra* note 9.

B. Human-Related Drivers Increasing Sediment Transport

Streambank and channel erosion are increased when the power of the flowing water exceeds the resistance of the channel bed or bank materials to being moved.[12] Stream power is essentially a function of the depth and slope of the flowing water (Figure 1). Erosion is negligible during dry periods when water levels are shallow and lower in gradient due to the meandering pattern of the stream.[13] Movement of bed and bank materials will increase during a flood (e.g., spring runoff) when water depths are greater and flows have a higher gradient due to the straighter, down-valley path of the flood.[14]

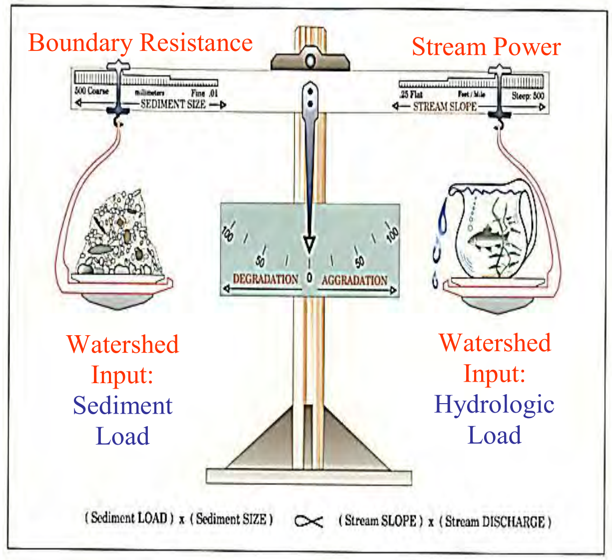

Figure 1: Balance explaining the factors of stream equilibrium (Lane, 1955). Graphic reprinted by permission from Wildland Hydrology, Inc.

Rivers erode and move in the landscape, but have the ability over time to transport the flow, sediment, and debris of their watersheds in such a manner that they generally maintain their dimension (width and depth), pattern (meander length), and profile (slope) without aggrading (building up) or degrading (scouring down).[15] A stream that is moving laterally on the valley floor, while maintaining its basic geometry and vertical position, is

12. KLINE, *supra* note 6, at 2–3.

13. *See* Brian Wu, *Great Lakes' Water Levels Cause Erosion Concern*, SCI. TIMES (Dec. 31, 2014, 3:29 PM), http://www.sciencetimes.com/articles/2259/20141231/lake-huron-water-levels-cause-erosion-concern.htm [https://perma.cc/7FLE-EJTA] (highlighting scientists' concern that high water levels lead to erosion).

14. Christine Kemker, *Sediment Transport and Deposition*, FONDRIEST ENVTL., INC., FUNDAMENTALS OF ENVT. MEASUREMENTS (Dec. 2014), http://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/ [https://perma.cc/X4RS-GCUN].

15. *See* SMITH, *supra* note 7, at 6 (explaining a river's ability to maintain equilibrium through constant reformation).

said to be in dynamic equilibrium.[16] Many rivers and streams in Vermont are not in an equilibrium condition due to human-imposed changes in (a) the condition of their bed and banks; (b) the channel slope and meander pattern; and/or (c) the quantity of flow and sediment inputs.[17] Vermont watersheds are in vertical adjustment (i.e., they are either eroding downward through sediment, or building up as a result of sediments deposited from upstream erosion) from the following sequence of events:

- Deforestation—the widespread clearing of forests that occurred in nearly every part of Vermont over the past 200 years "led to dramatic increases in the volume of water and sediment runoff."[18] Channels and floodplains were often buried in over three feet of sediment, "much of it glacial lake sediments that had yet eroded from higher on the valley perimeter. The channels rose up, then eroded back down through these materials, but terraces [i.e., high floodplain features] inaccessible to the rivers remain as a legacy of historic statewide deforestation;"[19]
- Snagging and ditching – "clearing boulders, beavers, and woody debris for logging (sluicing logs from uplands to village mill sites) and flood control, and ditching poorly-drained land for agricultural improvements increased the rate of water and sediment runoff. Many pristine-looking mountain streams in Vermont contain only a fraction of their former channel roughness and resistance, and store far less sediment and debris" than they did before European settlement;[20]
- "Villages, farms, roads, and railroads – early settlements led to the first attempts to channelize rivers and streams, resulting in increased channel slope, stream bed degradation (incision), and floodplain encroachments. Drainage Societies were started over 100 years ago to straighten and channelize streams to accommodate farms and early settlements. These channel works have been periodically maintained through gravel removal, realignment, channel armoring, and extensive flood

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16. GEORGE ZAIMES & ROBERT EMANUEL, STREAM PROCESSES PART I: BASICS 6 (2006), http://www.extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1378g.pdf [https://perma.cc/GB8X-3PFD].

17. MIKE KLINE, ALTERNATIVES FOR RIVER CORRIDOR MANAGEMENT (2006), http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_managementAlternatives.pdf [https://perma.cc/5FJR-ZTAU].

18. *Id.* at 2.

19. *Id.*

20. *Id.*

remediation projects" and have left a legacy of unstable river systems with increased erosion;[21]

- "Mills, dams, and diversions – led to alterations in the amount and rate of water and sediment runoff. While dozens of dams are in place in each Vermont watershed today, historically there were hundreds. The small mill ponds of yesteryear have been replaced by larger dams used for hydroelectric generation and the creation of impoundments for flood control."[22] Any effort to restore river systems to equilibrium and to address water quality must take these alterations into account;
- "Gravel removal – advocated as a way to maintain straighter, deeper channels and control flooding; large-scale gravel mining resulted in bed degradation, head cutting, channel over-widening, and severe bank erosion. The interstate highways, state roads, and thousands of miles of dirt roads in Vermont were built on materials commercially extracted from the State's rivers;"[23]
- Encroachments, stormwater, and urbanization—have "resulted in increased impervious surfaces and ditching to support economic development. Land use conversions have increased the rate and volume of water relative to sediment runoff, thereby contributing to channel incision and enlargement." Development and use of "lands previously occupied by river meanders or inundated during floods has created unrealistic and unsustainable human expectations in the absence of continuous or periodic channel management activities."[24]

The combination of these watershed, floodplain, and channel modifications led to increases in stream power and more highly erodible channel boundaries, which is why today Vermont streams are moderately to severely incised.[25] Straightened, steepened channels are now

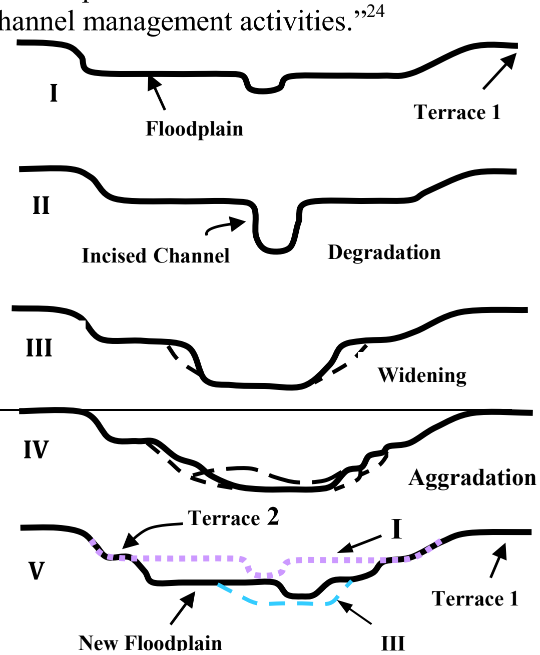

Figure 2: Five stages of channel evolution after Schumm (1984) and Simon and Hupp (1986).

21. *Id.*
22. *Id.*
23. *Id.*
24. *Id.* at 2–3.
25. *Id.* at 3.

adjusting or "evolving" back into more sinuous, gentle gradient channels through a widening and aggradation process (Figure 2).[26] If we are successful in giving our rivers room to recover equilibrium through a mix of the public policy approaches described below and captured in the Lake Champlain TMDL implementation plan, we will see a significant improvement in water quality, first in the streams and rivers themselves, then ultimately in Lake Champlain.

C. Fluvial Geomorphic Assessment Explains Erosion

Stream geomorphic assessments are conducted in Vermont to confirm a stream's departure from equilibrium, its historic and ongoing channel adjustments, and its sensitivity to change. The departure analysis examines those human-caused stressors that create disequilibrium. Meander belts (i.e., those lands defined by the lateral extent of meanders) are the basis for river corridors, which are delineated to examine whether stressors have changed the channel planform and slope expected within different valley settings.[27] Vermont documented the modifications that changed channel slope, depth, and bed and bank conditions and therefore the equilibrium equation (Figure 1). Geomorphologists constructed watershed maps to compare changes in the sediment transport between reference (i.e., background) and existing conditions. From these data and maps, the Vermont river scientist understands the origin of river instability, the stage of channel evolution within the stream network, and the channel and floodplain management practices that would be required in managing streams through the evolution process toward an equilibrium condition. In summary, streambank and channel erosion is contributing to the impairment of Lake Champlain water quality because (a) human-generated stormwater is increasing flood peaks, making streams more powerful; (b) channelization practices (e.g., dredging, berming, straightening, and armoring) have increased channel depth and slope, making streams more powerful; (c) removal of riparian vegetation and instream woody debris have reduced channel resistance, making streams more powerful; and (d) powerful, transport-dominated streams have deepened significantly and have far less access to floodplains and riparian wetlands where sediment and nutrient storage may occur.

Unstable streams and the loss of natural watershed storage is the legacy of deforestation, land drainage, and floodplain encroachment.[28] This body

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26. *Id.*
27. Kline & Cahoon, *supra* note 5, at 5.
28. *Id.*

of work was used to develop the Environmental Protection Agency's ("EPA") Lake Champlain TMDL and the strategies within Vermont's Implementation Plan.

Understanding this problem provides an important roadmap to developing long-term, effective solutions that will benefit Vermont communities through reduced flood damage, improved fish and wildlife habitat, and better water quality.

II. SOLUTIONS

A. Institutional Changes—Creating a Rivers Program

1. Unique State Program with New and Evolving Span of Control

During the time period for which TMDLs have been in place for Lake Champlain, Vermont has created a Rivers Program and increased its span of control.[29] It is rare, if not unique, in the U.S. for a state to have a program charged with the regulation of activities affecting the physical integrity of both rivers and floodplains to achieve water quality, ecological integrity, and public safety goals.

Many state environmental programs began in response to federal law and funding. Like other states, Vermont started separate river-related programs to address specific issues identified by Congress in the Fish and Wildlife Coordination Act of 1934,[30] the National Flood Insurance Act of 1968,[31] and the Water Pollution Control Act of 1972.[32] Vermont was not alone in failing to appreciate the connection or synergy between the practices needed to address seemingly disparate social, environmental, and economic problems. By the 1990s, Vermont could count more than a dozen programs spread over numerous state agencies affecting the quality and quantity of stream and floodplain resources.[33]

While Vermont still works to address program segregation, the innovations forwarded in the Department of Environmental Conservation ("DEC") TMDL Implementation Plan for increasing stream equilibrium and natural floodplain function can be largely attributed to the building of

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29. *Rivers Program*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/rivers [https://perma.cc/E22C-DV94] (last visited May 3, 2016).

30. Fish and Wildlife Coordination Act of 1934, 16 U.S.C. §§ 661–667(e) (1934).

31. National Flood Insurance Act of 1968, 42 U.S.C. §§ 4001–4131 (2014).

32. Federal Water Pollution Control Act of 1972, 33 U.S.C. §§ 1251–1388 (2008).

33. *Department and Program Descriptions*, VT. AGENCY OF NAT. RES., http://anr.vermont.gov/about_us/central-office/departments-programs [https://perma.cc/V8EB-NWHU] (last visited Apr. 2, 2016).

its current-day Rivers Program.[34] The integration began in 1965 when the Vermont General Assembly promulgated a statute for the regulation of stream flow,[35] which applied to the construction and operation of dams and diversion and called for state governance of activities that would change, alter, or modify the course, current, or cross section of any watercourse. The passage of this statute was unique at the time in establishing standards to achieve social, environmental, and economic-based outcomes (e.g., public safety, property protection, and fish and wildlife protection).

In the early years, the state stream alteration engineer was focused primarily on projects to ensure public safety and infrastructure investments.[36] However, the extensive gravel mining and channelization of rivers, which were sought as a source of materials for state and federal highway construction and perceived as a method for flood control, was met with vocal protest from Vermont anglers and led to the passage of the 1988 Rivers Bill, limiting river gravel extraction.[37] The bill also linked stream alterations to the detriment of Outstanding Resource Waters ("ORW").[38] It created the ORW designation specific to the non-degradation provisions of federal and state anti-degradation policy to limit new hydropower dams and diversions.[39] Through the early 1990s, DEC strengthened its capacity to limit water quality degradation from in-stream structures and activities, including shifting its river management engineers from the Facilities and Engineering Division to the Water Quality Division.

The 1990s were a time when EPA was accelerating its shift from point to nonpoint source pollution control. Many states, including Vermont, focused new Clean Water Act ("CWA") Section 319 funding[40] on land-based pollution treatments favoring "green" over "gray" structural stream controls. Nonpoint source programs, including wetland and stream buffer protection programs, recognized that real progress in restoring the physical, chemical, and biological integrity of our waters would occur with the

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34. VT. AGENCY OF NAT. RES. ET AL., VERMONT LAKE CHAMPLAIN PHOSPHORUS TMDL PHASE 1 IMPLEMENTATION PLAN 50–51 (2014), http://dec.vermont.gov/sites/dec/files/wsm/erp/TMDLcmnts/LCTMDLphase1plan.pdf [https://perma.cc/GWT5-SX5P].

35. VT. STAT. ANN. tit. 10, § 1001 (2016).

36. Kline & Cahoon, *supra* note 5, at 228.

37. *Id.* at 230.

38. No. 138. An Act Relating to Regulation of Flood Hazard Areas, River Corridors, and Stream Alteration, VT. STAT. ANN. tit. 10, §1021. (linking stream gravel removal to OWR in the statute).

39. VT. STAT. ANN. tit. 10, § 1002.

40. 33 U.S.C. § 1329 (2016) (statute show funding for point sources that are land-based).

acceptance that land use and land cover changes would be needed.[41] Vermont connected the final dots after a series of devastating floods in the 1990s prompted the Vermont General Assembly to pass Act 137, calling for "a flood control program that balances the need to protect the environment with the need to protect public and private property."[42]

In 1998, the Rivers Program was formed by combining the Stream Alteration and (Section 319) Stream Restoration programs.[43] This pivotal connection of river and riparian lands management in Vermont came about at the time when water resource professionals throughout the nation were flocking to training courses on fluvial geomorphology. The Rivers Program participated and brought this science home where it served as an organizing principle for the new Vermont program.[44] Its first policy initiative was crafted in the Act 137 report to the Legislature wherein riverine erosion was established as Vermont's primary flood-related hazard (over inundation) and called on Vermont agencies and municipalities to account for both the instream and land-based activities that were causing streams to become more highly erosive (geomorphically unstable).[45]

One year later, the floodplain program that administered the National Flood Insurance Program was folded into the Rivers Program.[46] Under new management, DEC began defining "floodways" in Act 250 cases to include both the FEMA-defined floodway and fluvial erosion hazard ("FEH") areas.[47] This controversial break with traditional floodplain management resulted in a landmark decision in the *Woodford Packer* case, which put Vermont in the vanguard of establishing fluvial geomorphic-based procedures for regulating developments to avoid FEH.[48]

As this case was unfolding, the 2002 Lake Champlain TMDL was prepared by the Water Quality Division and the new Rivers Program

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41. U.S. ENVTL. PROT. AGENCY, *Types of Nonpoint Source*, https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/types-nonpoint-source [https://perma.cc/F4X2-DMMP] (last updated Oct. 31, 2015).

42. 1998 Vt. Acts & Resolves 137 (codified as amended at VT. STAT. ANN. tit. 10, § 905b(3) (1998)).

43. *Rivers Program*, *supra* note 29 (providing a description of the responsibilities of the Rivers Program after combining other state programs).

44. *Geomorphic Assessment*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/geomorphic-assessment [https://perma.cc/MKX7-WR62] (last visited Apr. 4, 2016).

45. VT. AGENCY OF NAT. RES., OPTIONS FOR STATE FLOOD CONTROL POLICIES AND A FLOOD CONTROL PROGRAM 4, 16 (1999), http://docplayer.net/1243241-Options-for-state-flood-control-policies-and-a-flood-control-program.html [https://perma.cc/JEA8-GUJX].

46. *Rivers Program*, *supra* note 29.

47. *In re* Woodford Packers, Inc., 830 A.2d 100, 106 (Vt. 2003).

48. *Id.* at 102–04.

posited that University of Vermont phosphorus loading studies[49] had missed a key source of the nutrient: unstable streams. The argument lacked empirical data, but it was based on sound science and was, therefore, included along with a robust budget to carry out river and floodplain restoration projects.[50] When Governor Douglas took office in 2003, he announced the cleanup of Lake Champlain as the main component of his environmental agenda and the Legislature followed suit by allocating funds identified in the new TMDL.[51] With new staff, operating funds, and an annual million dollar budget to support a grants program for the purpose of restoring stream equilibrium, the Rivers Program was off and running.

These formative years of the Program included a string of fortunate events, including the near-complete failure of its flagship Trout River Restoration Project in Montgomery, Vermont.[52] Fortune from failure is accurate because, over a three-year period, the Program devoted nearly all of its resources toward major river restoration projects under the premise that the state could engineer and construct the desired stream equilibrium conditions on a reach-by-reach basis.[53] But even streams with an idealized geometry are dynamic and watching the next flood erase beautifully constructed meanders was a powerful message that rivers in Vermont were adjusting and equilibrating at scales much greater than the scope of the projects. We also witnessed that during the years spent restoring one mile of river, new encroachments were occurring along many miles of river that would force the state to keep more rivers channelized over time.[54] This lose-lose situation prompted the Rivers Program to put the brakes on future large-scale channel restorations.

In the "lessons learned" category of the Trout River Project, we also made note that when the floods receded in Montgomery, no one rushed in with yellow machines to put things back the way they were. The most successful aspect of the Project was that a corridor of land encompassing

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49. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 19 (2015), http://winooskinrcd.org/wp-content/uploads/phosphorus-tmdls-vermont-segments-lake-champlain.pdf [https://perma.cc/7GW8-5U57]; *see* Joshua E. Brown, *Stream Study Raises New Questions About Lake Pollution*, U. OF VT. (Nov. 11, 2015), http://www.uvm.edu/~uvmpr/?Page=news&storyID=21802 [https://perma.cc/65GH-Z3GR] (demonstrating that UVM studies on phosphorus loading do not point to unstable streams as a source).

50. U.S. ENVTL. PROT. AGENCY, *supra* note 49, at 16.

51. VT. AGENCY OF NAT. RES. & N.Y. STATE DEP'T OF ENVTL. CONSERVATION, LAKE CHAMPLAIN PHOSPHOROUS TMDL (2002), http://www.dec.ny.gov/docs/water_pdf/champlain_final_tmdl.pdf [https://perma.cc/U4QY-89UV].

52. *The Trout River*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/Champlain2000/c2k/troutr.htm [https://perma.cc/5C5S-E2Y9] (last updated June 5, 2000) (providing a status report on the Trout River project).

53. KLINE, *supra* note 6, at 13.

54. *The Trout River*, *supra* note 52, at 6.

the constructed meanders had been protected through landowner agreements.[55] Within just a couple of years, the Trout River, free to move, was forming its own brand of dynamic equilibrium.[56] From this lesson, river corridor protection became the Program's primary objective.

What began in 2003 would be the work of generations of Vermont river managers: getting Vermonters to embrace an "avoidance approach"; giving rivers the room to move; and managing toward natural dynamic equilibrium conditions and the natural processes that will minimize erosion over time. Changing the centuries-old paradigm that the only safe and productive river was a structurally managed river would take compelling place-based river stories supported by data that could explain the benefit and cost of a passive versus active restoration program.

2. Creating a Constituency—Funding, Outreach, and Technical Assistance

A new river management paradigm has come about in Vermont due to the ever-broadening application of practices based on fluvial geomorphic principles. When the 2002 Lake Champlain TMDL was being adopted, the Rivers Program pulled in many collaborating agencies to help develop a stream geomorphic assessment ("SGA") program with a scientifically sound data collection protocol;[57] a web-based data and mapping system accessible to all users;[58] and a method for predicting stream channel and floodplain evolution that technically supports the resolution of river and land use conflicts.[59] We had to create an assessment methodology that would help lay people understand how human activities and sound land use practices can be conducted in a manner that is both ecologically and economically sustainable. Water resource planners and practitioners have increasingly accepted working at much greater spatial and temporal scales than they might have otherwise thought prudent because they participated in the underlying science.

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55. KLINE, *supra* note 6, at 84.

56. *The Trout River*, *supra* note 52, at 10.

57. *Stream Geomorphic Assessment Protocol*, VT. AGENCY OF NAT. RES., https://anrweb.vt.gov/DEC/SGA/instructions/protocol.aspx [https://perma.cc/LGT7-6XQE] (last visited Apr. 3, 2016).

58. VT. AGENCY OF NAT. RES., STREAM GEOMORPHIC ASSESSMENT BRIDGE AND CULVERT DATA MANAGEMENT MANUAL 1 (2008), http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_SGAB%26CDataManagementManual2008.pdf [https://perma.cc/9K5S-7LB8].

59. VT. AGENCY OF NAT. RES., STREAM GEOMORPHIC ASSESSMENT PROGRAM INTRODUCTION 2, http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_geomorphassess.pdf [https://perma.cc/QJ2T-D57P] (last visited Apr. 3, 2016).

Essential to the success of the SGA program was making sure that, in a world where changes in land use and land cover are largely voluntary, the data must be obtained by collaborators and people close to the land. In other words, the data could not be collected and "owned" solely by a group of state scientists. The data had to be the property of those who would create and share "stories of the river," explaining why new and different actions were important. To incentivize local ownership of these river stories, the Rivers Program established that TMDL river restoration funds would be made available as grants to watershed organizations and municipalities for restoration and protection projects identified in River Corridor Plans[60] based on stream geomorphic data collected using the ANR protocols. Supporting on-the-ground projects only if they were based on sound, replicable science created a "gold rush" toward the assessment of stream geomorphology in Vermont.[61]

To date, the citizens of Vermont, their cadre of ANR-trained river science consultants, and many partner agencies and organizations have collected and quality-assured over 8,000 river miles of Phase 1 (remote sensing) geomorphic data and over 2,100 river miles of Phase 2 (field collected) geomorphic data to prepare more than 100 river corridor plans.[62] Each year since 2004, the agency and its partners have funded at least two dozen river restoration and protection projects identified and prioritized in the river corridor planning process.[63] All of the data and plans are available online and geo-referenced in the ANR Natural Resource Mapping Atlas.[64]

In 2006, the Rivers Program began purchasing river flumes (metal trays with water flowing through a sand-like medium) that allow people to watch firsthand how rivers work at a miniaturized scale. With freshly-minted river corridor plans, the conservation districts and watershed groups have sponsored local gatherings to serve up the science with cookies and cider, telling the "river story," and using hands-on experiments at the flume to convince town officials and landowners to work with them outside their dredge and armor comfort zone. It has been a beautiful demonstration of applied folk science.

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60. KLINE, *supra* note 6, at 12.

61. *Id.* at 14 ("The State's goal of managing toward stream equilibrium condition is often compatible with more localized goals.").

62. VT. DEP'T OF ENVTL. CONSERVATION, STREAM GEOMORPHIC ASSESSMENT - FINAL REPORTS, https://anrweb.vt.gov/DEC/SGA/finalReports.aspx [https://perma.cc/YRD3-H2BD] (last visited Apr. 20, 2016).

63. *River Corridor Planning, Protection, and Restoration*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/river-corridor-planning-and-protection [https://perma.cc/VX3V-DY6M] (last visited May 11, 2016).

64. VT. AGENCY OF NAT. RES., *Natural Resources Atlas*, http://anrmaps.vermont.gov/websites/anra/ [https://perma.cc/T5G4-YT4X] (last visited Apr. 4, 2016).

While groups were explaining the condition of their local river, the Rivers Program was using all the data to impress state policymakers and program managers. As more and more agencies gained an appreciation for how geomorphically stable streams and natural functioning floodplains would serve their missions (such as clean water, fish habitat, soil conservation, property and infrastructure protection, hazard mitigation, and economic resiliency), they too began creating funding incentives and technical assistance for projects and protections identified in river corridor plans. This translated into new statutes and the regulatory approaches as described below.

3. Statutory Changes and Rulemaking

By 2007, the TMDL funding originally allocated for river restoration grants was moved to the ANR Secretary's office to help start a Clean and Clear Program charged with addressing a much broader set of nutrient sources. With assistance from EPA and the Lake Champlain Basin Program, Clean and Clear placed a greater emphasis on gaining knowledge and supporting farm and urban stormwater management practices.[65] Field trips to farms revealed miles of ditches, in both field and stream, with no buffers filtering the surface runoff from ever-expanding row crops. During the debate over buffers on ditched streams, the anecdote was shared that a farmer would rather culvert streams underground than give up cropland to meet buffer requirements. This thinking helped to align political forces advocating greater state jurisdiction of small streams and riparian buffers.

The 2010 General Assembly passed Act 110, which erased the ten square mile jurisdictional threshold in the state regulation of stream alterations.[66] Changing the course, current, or cross-section of any perennial stream by the excavation or fill of ten cubic yards of material now required a permit.[67] Prohibiting adverse effects to public safety from fluvial erosion hazards was also added to the criteria for stream alteration permitting.[68] Farmers who might contemplate the piping of small streams under their fields would now need a state permit to do so.[69]

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65. VT. AGENCY OF NAT. RES., VERMONT CLEAN AND CLEAR ACTION PLAN 1 (2009), http://www.wwwalker.net/champ/tmdl/references/VT%20Clean%20and%20Clear%20Annual%20Report%20(2009).pdf [https://perma.cc/9QXN-E4GD].

66. DEP'T OF ENVTL. CONSERVATION, VT. AGENCY OF NAT. RES. ACT 110 STREAM ALTERATION REPORT TO THE VERMONT GENERAL ASSEMBLY 1 (2011), http://www.leg.state.vt.us/reports/2011externalreports/265340.pdf [https://perma.cc/FK4M-DATW].

67. *Id.*

68. *Id.* at 3.

69. VT. STAT. ANN. tit. 10, §§ 1002(10), 1022.

Act 110 started out as a buffer bill. It was the intent of the bill to require all riparian landowners to establish and maintain a twenty-five- to fifty-foot vegetative buffer on all streams.[70] The Rivers Program came out against the buffer provisions.[71] The committee room became a classroom featuring a short course on fluvial geomorphology. The Program eventually convinced representatives that requiring a buffer may establish the desired vegetation, but it would also establish a setback standard for new encroachments; a twenty-five- or even fifty-foot setback on streams, if strictly observed, would be to the detriment of larger streams that need hundreds of feet to complete the channel evolution process.[72] Streams and rivers that were historically straightened would be locked into a channelization condition, i.e., managed as shaded ditches.[73] Any buffer-related water quality and habitat gains would be eroded away during floods when the river widened through stages III and IV of the channel evolution process (Figure 2), or further deepened from being pushed back to stage II with bank stabilization practices employed to save the required buffer.[74] The Committee went on to embrace the river corridor concept. Vermont became the first state to include the protection of stream equilibrium as public policy in state statute.[75] Act 110 solidified ANR's practice of using river corridors to define the protected floodway in Act 250 land use cases[76] and provided a mandate for creating municipal incentives to strengthen local river corridor protections.

The next leap forward came in the aftermath of Tropical Storm Irene in August of 2011. The 2012 General Assembly came together with resolve to address shortcomings in state jurisdiction over post-flood, instream "recovery" work and the lack of adequate floodplain protections.[77] Act 138, the Rivers Bill, mandated several transformations in the Rivers Program.[78]

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70. *Id.*

71. Mike Kline & Kari Dolan, VERMONT AGENCY OF NATURAL RESOURCES RIVER CORRIDOR PROTECTION GUIDE: FLUVIAL GEOMORPHIC-BASED METHODOLOGY TO REDUCE FLOOD HAZARDS AND PROTECT WATER QUALITY 4–5 (2008), http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_RiverCorridorProtectionGuide.pdf [https://perma.cc/AC6P-EQYY] [hereinafter RIVER CORRIDOR PROTECTION GUIDE].

72. *See* STREAM GEOMORPHIC ASSESSMENT PROGRAM INTRODUCTION, *supra* note 59, at 6 (describing the Program's stream geomorphic classification assessment tool).

73. RIVER CORRIDOR PROTECTION GUIDE, *supra* note 71.

74. *See id.* (explaining that flooding often creates loss of vegetation and further erosion).

75. VERMONT NATURAL RESOURCES COUNCIL, READING VERMONT'S RIVERS (2013), http://vnrc.org/wp-content/uploads/2013/07/Reading-Rivers-reduced.pdf [https://perma.cc/8FQ3-V5LP].

76. 2010 Vt. Acts & Resolves 110 (codified at or as amended at VT. STAT. ANN. tit. 10, §§ 1422(12), 1427(b) (2010)).

77. VT. DEP'T OF ENVTL. CONSERVATION, SUMMARY OF "RIVERS BILL" COMPONENTS OF ACT 138 1 (2012).

78. VT. STAT. ANN. tit. 10, § 1421.

In addition to a call for training programs to teach stream equilibrium concepts to highway workers, the Bill requires the adoption of two sets of state rules: one governing stream alterations, including emergency protective measures as conducted by municipalities; and a second governing land use activities exempt from municipal regulation for the protection of flood hazard areas.[79] The river corridor planning and protection provisions established by Act 110 were also revised and strengthened.[80]

In 2013 and 2014 the Legislature passed Acts 16 and 107, which mandated the inclusion of flood resiliency chapters in town plans and authorized ANR to include river corridor protections in the new state floodplain rules.[81] The above mentioned statutes collectively recognize the vital importance of functioning floodplains and river corridors in managing streams toward a naturally stable, least erosive form (i.e., equilibrium condition).

B. Managing Toward Stream Equilibrium

1. Creating an Integrated Set of Standards

Rulemaking provided the opportunity to tighten the stitches between Vermont's river, river corridor, and floodplain management programs and to demonstrate that vertical stream channel stability and floodplain function are two sides of the same coin. The new rules establish a set of performance-based standards for stream equilibrium, connectivity, and river corridor protection, all of which promote the fluvial processes that connect rivers and floodplains as one functioning riparian system.

The Vermont Stream Alteration Rule establishes that non-emergency actions shall not change the physical integrity of the stream in a manner that causes it to depart from, further depart from, or impedes the attainment of stream equilibrium conditions by resulting in an unnatural aggrading or degrading of the stream channel bed.[82] Activities shall not alter the flow patterns, natural streambank stability, or floodplain connectivity in a manner that: a) results in localized, abrupt changes to the alignment of streambanks or profile of the stream bed; or (b) creates a physical

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79. SUMMARY OF "RIVERS BILL" COMPONENTS OF ACT 138, *supra* note 77, at 2.

80. *Id.*

81. VT. STAT. ANN. tit. 24 § 4302 (2016); 2014 VT. ACTS & RESOLVES 107 (codified as amended Vt. Stat. Ann tit. 10, § 754(a).

82. VT. AGENCY OF NAT. RES., VERMONT STREAM ALTERATION RULE 9, http://dec.vermont.gov/sites/dec/files/documents/WSMD_StreamAlterationRule_2013_12_24.pdf [https://perma.cc/6BJB-RVVH] (last visited July 2, 2016).

obstruction or velocity barrier to the movement of aquatic organisms.[83] No longer are people permitted to construct or maintain a berm in a floodplain or river corridor unless it is authorized as an emergency protective measure.[84]

On the land use side of the equation, development under state jurisdiction (e.g., decisions rendered under Act 250 Criterion 1(D)) must be sited outside of the river corridor to ensure there is no increase in fluvial erosion hazards by constraining the river and causing it to depart from, or further depart from, equilibrium conditions.[85] Exceptions are made for stream crossings, infill, and redevelopment.[86] DEC applies a performance standard to ensure that if development is approved, it will not result in the need for any new stream channelization that would alter the flow and sediment dynamics of the stream, triggering channel adjustments and erosion in adjacent and downstream locations.[87]

These precedent-setting standards recognize that natural floodplain function depends on sound river management. They work to achieve a geomorphically stable and ecologically functioning river, which depends on the erosion and deposition processes in a meander belt and riparian buffer system unconstrained by human activity.[88] The standards implement Vermont's anti-degradation policy, recognizing equilibrium conditions as supporting high quality waters and a broad set of beneficial surface water uses and values.[89] ANR protects the fluvial processes—and the resulting channel adjustments driving channel evolution—as necessary to guard against backsliding to disequilibrium stages in which increases in sediment and nutrient runoff into streams, rivers, and ultimately Lake Champlain, would be expected.[90]

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83. *Id*. at 10.

84. *Id*. at 8.

85. DEP'T OF ENVTL. CONSERVATION, VT. AGENCY OF NAT. RES., FLOOD HAZARD AREA AND RIVER CORRIDOR PROTECTION PROCEDURE 20 (2014), http://dec.vermont.gov/sites/dec/files/documents/dec-fharcp-2014-12-5.pdf [https://perma.cc/VFD9-B7LA] (unless the proposal satisfies "No adverse impact standard").

86. *Id.* at 21–22.

87. *Id.* at 22.

88. *Id.* at 25; MILONE & MACBROOM, INC., FITZGERALD ENVIRONMENTAL ASSOCIATES, LLC & VT. AGENCY OF NAT. RES., VERMONT STANDARD RIVER MANAGEMENT PRINCIPLES AND PRACTICES: GUIDANCE FOR MANAGING VERMONT'S RIVERS BASED ON CHANNEL AND FLOODPLAIN FUNCTION (2015), http://dec.vermont.gov/sites/dec/files/documents/wsmd-rv-standard-river-management-principles-practices-2015-06-12.pdf [https://perma.cc/6465-QRUN].

89. FLOOD HAZARD AREA AND RIVER CORRIDOR PROTECTION PROCEDURE, *supra* note 85, at 25.

90. *Id.*

2. Restoring Floodplains with Standard River Management Principles and Practices

The solution to excessive streambank and channel erosion is managing toward stream equilibrium. Activities should not alter a stream in a manner that decreases its power to transport sediment, causing it to aggrade (or fill in), or increases its power so much that the channel bed erodes.[91] The central principle is to protect and restore components of channel and floodplain geometry to more evenly distribute stream power (energy) and maximize overall vertical stability.[92]

Finding opportunities to restore channel and floodplain geometry and achieve equilibrium in Vermont's straightened streams would be challenging even in a perfect world where there were no human constraints. But after a flood, protecting buildings, roads, and utilities is a legal right and we are only beginning to weigh the rights of others to the accrued benefit of functioning floodplains. What changed in the aftermath of Irene is that, while municipalities may continue to dredge and fill streams to address imminent threats to public safety and property without prior authorization from the state, in-stream work must be conducted in accordance with state rules to avoid unnecessary stream and floodplain impacts.

In tandem with adopting rules for both emergency and non-emergency in-stream measures, the Vermont Rivers Program contracted the development of Standard River Management Principles and Practices.[93] This manual describes specific designs and methods for managing toward equilibrium conditions and provides the basis for training the road and utility workers on how to avoid making streams less stable when dredging and filling to address severe post-flood damage.[94] Training flood responders and adopting rules to ensure compliance is a critical component of the Lake Champlain TMDL Implementation Plan.

In addition to efforts aimed at decreasing the extent and severity of stream disequilibrium caused by ill-advised post-flood channelization, Vermont is using state and federal funding to promote active restoration of floodplains.[95] Occasionally, there are opportunities to excavate a

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91. KLINE, *supra* note 6, at 30.

92. *Id*.

93. VERMONT STANDARD RIVER MANAGEMENT PRINCIPLES AND PRACTICES, *supra* note 88.

94. *Id.* at 177.

95. VT. DEP'T OF ENVTL. CONSERVATION, RIVER, RIVER CORRIDOR, & FLOODPLAIN MANAGEMENT PROGRAMS 7 (2013) http://www.leg.state.vt.us/reports/2013ExternalReports/285582.pdf [https://perma.cc/6CYX-NSP9].

sufficiently wide new floodplain (i.e., bring the floodplain down to the stream). More often, we elevate the stream so that the annual flood will be able to spill out onto the old floodplain feature that became abandoned when the stream incised. Even more common are the projects to create smaller floodplain benches during streambank stabilization projects along roadways.

Active floodplain restoration is far less costly than in-channel restoration and addresses the erosion caused by an over-deepening of flood flows.[96] Once a stream is reconnected to a floodplain, it becomes more depositional. Coarse sediments deposit in the channel and begin forming meanders. Flood waters, now slowing on the floodplain, drop significant quantities of fine sediment and nutrient. A project involving the removal of six miles of rail levee along the Black Creek and Lamoille River in Vermont reconnected 200 acres of floodplain.[97] In a one-year period covering two flood cycles, measurements were made of the fine sediment and phosphorus that deposited on four of the reconnected sites (representing ten percent of the total reconnected floodplain).[98] The state's consultants found that 950 cubic yards of sediment and 1.3 metric tons of phosphorus were deposited and stored on the now-functioning Lamoille River floodplains.[99]

C. Focus on Avoidance

1. The River Corridor

The alternatives for addressing excessive channel erosion are to: (a) manage it with hard armor; (b) hasten the evolution process with restoration practices; or (c) limit channel and floodplain encroachments so that the evolution process can proceed unimpeded to an equilibrium state.[100] Hard armoring is often the only choice along the roads and villages of

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96. KLINE, *supra* note 6, at 50.

97. ROY SCHIFF, BARRY CAHOON, & MIKE KLINE, BLACK CREEK AND LAMOILL RIVER FLOODPLAIN RESTORATION PROJECT, http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/LVRT_RMS.pdf [https://perma.cc/E6YH-XAEA] (last visited July 1, 2016).

98. *Id.* at 96.

99. VT. DEP'T OF ENVTL. CONSERVATION, STATE OF VERMONT: 2010 WATER QUALITY INTEGRATED ASSESSMENT REPORT 101 (2010) http://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_305b%20WQ%20Report_2010.pdf [https://perma.cc/7CQ6-N2HV].

100. VT. DEP'T OF ENVTL. CONSERVATION, CHANNEL EROSION http://dec.vermont.gov/sites/dec/files/documents/WSMD_swms_StressorPlan_Channel%20Erosion_Web_V3.pdf [https://perma.cc/Q5VR-HCB7] (last visited July 9, 2016).

Vermont, but this often shunts erosion to downstream reaches.[101] If one considers private landownership, the number of incised channels, and the limits of time and money, one may reasonably conclude that Vermont will only achieve the objective of watershed-wide equilibrium if encroachments are limited and floods are not impeded from creating stream meanders and floodplains. The question is "how much room does the river need"?

A river requires sufficient room to accommodate equilibrium conditions and the channel adjustments that occur when channel geometry is changing vertically and laterally to achieve equilibrium.[102] Smith et al. suggest the "Active River Area" be set aside, which is essentially the entire valley floor.[103] Several western states use "Channel Migration Zones."[104] Vermont defines a "river corridor" to include the existing or calculated meander belt of the river at a least erosive, equilibrium slope and depth.

The meander belt extends laterally across the river valley from each of the outermost meander bends, thereby encompassing the natural planform variability of the stream channel (Figure 3), which maintains the equilibrium slope and minimizes vertical channel instability over time.[105] If the river has been straightened, the natural meander belt may not be discernable. In this case the river corridor is modeled by calculating the width of the meander

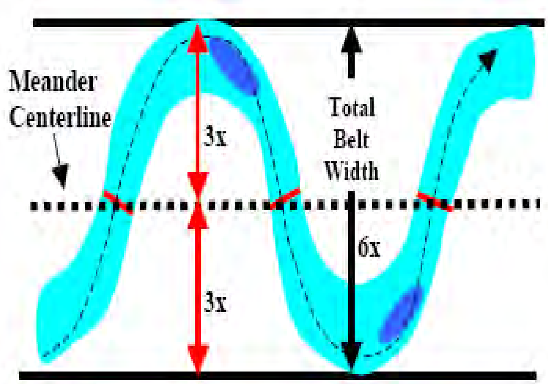

Figure 3: Depiction of meander centerline and belt width delineation.

101. U.S. FED. EMERGENCY MGMT. AGENCY, ENGINEERING WITH NATURE: ALTERNATIVE TECHNIQUES TO RIPRAP BANK STABILIZATION 8, https://www.fema.gov/pdf/about/regions/regionx/Engineering_With_Nature_Web.pdf [https://perma.cc/4KCG-DPXE] (last visited Apr. 3, 2016).

102. *River Corridors*, VT. FLOOD READY, http://floodready.vermont.gov/flood_protection/river_corridors_floodplains/river_corridors [https://perma.cc/KQE9-Y7QM] (last visited Apr. 1, 2016).

103. SMITH ET AL., *supra* note 7.

104. *See* CYNTHIA F. RAPP & TIMOTHY A. ABBE, A FRAMEWORK FOR DELINEATING CHANNEL MIGRATION ZONES (2003), https://fortress.wa.gov/ecy/publications/publications/0306027.pdf [https://perma.cc/7BDK-DQLK] (providing details on channel mitigation zones).

105. ANN L. RILEY, RESTORING STREAMS IN CITIES: A GUIDE FOR PLANNERS, POLICYMAKERS AND CITIZENS (1998).

belt as a multiple of the bankfull channel width.[106] Figure 3 depicts the use of a meander centerline to split a meander belt width modeled as six times the channel width, with three channel widths allocated to either side of the centerline. The Vermont Flood Hazard Area and River Corridor Protection Procedures provide further detail on the river corridor delineation process.[107]

Thus, managing a river corridor to accommodate equilibrium and associated channel adjustment processes will serve to reduce damages to existing structures and property, avoid new damages, protect public safety, achieve the general health of the river system (including sediment and nutrient load reductions), and avoid the high cost to install and maintain channelization practices.[108] Precluding the use of channelization practices, in turn, avoids the unintended consequences of transferring bank erosion and other damaging effects from concentrated flow and vertical channel adjustments to other locations along the river.[109]

The Vermont General Assembly specifically called for the inclusion of buffers within the river corridor.[110] Therefore, river corridors are defined and mapped with an additional fifty-foot setback on either side of the meander belt as a margin of safety and to allow space for the maintenance of a vegetated buffer throughout the channel evolution process, including the final evolution stage when the meanders are extended to the edge of the meander belt.[111] A vegetated buffer provides a host of ecosystem services, but in the case of the river corridor, they are established for their value in streambank stability and slowing flood water velocities in the near-bank region.[112] Vegetated buffers are a least-cost, self-maintaining practice, which provide natural boundary conditions and streambank resistance against erosion and moderate lateral channel migration.[113]

Vermont's plan for implementing the TMDL includes a commitment to address the loading from streambank and channel erosion by increasing

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106. Garnett P. Williams, *River Meanders and Channel Size*, 88 J. HYDROLOGY 147, 150 (1986).

107. VT. AGENCY OF NAT. RES., FLOOD HAZARD RIVER AND RIVER CORRIDOR PROTECTION PROCEDURE, 33 (2014), http://dec.vermont.gov/sites/dec/files/documents/dec-fharcp-2014-12-5.pdf [https://perma.cc/3QBM-UMTF].

108. *River Corridors*, *supra* note 102.

109. VT. AGENCY OF NAT. RES., FLOOD HAZARD AREA AND RIVER CORRIDOR PROTECTION PROCEDURE (2014) (unpublished draft), http://floodready.vermont.gov/sites/floodready/files/documents/2014-10-06%20%20Final%20Draft%20Flood%20Hazard%20Area%20and%20River%20Corridor%20Protection%20Procedures.pdf [https://perma.cc/CK9C-USWG].

110. VT. STAT. ANN. tit. 10, § 1422(12).

111. KLINE, *supra* note 6, at 66.

112. *Id.* at 66–67.

113. *Id.* at 67.

nutrient storage on functioning floodplains primarily through river corridor protection.[114] With seventy-five percent of Vermont stream channels moderately to severely incised, the potential for restoring floodplain storage is great—if we stay out of the way to let floodplains naturally reform. Vermont must work to avoid new encroachments and make every effort to identify and remove non-essential structures that are impeding channel evolution.

2. Regulatory Solutions at the State and Municipal Level

The most effective way to limit encroachments in river corridors and floodplains is to avoid them in the first place. Increased regulation by the state and by municipalities is occurring in response to an increased public awareness of the safety risks and property damage from floods. Water quality improvement is not used to start the conversation about new local land use regulations, but is acknowledged as a benefit.

The State Flood Hazard Area and River Corridor Rule limits new encroachments that are exempt from municipal regulation, including state buildings, state transportation infrastructure, farm and logging-related developments, and utilities regulated by the Public Service Board under section 248.[115] The DEC Flood Hazard Area and River Corridor Protection Procedures mirror the rule in applying the No Adverse Impact standard to land use activities regulated by the state under Act 250 Criterion 1(D).[116] This leaves one major land use regulatory arena where the state plays only an advisory role—river corridor and floodplain development that is sub-jurisdictional in Act 250 and, therefore, only regulated by a municipality.[117]

Municipalities that have adopted flood hazard area or river corridor bylaws are required to submit permit applications for flood hazard area and river corridor development to DEC for review and comment pursuant to 24 V.S.A. § 4424(a)(2)(D).[118] The Rivers Program reviews applications for completeness and then evaluates the development proposal against the effective flood hazard area and/or river corridor map in conjunction with the standards adopted by the municipality (a vast majority of which are the minimum standards required by FEMA for enrollment in the NFIP).[119] The

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114. *Id.* at 87.

115. FLOOD HAZARD AREA AND RIVER CORRIDOR PROTECTION PROCEDURE, *supra* note 111, at 3–4.

116. *Id.* at 21.

117. *Id.* at 3.

118. VT. STAT. ANN. tit. 24, § 4424(a)(2)(D) (2015).

119. FLOOD HAZARD AREA AND RIVER CORRIDOR PROTECTION PROCEDURE, *supra* note 109, at 24, 26.

Program provides written comments and recommended permit conditions with regard to any aspect of the proposal not in compliance with the municipal bylaw.[120] The data below was gathered in preparing the 2015 Rivers Program's Results-Based Accountability report to the legislature and is offered here to illustrate the relative number of projects reviewed under the three above-mentioned jurisdictions.

ANR Permitted Floodplain and River Corridor Projects	63
Act 250 Floodway Determinations to Protect Floodplains and River Corridors	65
Municipally Permitted Floodplain and River Corridor Projects	845

The compliance of municipalities with the state review requirement is estimated to be in the thirty- to fifty-percent range.[121] To help address this lack of participation, the legislature established the Flood Resilient Communities Program to increase funding incentives for municipalities that have adopted river corridor and floodplain protections.[122] A number of incentives have been established, but the most significant to date has been the 2013 amendments to the rules governing the Emergency Relief and Assistance Fund ("ERAF"), which helps the municipality meet the federal twenty-five percent match requirements under FEMA flood recovery programs.[123]

Towns that have adopted river corridor protection bylaws would see the percentage split of the federal match between the town and state change in their favor: from a fifty-fifty split to a twenty-five to seventy-five split.[124] For instance, if a town experiences one million dollars in damages, FEMA Public Assistance Program would pay $750,000; the state share would increase from $125,000 to $187,500 if the municipality has a river corridor bylaw or its equivalent in place.

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120. *Id.* at 5.
121. Author's personal knowledge.
122. VT. STAT. ANN. tit., 10 § 1428.
123. *Emergency Relief and Assistance Fund*, VT. FLOOD READY, http://floodready.vermont.gov/find_funding/emergency_relief_assistance [https://perma.cc/7C4R-W8TD] (last visited Apr. 12, 2016).
124. *Id.*

By the end of 2015, there were 35 Vermont municipalities (out of 251) that had adopted river corridor maps and zoning bylaws.[125] Over a dozen other communities were in the process of considering or adopting river corridor protections, primarily because of the ERAF incentive.[126] However, EPA and the state are hearing concern by some (expressed as comments on the draft TMDL) that this progress is too slow.[127] It is said that leaving the regulation of encroachment to the discretion of municipalities may not realize the targeted reductions from the restoration of floodplain and equilibrium conditions within any reasonable timeframe, if ever.

3. Conservation Easements

Streambank stabilization is a part of the state rule governing agricultural practice that is promulgated to protect water quality on farms.[128] This means that if farmers in Vermont want to stabilize a streambank, they may do so without a permit from ANR as long as they do not cause a fluvial erosion hazard. Although this exception in the stream alteration statute means ANR is limited in its governance of a major channel erosion stressor, many farmers turn to state and federal agencies (including river management engineers with the DEC Rivers Program) or technical and financial assistance when they seek to establish or maintain rip-rap on a streambank.

This point of contact gives ANR and its partners the opportunity to discuss conservation as an alternative to the furtherance of channelization practice, particularly on reaches identified in a river corridor plan as being a high priority for a river corridor easement. Along reaches that are high sediment deposition zones—where the farm family has struggled to control

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125. MIKE KLINE, FUNCTIONING RIVER AND FLOODPLAIN SYSTEMS: VERMONT'S MANAGEMENT STANDARD (2015) http://floodready.vermont.gov/sites/floodready/files/documents/Functioning%20River%20and%20Floodplain%20Systems--Vermont%E2%80%99s%20Management%20Standard.pdf [https://perma.cc/XZ85-SD3K].

126. VT. DEP'T OF ENVTL. CONSERVATION, RIVER CORRIDOR AND FLOODPLAIN MANAGEMENT PROGRAM AND SHORELAND PROTECTION PROGRAM 3 (2015), http://legislature.vermont.gov/assets/Legislative-Reports/2014-Act-110-LegReport-January-2015.pdf [https://perma.cc/C74L-MERE].

127. Letter from Karen B. Horn, Dir., Pub. Policy & Advocacy Dep't, Vt. League of Cities & Towns to Stephen Perkins, Lake Champlain TMDL Project Manager, U.S. Envtl. Prot. Agency, Region 1 (Oct. 15, 2015), http://www.vlct.org/assets/Advocacy/vlct_testimony/2015-10-15_lake_champlain_tmdl_comments.pdf [https://perma.cc/L2L2-ASE4].

128. VT. AGENCY OF AGRIC., FOOD & MKTS., REQUIRED AGRICULTURAL PRACTICES REGULATIONS FOR THE AGRICULTURAL NON-POINT SOURCE POLLUTION CONTROL PROGRAM 7, http://agriculture.vermont.gov/sites/ag/files/pdf/water_quality/VAAFM-Draft-RAP.pdf [https://perma.cc/HWF3-36FH].

a very dynamic stream for a very long time—the idea of being paid for an easement rather than paying out for a rip-rap installation has become attractive to some farmers. The river corridor easement is a unique conservation tool that has increasingly become a key component of DEC's plan for restoring floodplain function and nutrient storage.[129]

Land use regulation and traditional conservation tools may be effective in limiting new encroachments, but they do not limit riparian landowners from structurally controlling the streams on their land.[130] The river corridor easement is used separately or in conjunction with other conservation tools to purchase the channel management rights in the meander belt of the stream.[131] The farmer must leave an open buffer along the river, but may otherwise continue to farm in the corridor as a "guest of the river." They have sold their right to change the course, current, or cross-section of the stream or impede the channel evolution process.

The specifics and rationale for the Vermont river corridor easement are presented on DEC's River Program web page.[132] By the end of 2015, the Rivers Program and its conservation partners executed over sixty river corridor easements on rivers identified as key flood flow and sediment attenuation assets.[133] These are reaches where the river is rated as highly sensitive where floodplain function is likely to return sooner rather than later.

4. Other Incentives and Agency Collaborations

The Rivers Program might perfect its technical, regulatory, and funding assistance tools, but if it were addressing streambank and channel erosion on its own, only a fraction of the activities driving stream instability would be addressed. Vermont is making significant progress because of the funding incentives, siting restrictions, and technical assistance established within other programs and agencies. It would now be the exception to find a state or federal agency in Vermont with an interest in water quality or flood hazard mitigation that does not work with its constituency to stay out of

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129. MIKE KLINE, A GUIDE TO RIVER CORRIDOR EASEMENT 1 (2010), http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_RiverCorridorEasementGuide.pdf [https://perma.cc/FL9H-MPZL].

130. *See id.* at 7 (explaining that riparian restoration and protection goals can be achieved with river corridor easements).

131. Kline & Cahoon, *supra* note 5, at 7.

132. *Rivers Program*, *supra* note 29.

133. *Id.* (navigating the website of the Rivers Program shows that vast amount of corridor easements and flood flow areas).

river corridors, avoid stream channelization, and promote floodplain protection and restoration. The following are just a few examples:

- The Vermont Natural Resources Conservation Service ("NRCS") provides Environmental Quality Incentives Program funds for streambank stabilization only if an interagency "stream team" determines that the project will occur in a stream segment already at or near equilibrium slope such that the erosion will not be just shunted downstream and cause more erosion.[134]
- VTrans recently contracted for the design of modelling tools to combine river and transportation corridor planning (to include the relocation of roads where feasible) and agreed not to fund new local transportation enhancement or bike path projects located in a state delineated river corridor.[135]
- Vermont Agency of Commerce and Community Development provides incentives for river corridor protection through its Community Development Block Grant program and has assembled a large cache of technical assistance through its Vermont Economic Resiliency Initiative web page.[136]
- DEC storm- and waste-water programs minimize the encroachment of outfalls and other treatment structures from contributing to further channelization and disequilibrium within river corridors.[137]

The State is establishing up-front guidance and the "power of the purse" to avoid those encroachments over which it has no regulatory authority but would not have permitted or authorized if it did. Giving municipalities and landowners a consistent message makes a huge difference when trying to change the public expectation that "floods should stay in the channel" and "streams should stay put."

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134. U.S. DEP'T OF AGRIC., ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP): CONSERVATION PRACTICES (2009), http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_020351.pdf [https://perma.cc/XR8C-HZ4L].

135. *Rivers Program*, *supra* note 29.

136. Chris Cochran, *Vermont Economic Resiliency Initiative*, VT. AGENCY OF COMMERCE & CMTY. DEV., http://accd.vermont.gov/strong_communities/opportunities/planning/resiliency/VERI [https://perma.cc/TBG6-5J9Q] (last visited Apr. 2, 2016).

137. Author's personal knowledge., *supra* note 123.

III. Role of Streambank Solutions in Lake Champlain TMDL

A. A Round Peg in a Square Hole

Previous sections defined the impacts of human-caused stream channel evolution at a watershed-scale (i.e., the increased load contribution of streambank and channel erosion) and how Vermont has built a constituency for applying unique landscape-scale solutions. Now the challenge is to explain how the TMDL framework will be used as a tool to get the job done. Inherent in the term "total maximum daily load" is the paradigm of a human-made system that can be controlled. Applying the requirements of a TMDL to programs dealing with nature-based systems, where human "control" is often best avoided, may be an attempt to fit a round peg in a square hole.

1. Difficulty Modeling a Stochastic, Open-System, Precip-Driven Load

Naturally functioning floodplain, wetland, and river systems are valued for the services they provide in remediating human-alterations of hydrology, aquatic habitat, and water quality.[138] These systems have a buffering capacity because of the extensive and open (i.e., uncontrolled) water-sediment exchange with adjoining lands and the natural disturbance regimes that have created them (e.g., floods of various magnitudes).[139] Natural disturbances are not predictable. Their frequencies may only be discerned over long periods of time; they are stochastic. Water, sediment, and nutrient loads going through and out of these natural systems may become altered by humans, but they are not and cannot be regulated in the same way as the material that travels through a wastewater or stormwater treatment system.[140] The storage and transport of organic sediments and phosphorus in stream networks are influenced by topographic vagaries, geologic processes, and the stochastic nature of snowmelt and rainstorms.[141]

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138. U.S. FED. EMERGENCY MGMT. AGENCY, CHAPTER 8: FLOODPLAIN NATURAL RESOURCES AND FUNCTIONS 1, http://www.training.fema.gov/hiedu/docs/fmc/chapter%208%20-%20floodplain%20natural%20resources%20and%20functions.pdf [https://perma.cc/WP23-THHW] (last visited July 1, 2016).

139. Christian Feld, *What Rivers Do for Us*, FRESHWATER BLOG (July 30, 2013), http://freshwaterblog.net/2013/07/30/what-rivers-do-for-us/ [https://perma.cc/QY3N-84K7].

140. *See* FLOODPLAIN NATURAL RESOURCES AND FUNCTIONS, *supra* note 138, at 3–4 (explaining the filtering process of floodplain vegetation).

141. Robert J. Naiman et al., *Fundamental Elements of Ecologically Healthy Watersheds in the Pacific Northwest Coastal Ecoregion*, *in* WATERSHED MANAGEMENT: BALANCING SUSTAINABILITY AND ENVIRONMENTAL CHANGE 127, 138 (Robert J. Naiman ed., 1992), http://andrewsforest.oregonstate.edu/pubs/pdf/pub1608.pdf [https://perma.cc/J2GA-VJ6W].

The urban stormwater and wastewater system has a design capacity, whereas the spatial and temporal scales at which storage and transport occur in "open" river watershed systems are very difficult to predict or model as part of a TMDL. For instance, the sediments entering from an eroding bank in a headwater stream may deposit and erode through successive meander features during small floods, then move down through the stream-river network over several decades before depositing on a broad floodplain near the river's mouth during a larger flood event. The geography and time period of this sequence would be extremely difficult to model.

Collaboration between EPA, Tetra-Tech, Lake Champlain Basin Program, and the Rivers Program used the available hydrology, soil erodibility, and stream geomorphology data to estimate the streambank sediment and phosphorus contributions from the erosion processes (i.e., the movement of material) likely to play out starting at the existing channel evolution stage and, over a period of decades, concluding at an equilibrium stage where storage has been restored.[142] Although still rudimentary, this was a first-in-the-nation effort to include a fluvial geomorphic-based loading calculation in a large watershed TMDL.[143]

There are no dials to turn or units of treatment that can be added. The CWA construct of allocating a daily load and then ramping up the available technology to reduce that particular load is almost antithetical to the program needed to reduce streambank and channel erosion. We cannot structurally control erosion in streams without impairing the stream ecosystem and eventually making the erosion worse.

The Lake Champlain TMDL is remarkable, however, because it takes this round peg and puts it into the square hole. It embraces the idea that our success in reducing streambank and channel erosion will be measured by the removal of structures and the protection of natural floodplain functions, all of which will occur over a much greater time period than would have been believable under the societal pressures that typically exist when a TMDL is required.

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142. *Geomorphic Assessment*, *supra* note 44 (providing access to the Rivers Program's technical assistance for conducting geomorphic assessments); EDDY J. LANGENDOEN ET AL., LAKE CHAMPLAIN BASIN PROGRAM, QUANTIFYING SEDIMENT LOADINGS FROM STREAMBANK EROSION IN SELECTED AGRICULTURAL WATERSHEDS DRAINING TO LAKE CHAMPLAIN 45 (2012); TETRA TECH, INC., LAKE CHAMPLAIN BMP SCENARIO TOOL: REQUIREMENTS AND DESIGN 27 (2015) (explaining the process of channel evolution and impact of human development).

143. Author's Communication with Eric Perkins, Environmental Protection Agency, Region 1.

2. Flood Magnitudes and Frequencies Drive Spatial and Temporal Scales

A course of action that leans on the power of nature to heal begs the question, "How long is this going to take?" The answer lies in how quickly we are able to minimize our obstruction of floodplain redevelopment along incised streams and the length of time it takes for the channel evolution process to play out. The channel widening and floodplain formation stages of the evolution process are driven by floods and are therefore dependent on the magnitude and frequency of flood events.[144] The rate of the process is also a function of sediment supply.

An incised mid-section reach of Lewis Creek (in Addison County, Vermont) evolved and formed a new floodplain after several flood events over a period of five to ten years due to the large quantity of course gravels available in that part of the watershed.[145] By contrast, channel evolution in the incised reaches of the neighboring LaPlatte River may take many decades to play out because of the higher cohesive clay content of the banks and lower quantities of course sediment in the lower part of this watershed.[146] Variability is also introduced by changes in climate. If there are more floods in a wetter climate, floodplains will form faster over larger spatial scales and in a shorter period of time.[147]

B. Functioning Floodplains−Storage at a Landscape Scale

Streambank and channel erosion loads are indirectly reduced when human activities help convert the transport stream into a depositional stream. Instead of focusing on load measurements at the end of a pipe or ditch, the river and floodplain manager should measure available landforms where organic sediments and nutrients may settle and store during the higher frequency storms. At present, only the large, lower frequency floods

144. ZAIMES & EMANUEL, *supra* note 16, at 8.

145. DEP'T OF ENVTL. CONSERVATION, STREAM GEOMORPHIC ASSESSMENT OF LEWIS CREEK PILOT PROJECT REPORT 38 (2004).

146. LAPLATTE WATERSHED PARTNERSHIP, PHASE 2 STREAM GEOMORPHIC ASSESSMENTS LOWER LAPLATTE RIVER & MCCABE'S BROOKE: SHELBURNE AND CHARLOTTE, VERMONT 16 (2007), https://www.uvm.edu/~streams/PDFFiles/laplatte_watershed_partnership.pdf [https://perma.cc/75V8-F2RM].

147. STEPHEN K. HAMILTON, BIOCHEMICAL IMPLICATIONS OF CLIMATE CHANGE FOR TROPICAL RIVERS AND FLOODPLAINS (2009), http://www98.griffith.edu.au/dspace/bitstream/handle/10072/37818/69217_1.pdf?sequence=1 [https://perma.cc/S38R-WPZY].

will stage high enough to access many of Vermont's "abandoned" floodplains.[148]

As floodplains and floodplain forests are restored from headwaters down to the larger river, the watershed's ability to absorb the power of the great floods will also increase.[149] This is significant because not only should sediment transport be decreased year-in and year-out, but Vermont should address the types of dramatic spikes that were seen in 2011 (both from the spring floods and that from Tropical Storm Irene). Hill slope failures are a part of the natural world, but there is little question that the number and magnitude of mass wasting sites (high-eroding embankments) have increased due to the duration of higher flood velocities when great floods occur in a watershed that has been dredged and straightened into a "fire hose" condition.[150]

Based on Vermont's published stream geomorphic assessment data, approximately twenty-five percent of the state's stream miles have functioning floodplains.[151] Considering the nonhuman-caused channel incision, there is a goal of restoring natural floodplain function on up to two-thirds of the moderately to severely incised alluvial stream channels currently found in Vermont.

IV. HOLISTIC SYSTEM FOR PHOSPHORUS STORAGE AND FLOOD RESILIENCE

A. Equilibrium as an Organizing Principle

ANR employs the avoidance strategies that exist at the intersection of Vermont's social, economic, and environmental objectives. To meet the Lake Champlain TMDL requirements, the State and municipalities must implement the same land use protections that would be used to mitigate flood and fluvial erosion hazards. Likewise, to restore complex and self-sustaining river and riparian habitats, rivers are managed toward an equilibrium condition to meander within open corridors where wetland and

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148. *See* Bradley Materick, *Geomorphology: The Shape of a River Corridor*, *in* FRIENDS OF THE WINOOSKI: A PADDLING AND NATURAL HISTORY GUIDE TO ONE OF VERMONT'S GREAT RIVERS 29 (2011), http://winooskiriver.org/images/userfiles/files/Paddling%20Guide%203-31-2011%20low%20res.pdf [https://perma.cc/V2RD-VKWD] (demonstrating that erosion has caused the Winooski River floodplain to lower and that logically only a large flood would be able to reach the "abandoned" floodplain).

149. RIVERWAYS PROGRAM, FACT SHEET #1: FUNCTIONS OF RIPARIAN AREAS FOR FLOOD CONTROL, http://www.lexingtonky.gov/Modules/ShowDocument.aspx?documentid=3470 [https://perma.cc/BW5K-5M4E] (last visited May 11, 2016).

150. KLINE, *supra* note 17.

151. Kline & Cahoon, *supra* note 5, at 4.

floodplains capture and store phosphorus before it causes an algal bloom in the lake.

While this synergy has made it easier to create a greater constituency within the whole of the body politic, meaningful change will be difficult. It has taken more than a decade to get people to understand that we have been trying to solve bank erosion as though we can constrict a river in one place without it expanding in another. DEC was treating symptoms without understanding the disease. There is now a better understanding of the spatial and temporal scales at which erosion happens in a watershed, but we are not dealing with a single landowner or municipality. Achieving the least-erosive equilibrium conditions of a stream will require open valley-bottom land, of which there may be very little remaining in Vermont, depending on one's definition of "open." People who own riparian lands generally do not consider their lands as part of the commons; their lands are an investment for which they expect some form of remuneration.

The science helps make a compelling case that river corridor lands should be held in the public trust (i.e., a part of the commons) as they are essential to the health and welfare of the general public. At the present time, the policy has been to seek buyouts, purchase easements, or promote the municipal adoption of land use bylaws.[152] Many advocate for the State to establish jurisdiction over land use in river corridors, reasoning that to turn theory into practice at the municipal level (i.e., regulating your neighbor) will be very difficult.[153] To help dispel the misgivings about flood hazard zoning, Vermont Law School sponsored an important discussion to clarify that land use regulation for the purpose of protecting public safety has withstood legal challenge from a takings standpoint.[154]

Climate change and water resources may make Vermont an attractive place to live during the remainder of this century, leaving one to guess whether decreases in the number of municipal floodplain and river corridor project reviews would be offset by increases due to the pressures of immigration. With state rules, procedures, and mapping in place, flood damage occurring every year, and the TMDL requirements in place, the interest for broader state authority limiting encroachments in the river corridor is becoming more intensified.

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152. *River Corridor Planning, Protection, and Restoration*, *supra* note 63.

153. David K. Mears & Sarah McKearnan, *Rivers and Resilience: Lessons Learned from Tropical Storm Irene*, 14 VT. J. ENVTL. L. 177, 206–07 (2013).

154. KATHERINE BARNES ET AL., VT. LAW SCHOOL LAND USE CLINIC, MUNICIPAL FLOOD CONTROL REGULATION: LEGAL OPPORTUNITIES AND RISKS 81 (Katherine Garvey et al. eds., 2012), http://ecvermont.org/wp/wp-content/uploads/2013/02/TRORC-floods-final-082712.pdf [https://perma.cc/D37S-LPCZ].

An even thornier question is, "Will the existing open lands be enough to capture the flood flows, sediment, and nutrient that must be attenuated to achieve our public health and safety objectives and if not, how will the state compensate for the lands currently hosting crops or homes that might be needed for floodplain services?" At present, if your tool shed is on the river bank and becomes threatened, ANR is required to authorize bank stabilization unless it can show that the action will endanger someone else. We know that cumulatively each act of channelization makes us less safe and increases phosphorus loading, but definitively showing a singular cause and effect such that the State would condemn a person's investment is a very high bar.

At present, economics and the benefit-cost ratio may be driving the pace of our withdrawal from the river corridor. Channelization is becoming increasingly expensive and government programs are cost-sharing less and less (when we are not in flood recovery mode and politically motivated to make everyone whole). Some infrastructure is starting to move out of the corridor through planning and projects conducted by Green Mountain Power and VTrans.[155] Moving roads would make a very big difference if there could be enough of it; but again, it may come down to the question of, "When does the tool shed or the flood-damaged home need to be removed or should it only happen when the government can afford to buy the person out?"

B. Integration of Instream Process and Stormwater Treatment Systems

Stream geomorphic science tells us that when the flows of a stream are increased, it will equilibrate through erosion to gain a larger sediment load and/or increase resistance with a larger cross-section. Herein lies the important intersection of the stormwater and rivers programs now being expanded to meet the TMDL. The fact that untreated urban stormwater played a significant role in the incision and enlargement of Chittenden County streams is well documented.[156] Now with the role of agricultural

155. VT. AGENCY OF TRANSP., ADAPTING VERMONT'S TRANSPORTATION INFRASTRUCTURE TO THE FUTURE IMPACTS OF CLIMATE CHANGE: VTRANS CLIMATE CHANGE ADAPTATION WHITE PAPER 7–8 (2012), http://vtransplanning.vermont.gov/sites/aot_policy/files/documents/planning/Climate%20Change%20Adaptation%20White%20Paper.pdf [https://perma.cc/9WZZ-ASUG]; INST. FOR SUSTAINABLE CMTYS., VERMONT'S ROADMAP TO RESILIENCE: PREPARING FOR NATURAL DISASTER AND THE EFFECTS OF CLIMATE CHANGE IN THE GREEN MOUNTAIN STATE (2014), http://www.iscvt.org/wp-content/uploads/2014/06/vermonts-roadmap-to-resilience-web.pdf [https://perma.cc/FQ54-VHFV].

156. *See* VT. AGENCY OF NAT. RES., WINOOSKI RIVER BASIN WATER QUALITY MANAGEMENT PLAN 5, 43 (2012),

and municipal road-related stormwater being factored into the Lake Champlain TMDL, there is an increasing challenge to understand the nexus between the ditch and the stream.

New rules will attempt to define best practices that would reduce the hydrologic and instream modifications that often follow farmland and roadside drainage. In small watersheds, DEC and its partners will spend many days in the field deciphering where ditches end and perennial streams begin. Due to its investments in understanding river science, Vermont is uniquely poised to design an efficient process for delineating these intersections and learning to combine the traditional stormwater practices with stream equilibrium principles and practices.

One challenge is making the outlet of a stormwater conveyance blend into the natural floodplain as it enters the river corridor. If the ditch outfall, spreader, or settling area is hardened and becomes an immutable structure that must be protected from stream meander migration, then the stormwater treatment system becomes part of the overall channelization problem causing streambank and channel erosion. At present, ANR is working to ensure that state technical, regulatory, and funding assistance for stormwater treatment is predicated on system designs that do not further impede channel evolution or equilibrium processes within the river corridor.[157]

C. Lake Champlain TMDL Is a Milestone in U.S. Watershed Restoration

This article ends with a question: "Will Vermont's efforts to implement the Lake Champlain TMDL help create a populous that is striving to live and work outside the natural floodplain, entering the corridor only when we must, as a guest of the river?"

One could argue that never before has a state, with its local, regional, and federal partners, created the set of ingredients that might now be combined to bring about this cultural change. A TMDL written and adopted by EPA that recognizes the space and time needed to not only accommodate new structural pollution treatment systems but the nature-driven processes that will create functioning, landscape-level treatment systems, is truly a milestone in U.S. watershed restoration.

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http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_basin8final.pdf [https://perma.cc/7FJH-SMN9] ("The basin occupies . . . a little less than half of Chittenden County.").

157. *Stormwater Program*, VT. DEP'T OF ENVTL. CONSERVATION, http://dec.vermont.gov/watershed/stormwater [https://perma.cc/E6ZD-A27H] (last visited May 11, 2016).

STORMWATER RUNOFF FROM DEVELOPED LANDS

Julie Moore

INTRODUCTION

Stormwater runoff is water from rain or melting snow that "runs off" across the land instead of soaking (or infiltrating) into the ground. This runoff flows over the surface of the land to the nearest stream, creek, river, lake, or pond (a "receiving water"). Stormwater runoff that receives little or no treatment before it reaches a receiving water can pick up and carry many pollutants. These contaminants can include sediment and other pollutants from construction sites, agricultural land, the surface of gravel roads, anywhere bare soil exists, as well as trash, pet waste, poorly managed grass clippings and yard waste, residuals from pesticide and fertilizer applications, and sand and salt from winter road treatments, all of which can harm receiving waters in sufficient quantities.[1]

Polluted runoff often occurs anywhere people use or alter the land. Much of the pollution problem in the developed—especially urban—landscape is caused when untreated runoff from hard—or impervious—surfaces such as rooftops, patios, sidewalks, driveways, parking areas, and roadways cannot seep into the ground and instead is conveyed directly to the nearest stream via ditches and storm drains. In Vermont, about ninety percent of our annual storm events result in one inch or less of rainfall.[2] Although such individual storm totals may sound modest, a one-inch rainstorm over one acre in an urban setting with a high percentage of impervious surfaces can produce upwards of 25,000 gallons of runoff compared to only about 2,000 gallons of runoff in a forested environment.[3] Further, a significant body of research has shown that, across a variety of climates and ecologies, once ten percent of a watershed's area is covered with impervious surfaces, receiving waters show clear signs of declining health – including impacts to hydrology and flow regimes, channel stability, in-stream habitat, water quality, and biological diversity.[4]

Current estimates from the U.S. Environmental Protection Agency ("EPA") suggest that although developed lands constitutes only 5% of the land use in the Lake Champlain Basin, phosphorus loading in stormwater runoff from developed areas comprises approximately 13.8% of the total phosphorus load delivered to the lake annually.[5] When compared to the estimated phosphorus loading from the agricultural sector—estimated to contribute about 38% of the nonpoint source phosphorus load to the lake[6]—developed lands contribute a smaller portion of phosphorus loading.

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1. NAT'L RESEARCH COUNCIL OF THE NAT'L ACADS., COMM. ON REDUCING STORMWATER DISCHARGE CONTRIBUTIONS TO WATER POLLUTION, URBAN STORMWATER MANAGEMENT IN THE UNITED STATES vii, 5 (2009), http://www.nap.edu/catalog/12465/urban-stormwater-management-in-the-united-states [https://perma.cc/DG2D-CW76].

2. VT. AGENCY OF NAT. RES., THE VERMONT STORMWATER MANAGEMENT MANUAL, VOL. 1 – STORMWATER TREATMENT STANDARDS 1-1, 1-3 (Apr. 2002), http://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Resources/sw_manual-vol1.pdf [https://perma.cc/G8FE-9V4N] [hereinafter VERMONT STORMWATER MANUAL].

3. N.H. DEP'T OF ENVTL. SERVS., NEW HAMPSHIRE STORMWATER MANUAL, APPENDIX E: BMP POLLUTANT REMOVAL EFFICIENCY (2008), http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_apxe.pdf [https://perma.cc/V46L-ZSTE] [hereinafter APPENDIX E]

4. Thomas R. Schueler et al., *Is Impervious Cover Still Important? Review of Recent Research*, 14 J. HYDROLOGIC ENG'G 309, 309-10, 313 (Apr. 2009).

5. LAKE CHAMPLAIN BASIN PROGRAM, ISSUES IN THE BASIN: LAKE CHAMPLAIN BASIN ATLAS (2008), http://atlas.lcbp.org/HTML/is_pnps.htm [https://perma.cc/7CP7-D8ME]; STATE OF VT., VERMONT LAKE CHAMPLAIN PHOSPHOROUS TMDL PHASE 1 IMPLEMENTATION PLAN 14, 36 (2015), https://www.vtbar.org/UserFiles/Files/EventAds/2a%20TMDL%20Materials%20Part%202a.pdf [https://perma.cc/A9T3-2SH5] [hereinafter PHASE I IMPLEMENTATION PLAN].

6. ISSUES IN THE BASIN, *supra* note 5.

However, on an acre-for-acre basis, developed-land areas generate a disproportionate share of the phosphorus load to the lake.

I. TRADITIONAL STORMWATER MANAGEMENT

Traditionally, stormwater runoff has been drained away from our homes, businesses, parking lots, and roads as quickly as possible through the use of gray or hard infrastructure—networks of drainage systems that combine gutters, curbs, storm sewers, and ditches, which carry runoff directly to the nearest receiving water without further management or treatment. While this infrastructure is very efficient in conveying runoff, it can cause significant stormwater management problems because it prevents natural infiltration processes and speeds water movement.[7] Because gray infrastructure does little to improve water quality and reduce water quantity, stormwater discharges from these systems often contribute to unhealthy stream flow regimes marked by high peak flows and chronic flash flooding, altered stream morphologies, elevated nutrient and contaminant levels, excessive sedimentation, loss of species diversity, and higher water temperatures.[8]

First generation stormwater controls focused on addressing the peak rate of storm water discharge from flood-producing storm events.[9] In the early 2000s, the need for improved stormwater management began to receive more significant attention. As stormwater management efforts evolved, they tended to be multi-pronged and included efforts to minimize the impacts of post-construction stormwater runoff by working to mimic pre-development hydrology. The suite of metrics used to guide the stormwater management design often included:

- minimizing the increase in the peak runoff rate;
- providing storage for volume, peak flow control, and water quality; and,
- providing detention storage, if required, to prevent flooding.[10]

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7. AM. RIVERS, GREEN INFRASTRUCTURE TRAINING, https://www.americanrivers.org/threats-solutions/clean-water/stormwater-runoff/ [https://perma.cc/64DP-S73P] (last visited Apr. 4, 2016).

8. VT. LEAGUE OF CITIES & TOWNS, VERMONT GREEN STORMWATER INFRASTRUCTURE (GSI) SIMPLIFIED SIZING TOOL FOR SMALL PROJECTS: FACT SHEET NO. 1: INTRODUCTION 2 (2015), http://www.vlct.org/assets/MAC/2015_GSI-Simplified-Sizing-Tool-Fact-Sheets.pdf [https://perma.cc/VE7N-Z2H9] [hereinafter FACT SHEET NO. 1].

9. OHIO ENVTL. PROT. AGENCY, POST-CONSTRUCTION Q&A DOCUMENT 2 (2007), http://www.epa.ohio.gov/dsw/storm/CGPPCQA.aspx#116545725-4-why-is-ohio-epa-requiring-the-implementation-of-post-construction-bmps [https://perma.cc/U8XM-25VF].

10. STONE ENVTL. INC., ADVANCED STORMWATER STANDARDS COMPILATION: FINAL REPORT (2012),

II. Stormwater Management Regulations in Vermont

Stormwater management for the developed landscape is particularly challenging in the Lake Champlain Basin, not only due to the decentralized nature of the discharges and the disparity of needs and funding between Vermont's modest cities and rural communities, but also (and perhaps especially) due to the multiple levels of government (local, state, and federal) responsible for implementing regulations and providing policy guidance.

The Clean Water Act of 1972 ("CWA") focused efforts on the protection of rivers, streams, and lakes from pollution.[11] As part of this Act, EPA created the National Pollutant Discharge Elimination System ("NPDES"). NPDES is used to track and control sources of pollution through permits. EPA delegated the authority to issue and to enforce NPDES permits to the State of Vermont in 1974.[12] Beginning in 1997, the State of Vermont regulated discharges from large construction sites under the NPDES program.[13] Since that date, all construction projects that disturb five or more acres of soil have been required to install and maintain adequate erosion prevention and sediment control measures. Since September 2006, all construction projects disturbing [one acre or more of] soil must obtain authorization to discharge from their construction project, and usually this authorization occurs under Vermont Agency of Natural Resources' ("ANR") Stormwater Construction General Permit.[14]

In addition to managing construction-related disturbance under the CWA, Vermont has adopted its own stormwater permitting program to help manage the post-construction stormwater discharges that federal law leaves unregulated.[15] ANR has issued operational permits under state authority since the late 1970s, with the scope of the permit program expanding over

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http://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/ManualUpdate/sw_advanced_standards_compilation.pdf [https://perma.cc/6J2H-3WK8].

11. U.S. Envtl. Prot. Agency, Laws & Regulations: Summary of the Clean Water Act, http://www.epa.gov/laws-regulations/summary-clean-water-act [https://perma.cc/R8W9-YFZC] (last updated Oct. 8, 2015).

12. Laura Murphy, *Story of a De-Delegation Petition: Nuts, Bolts, & Happy Endings in Vermont*, 15 Vt. J. Envtl. L. 565, 567 (2014), http://vjel.vermontlaw.edu/files/2014/04/Murphy_forprint.pdf [https://perma.cc/P2BG-4SVM].

13. Kim L. Greenwood, Unchecked and Illegal: How ANR Is Failing To Protect Vermont's Lakes and Streams, Vt. Nat. Resources Council (2008), http://vnrc.org/wp-content/uploads/2012/09/Unchecked_and_Illegal.pdf [https://perma.cc/3CHS-RXZB].

14. *Id.* at 9; State of Vt., Agency of Nat. Res., Dep't of Envtl. Conservation, General Permit for 3-9020 for Stormwater Runoff from Construction Sites 2–3 (2008).

15. Daniel D. Dutcher & David J. Blythe, *Water Pollution in the Green Mountain State: A Case Study of Law, Science and Culture in the Management of Public Water Resources*, 13 Vt. J. Envtl. L. 705, 718 (2012), http://vjel.vermontlaw.edu/files/2013/06/Water-Pollution-in-the-Green-Mountain-State.pdf [https://perma.cc/TAX8-Y86J].

time.[16] "Program technical standards were updated in 1980, 1987, 1997, and 2002."[17] Jurisdiction under Vermont's stormwater permitting program depends on the amount of impervious surface created by new development, and since 2002 it has been set at one acre of impervious cover.[18] Although Vermont adopted its first standards for stormwater treatment in 1981, and those have undergone several significant revisions, current standards are largely unchanged since the Vermont Stormwater Management Manual was promulgated in 2002.[19]

Although, compared to many other states, Vermont has a relatively long history of stormwater management, the majority of existing impervious surface in Vermont, however, was developed before the current post-construction stormwater regulations went into effect in 2002 or "was sub-jurisdictional at the time of development, and consequently does not have stormwater permit coverage" or, often, any stormwater treatment system.[20] Further, a significant percentage of new development currently occurring in Vermont falls below the one-acre of impervious surface jurisdictional threshold, with stormwater discharge permitting applying primarily to commercial and industrial sites and, to a more limited extent, highway projects and large residential developments.[21] This is evidenced, in part, by the fact that ANR receives approximately three times as many applications for construction permit coverage where the regulatory threshold is one acre of disturbance as it does applications for post-construction permit coverage where the threshold is one acre of impervious surface.[22] Thus, a large percentage of known construction activity does not currently require an operational stormwater permit, meaning that post-construction stormwater management practices may not be implemented on the majority of new land development projects in the state.[23] This "unregulated development contributes to existing water quality

16. PHASE I IMPLEMENTATION PLAN, *supra* note 5, at 37.

17. *Id.*

18. *Id.*; Dutcher & Blythe, *supra* note 15.

19. VT. AGENCY OF NAT. RES., THE VERMONT STORMWATER MANAGEMENT MANUAL (2002), http://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Resources/sw_manual-vol1.pdf [https://perma.cc/B3ZX-7ENY].

20. VT. AGENCY OF NAT. RES., REPORT ON REGULATORY THRESHOLD FOR PERMITTING STORMWATER RUNOFF FROM IMPERVIOUS SURFACES: A RECOMMENDATION ON WHETHER THE LEGISLATURE SHOULD LOWER THE REGULATORY PERMITTING THRESHOLD FOR AN OPERATING PERMIT FOR STORMWATER RUNOFF IN 10 V.S.A. § 1264, 3 (Jan. 15, 2016), http://legislature.vermont.gov/assets/Legislative-Reports/2016-Act-64-Report-on-half-acre-stormwater-threshhold-Final.pdf [https://perma.cc/GBC5-PACF] [hereinafter VERMONT IMPERVIOUS SURFACE REPORT].

21. *Id.*

22. *Id.*

23. *Id.*

impairments, including excess sediment and scour in stormwater-impaired waters, and excessive phosphorus loading in Lake Champlain."[24]

In January of 2016, ANR filed a report with the Vermont legislature recommending that the post-construction permitting threshold be reduced to half-an-acre of impervious cover from the current one acre.[25] In its report, ANR estimated that this would result in a doubling of the number of post-construction stormwater permits issued annually, requiring treatment for an additional 100 acres of new construction each year.[26] This is important because although several Vermont communities have adopted robust local permitting standards for post-construction stormwater management, many communities have been reluctant to adopt standards stricter than state requirements, fearing that they could hinder business development.[27] Thus, absent expanded state regulation, is it unlikely treatment measure would be required for development activities creating between one-half and one acre of impervious cover.

III. Importance of Local Land Use Decisions in Managing Stormwater Runoff

Prior to the arrival of European colonists, the Lake Champlain Watershed mainly comprised vast tracts of forested land and wetlands and a limited amount of meadows and some farmland, all of which slowed runoff and captured and absorbed sediment and nutrients. Land development has altered or eliminated many of the features that moderate stormwater runoff, exposing soil to erosion. Intensified runoff carries soil and other pollutants into streams, lakes, rivers, and estuaries. Downstream, bank erosion and flooding increase and even upstream communities begin to experience road washouts and flooded basements.[28] Instead of a valuable resource, stormwater becomes a costly and sometimes dangerous problem.[29]

Where and how communities grow has a dramatic effect on water quality. Preventing water quality impacts requires that precautions be taken before, during, and after land development. In Vermont, municipal governments have principal responsibility for controlling land use and

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24. *Id.*

25. *Id.* at 2.

26. *Id.* at 3–4.

27. Two Rivers Ottauquechee Regional Planning Commission, Stormwater: The Unseen Threat to Vermont's Waters (2013), http://ecvermont.org/wp/wp-content/uploads/2013/03/Stormwater-TRORC-FINAL_7-23-13.pdf [https://perma.cc/BX87-4ML5].

28. N.Y. State Dep't of Envtl. Conservation & N.Y. State Dep't of State, Stormwater Management Guidance Manual for Local Officials 1 (2004), http://www.dec.ny.gov/docs/water_pdf/localall.pdf [https://perma.cc/YPG4-YYZS].

29. *Id*.

development. Because only a small amount of development in Vermont is regulated under existing federal or state permits, municipalities are largely left to manage stormwater in a way that suits their own individual conditions. However, integrating stormwater management into local land use regulations is not straightforward. A complicated web of local codes and standards often intersects with and even conflicts with stormwater management goals, including zoning and subdivision regulations, land use policies, floodplain regulations, and public works specifications.

It is not enough to implement a stormwater bylaw or ordinance, which implements standards for construction-related and/or post-construction stormwater management at the local level. While treating runoff from construction sites and newly created impervious areas is an important best practice, such measures capture only fraction, albeit a significant fraction, of stormwater runoff and its attendant pollutants.[30] Even if a development receives a stormwater permit, the permit is in effect permission to pollute and results in an additional load that the receiving water needs to bear.[31] Typical literature values for sediment removal in post-construction stormwater practices averages 80-90%, while phosphorus removal averages 40-65%.[32] Put another way, runoff from a forested acre is estimated to yield 0.10 pounds of phosphorus annually as a result of stormwater runoff, as compared to an acre in a medium density urban area which yields 2.58 pounds of phosphorus annually.[33] If stormwater management practices can reliably capture 65% of the 2.58 pounds, there is still a net increase of phosphorus loading of about 0.90 pounds per year as a result of every acre of impervious surface created.[34] As such, the most important strategies for reducing stormwater-related pollution are better planning and policies that seek to minimize site disturbance and the creation of impervious cover and preserving important site natural features.[35]

30. APPENDIX E, *supra* note 3.

31. *See* CHESAPEAKE BAY FOUNDATION, *The Chesapeake Clean Water Blueprint* (2016) http://www.cbf.org/how-we-save-the-bay/chesapeake-clean-water-blueprint/watershed-wide-pollution-limits [https://perma.cc/H3DB-4BPA] (explaining the pollution limits Chesapeake Bay can handle in conformance with its TMDL).

32. APPENDIX E, *supra* note 3.

33. N.H. DEP'T OF ENVTL. SERVS., NEW HAMPSHIRE STORMWATER MANUAL, APPENDIX D: TYPICAL STORMWATER POLLUTANT EMCS (2008), http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_apxd.pdf [https://perma.cc/BJF8-W3VR] (the author calculated 2.58 pounds of phosphorus captured by converting milligrams per liter to pounds per liter and applying the amount of runoff over an acre of medium-development-density land in the Lake Champlain Basin (21.8 inches of runoff)).

34. *Id.*

35. N.J. DEP'T OF ENVTL. PROT., NEW JERSEY BEST MANAGEMENT PRACTICES MANUAL 2-2 to 2-6 (2004), http://www.njstormwater.org/bmp_manual/NJ_SWBMP_2%20print.pdf [https://perma.cc/F8QY-XXEA].

Factors at the site-, neighborhood- and municipal-scale can all drive the creation of unnecessary impervious cover. These factors are often embedded in a community's land use codes and policies. A comprehensive approach to stormwater management therefore must include an examination of local land development regulations, policies, and ordinances to better align with watershed- and state-level water quality goals.[36] Existing land use regulations and road ordinances can even create unintentional barriers to or disincentives for stormwater best practice—often driving the creation of additional impervious surfaces via setback requirements, minimum road widths to serve as few as two homes, and parking minimums for commercial establishments.

Most Vermont municipalities engage in stormwater management at the site level by restricting development within the riparian buffer, wetlands, or other critical natural features. However, also engaging at the neighborhood or municipal scale can have far greater water quality benefits.[37] Including specific language in town plans that supports the protection and restoration of strategic natural features, such as riparian areas, articulates a clear preference for approaches that work to manage stormwater as close to its source as possible and improves a community's resilience to climate change is a strategy that can help provide a vision for future development.

IV. APPROACHES TO STORMWATER MANAGEMENT THROUGH THE LAND DEVELOPMENT PROCESS

When a vegetated watershed is deforested and paved, its streams see significantly higher peak flows during storms and often slow to a trickle between events—impacting fish and other smaller organisms that live on or in the bottom of the stream. High flows also scour streambanks and in-stream infrastructure, such as bridge abutments. Regulators and designers alike are striving to reverse these trends through the use of better stormwater management practices and by protecting pristine watersheds through preserving forests, soils, and native bedrock structure.[38] The purpose of the construction stormwater controls is to protect water resources from sediment and other pollutants while post-construction practices also incorporate water quantity controls for both routine and

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36. *Id.*

37. *Id.* at 3-3.

38. *Maintaining Pre-Development Hydrology: The Eight Hydrologic Functions of Forests and Trees*, DEEPROOT: GREEN INFRASTRUCTURE FOR YOUR COMMUNITY (Sept. 19, 2011), http://www.deeproot.com/blog/blog-entries/maintaining-pre-development-hydrology-the-eight-hydrologic-functions-of-forests-and-trees [https://perma.cc/9R3K-24HX].

extreme storm events. Effective stormwater management once construction is complete must include both water quality and water quantity controls.[39]

A. Construction Stormwater Management

When stormwater drains off a construction site, it carries sediment and other pollutants that harm lakes, streams, and wetlands. EPA estimates that 20 to 150 tons of soil per acre are lost every year to stormwater runoff from construction sites.[40] Preventing erosion can significantly reduce the amount of sediment and other pollutants transported by runoff from construction sites. For projects that will disturb more than one acre of land (e.g., involving clearing, grading, and excavating activities), site owners must obtain a permit from ANR. The permit requires implementation of a suite of sediment control, erosion, and pollution prevention measures. Since 2006, planned NPDES-permitted construction disturbance has averaged 1,500 acres per year.[41] There are no estimates available as to the number of acres per year of sub-jurisdictional construction activities, meaning projects that disturb less than one acre and therefore do not trigger state-level regulatory oversight in Vermont, but it is understood to be significantly more than the area of permitted construction disturbance[42].

"Uncontrolled runoff from construction sites is a water quality concern because of the devastating effects that sedimentation can have on local waterbodies."[43] In addition to concerns related to sediment pollution (because phosphorus tends to cling to soil particles), exposed soils at construction sites can result in large flushes of phosphorus to nearby receiving waters.[44] Numerous studies have shown that the amount of sediment—and attendant phosphorus—transported by stormwater runoff from construction sites with no controls is significantly greater than from sites with controls. During storms, construction sites may be the source of sediment-laden runoff, which can overwhelm a small stream channel's

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39. VERMONT STORMWATER MANUAL, *supra* note 2, at 1-1.

40. U.S. ENVTL. PROT. AGENCY, REPORT TO CONGRESS ON THE PHASE II STORM WATER REGULATIONS I-4 (1999), http://yosemite.epa.gov/ee/epa/ria.nsf/vwAN/W999C.pdf/$file/W999C.pdf [https://perma.cc/SQE4-4MNM].

41. VT. AGENCY OF NAT. RES. & VT. AGENCY OF AGRIC., FOOD & MKTS., VERMONT ECOSYSTEM RESTORATION PROGRAM: 2011 ANNUAL REPORT 37 (2012), http://www.leg.state.vt.us/reports/2012ExternalReports/276255.pdf [https://perma.cc/65HL-AVFX].

42. Personal communication with Kari Dolan, Ecosystem Restoration Program Manager, Vt. Dep't of Envtl. Conservation.

43. U.S. ENVTL. PROT. AGENCY, FACT SHEET 1.0 – STORMWATER PHASE II FINAL RULE: AN OVERVIEW 2 (2005), https://www.epa.gov/sites/production/files/2015-11/documents/fact1-0.pdf [https://perma.cc/P7ZT-6NS5].

44. VT. DEP'T OF ENVTL. CONSERVATION & N.Y. STATE DEP'T OF ENVTL. CONSERVATION, LAKE CHAMPLAIN PHOSPHORUS TMDL 65 (2002), http://www.dec.ny.gov/docs/water_pdf/champlain_final_tmdl.pdf [https://perma.cc/CDQ6-XA7J].

capacity, resulting in streambed scour, streambank erosion, and destruction of near-stream vegetative cover. Where left uncontrolled, sediment-laden runoff has been shown to result in the loss of in-stream habitat for fish and other aquatic species, an increased difficulty in filtering drinking water, the loss of drinking water reservoir storage capacity, and negative impacts on the navigational capacity of waterways.

B. Post-Construction Stormwater Management

The intent of post-construction management is to ensure that stormwater runoff from developed land does not negatively impact receiving waters either through hydrologic impacts or pollutant discharges. Hydrologic impacts coupled with the increased concentration of pollutants contained in stormwater runoff from developed lands result in degradation of the water resources to which the stormwater is discharged. The smaller the receiving stream, the greater the importance of controlling the hydrologic and subsequent hydraulic impacts of the construction project and its resultant impervious surfaces. Since 2006, Vermont has permitted an additional 233 acres of impervious surface each year,[45]—issuing more than 1,900 permits for post-construction stormwater management.[46] The state has also estimated that there is more than 100 acres of sub-jurisdictional impervious surface constructed each year, meaning the impervious surface is constructed on projects that are too small to trigger state regulatory oversight[47]; EPA has estimated the annual increase sub-jurisdictional impervious surface to be equal to the change in jurisdictional impervious.[48]

C. Municipal Separate Storm Sewer Systems ("MS4s")

In Vermont, there are currently twelve communities and three non-traditional entities (the Vermont Agency of Transportation, the University of Vermont, and the Burlington International Airport) designated as Municipal Separate Storm Sewer System ("MS4") permit holders. Under the federal MS4 permitting program, permittees must develop a stormwater management program that includes six Minimum Control Measures ("MCMs") designed to reduce the potential for pollutants to enter the MS4

45. U.S. ENVTL. PROT. AGENCY, TOTAL MAXIMUM DAILY LOAD DOCUMENT AND APPENDICES FOR VERMONT SEGMENT OF LAKE CHAMPLAIN, APPENDIX A: FUTURE GROWTH FROM DEVELOPED LANDS IN THE LAKE CHAMPLAIN BASIN 1 (2015), https://www.epa.gov/sites/production/files/2015-09/documents/appendix-a-future-growth.pdf [https://perma.cc/X5RG-N8B7] [hereinafter APPENDIX A].

46. Personal communication with Kari Dolan, *supra* 42.

47. VERMONT IMPERVIOUS SURFACE REPORT, *supra* note 20, at 4.

48. Personal communication with Kari Dolan, *supra* 42.

and discharge to surface waters. The MCMs include public education and outreach, public participation/involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping. The regulated MS4s permit holders submit annual reports detailing their progress on MCM implementation.

In addition, fourteen of the fifteen regulated MS4s discharge to receiving waters that have been identified as stormwater impaired and, as such, are required to develop Flow Restoration Plans ("FRPs") to reduce peak flows that reach the receiving waters during storms.[49] It is anticipated that the deployment of stormwater management infrastructure in implementing the FRPs will also contribute substantially to phosphorus reduction in Lake Champlain.[50] Regulated MS4 municipalities are required to track phosphorus reductions associated with these projects.[51]

D. Stormwater Discharges Associated with Industrial Activities

Vermont's Multi - Sector General Permit ("MSGP") addresses stormwater runoff associated with most industrial facilities. All permittees are required to implement best management practices ("BMPs"), such as good housekeeping, erosion prevention, and minimizing exposure, all of which serve to reduce potential pollutant discharges. Facilities manufacturing agricultural chemicals are required to monitor specifically for phosphorus in their stormwater discharges. If monitoring results are above the level set in the permit, the facilities must modify their plans to reduce the phosphorus discharge.

E. Stormwater Retrofits

In Vermont, a significant amount of impervious surface is not governed by a stormwater permit—by some estimates as much as ninety percent of all the impervious surface that currently exists statewide.[52] Many of these existing untreated or inadequately treated surfaces will require retrofits as part of an overall strategy to reduce nutrient and sediment loads in order to meet pollutant reduction targets for existing developed lands under the Lake Champlain Phosphorus TMDL.[53] "Stormwater retrofits are a diverse group of projects that provide nutrient and sediment reduction on existing

49. PHASE I IMPLEMENTATION PLAN, *supra* note 5, at 33.
50. *Id.*
51. *Id.*
52. *Id.* at 36.
53. *Id.* at 39.

development that is currently untreated by any BMP or is inadequately treated by an existing BMP."[54]

The primary challenges with stormwater retrofits are that most of Vermont's core developed areas are characterized by highly connected impervious surfaces, aging infrastructure, and limited pervious or open areas where retrofits can be successfully sited. These challenges are often compounded when the open space that is available is not particularly suitable for stormwater management. In these high-traffic areas, acceptance by the people who use the spaces where the controls are located is vitally important. Public perceptions and concerns about hydrologic performance (soil characteristics, standing water, and public health issues), safety, construction-related inconveniences, and maintenance needs are challenges to overcome for community acceptance and implementation of stormwater retrofits.[55]

F. Low Impact Development and Green Stormwater Infrastructure

Urbanization and development typically alter the landscape's hydraulic and hydrologic regimes—but this is not inevitable. Through the use of a combination of

> structural, nonstructural, and institutional practices, functional, environmentally friendly, sustainable, and beautiful living environments can be created. Surface and stormwater management play a large role in this movement.
>
> There have been many popularly named approaches that address some or all of these elements, including Low Impact Development (LID), Green [Stormwater] Infrastructure [("GSI")], Better Site Design, and Conservation Development . . . .[56]

These approaches to stormwater management are a significant shift from traditional gray infrastructure approaches that have been widely-used in Vermont and throughout the country because they are intrinsically

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54. Tom Schueler & Ceclia Lane, *Recommendations of the Expert Panel To Define Removal Rates for Urban Stormwater Retrofit Projects*, CHESAPEAKE STORMWATER NETWORK 4 (Jan. 20, 2015), http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2012/10/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Retrofits-short_012015.pdf [https://perma.cc/QNC9-SV9Z].

55. *Using Rainwater To Grow Livable Communities: Sustainable Stormwater Best Management Practices*, WATER ENV'T RES. FOUND. (2009), https://www.werf.org/liveablecommunities/toolbox/retrofit_chal.htm [https://perma.cc/4VPY-PPZS].

56. THOMAS N. DEBO & ANDREW J. REESE, MUNICIPAL STORMWATER MANAGEMENT 9 (2d ed. 2003).

decentralized, requiring a network of site-scale practices. Fundamentally, each of these approaches seeks to:

- Mimic[] acceptable hydrology . . .
- Balanc[e] ecological preservation and conservation with economic growth and development
- Build[] systems that are sustainable and maintainable
- Work[] at a small, integrated scale with accumulated results
- Deal[] with stormwater as a valuable resource.[57]

Vermont's Green Infrastructure ("GI") Initiative is a statewide effort that seeks to increase the adoption of LID principles and implementation of GSI practices. The Initiative works to implement strategies identified within the GI Strategic Plan. The Strategic Plan is supported by Executive Order 06-12 ("EO"), signed in March of 2012.[58] The EO calls for the creation of an Interagency Green Infrastructure Council, which includes the secretaries of the agencies of Natural Resources, Transportation, Commerce and Community Development and the Commissioner of Buildings and General Services or their designees.[59] The Council is tasked with identifying opportunities for integration of GSI practices in existing programs, initiating a process for developing GSI technical guidance, establishing a plan for implementing GSI on state properties and projects, identifying agency liaisons, identifying and undertaking GSI research and monitoring, and identifying sustainable funding sources.[60] Members of the Council are also tasked with developing a GSI Implementation Work Plan for their respective agency or department.[61] Work plans were completed on July 1, 2013 and the EO is in effect until January 1, 2017.[62] From 2009 until 2015, ANR staffed a GI coordinator position that led this initiative.[63] In August of

57. *Id.*

58. Exec. Order No. 06-12, STATE OF VT. EXEC. DEP'T (Mar. 7, 2012), http://governor.vermont.gov/sites/shumlin/files/documents/EO%2006-12%20Interagency%20Green%20Infrastructure%20Council.pdf [https://perma.cc/5AHT-7ZK9].

59. *Id.*

60. *Id.*

61. *Id.*

62. *Id.*; AGENCY OF ADMIN. ET AL., STATE OF VERMONT GREEN STORMWATER INFRASTRUCTURE AGENCY WORK PLANS (2013), http://bgs.vermont.gov/sites/bgs/files/pdfs/GSI_Work_Plan_Final.pdf [https://perma.cc/K5Q3-YWJ8] [hereinafter WORK PLANS].

63. WORK PLANS, *supra* note 62, at 16.

2015, lead responsibility for the Initiative was transferred to the Lake Champlain Sea Grant.[64]

Municipalities can incorporate LID and GSI into bylaws and ordinances in a variety of areas, including zoning districts, subdivision regulations, planned unit developments, dimensional requirements, stormwater management standards, erosion prevention and sediment control standards, river corridor and floodplain management regulations, flood and erosion hazard area bylaws, wetland regulations, riparian buffer or setback ordinances, habitat protection standards, transfer of development rights, building codes, and public works specifications.[65] The Vermont League of Cities and Towns recently introduced a Green Stormwater Infrastructure Toolbox, which includes both a model LID/GSI stormwater management bylaw and a spreadsheet-based tool to aid in the design of GSI practices for small sites.[66] In addition, also in 2015, the Vermont Association for Planning and Development Agencies ("VAPDA") published a Green Infrastructure Toolkit for Municipalities.[67] The toolkit is intended to serve as a clearinghouse of information for Vermont municipalities seeking to further investigate GSI policies and practices.[68]

V. VERMONT-SPECIFIC STORMWATER MANAGEMENT CHALLENGES

There are a number of challenges—perceived and real—related to on-going efforts to improve stormwater management in Vermont in order to reduce the impacts of the developed landscape on nearby receiving waters and the ultimate receiving water: Lake Champlain. These include designing GSI practices that are able to achieve water quality targets not only during the growing season, but during colder weather and that recognize and effectively address the limited infiltration capacity of many Vermont soils.

64. *Green Infrastructure Collaborative by DEC and UVM*, FLOW: ANRWSMDBLOG (Aug. 19, 2015), http://vtwatershedblog.com/2015/08/19/green-infrastructure-collaborative/ [https://perma.cc/U6J3-MZ3X].

65. VT. DEP'T OF ENVTL. CONSERVATION, LOW IMPACT DEVELOPMENT GUIDE FOR RESIDENTIAL SMALL SITES (2010) http://www.watershedmanagement.vt.gov/stormwater/htm/sw_gi_lid.htm [https://perma.cc/EKQ7-BGJP].

66. FACT SHEET NO. 1, *supra* note 8, at 1.

67. *Green Infrastructure Toolkit for Vermont Municipalities*, VT. PLANNING INFO. CTR., http://www.vpic.info/GreenInfrastructureToolkit.html [https://perma.cc/8SRU-4G9P (last visited April 9, 2016).

68. *Id.*

A. Cold Climate Considerations

Stormwater management practice designs in Vermont must consider the impacts of snowmelt.

> The heart of the problem with [runoff from] snowmelt is that water volume in the form of snow and ice builds for several months and suddenly releases with the advent of warm weather in the spring or during short interim periods all winter long. The interim melts generally do not contribute a significant volume of runoff when compared to the large spring melt. [While] snowmelt peaks are substantially less than those from rainfall, [] the total event volume of a snowmelt, although it occurs over a much longer period, can be substantially more. Ignoring the contribution of these large, spring melts to the annual runoff and pollution loading analysis could be a major omission in a watershed analysis. This type of comparison also shows why facility design is critical to the proper quantity and quality management of this meltwater.
>
> The water quality problems associated with [snowmelt] occur because the large volume of water released during melt and rain-on-snow events not only carries with it the material accumulated in the snowpack all winter, but also material it picks up as it flows over the land's surface. The winter accumulation can occur directly on a standing snowpack or on the side of a roadway where it is plowed. In either case, the material builds for several months prior to wash-off. Since snow is a very effective scavenger of atmospheric pollutants, [nearly] any airborne material present in a snow catchment will show up in meltwater when it runs off. Add to this the material applied to, or deposited on the land surface, for example to melt snow or prevent cars from sliding, and the wide range of potential pollutants becomes apparent. As with the volume of meltwater, a major portion of annual pollutant loading can be associated with spring melt events.
>
> The conventional pollutants of concern for most urban runoff situations are supplemented in meltwater runoff by additional contaminants added during the winter. The solids, nutrients, and metals present during the summer are joined by . . . salt and increased solids from [winter road treatments]. . . . Pesticide and fertilizer runoff and organic debris (leaves, grass clippings, seeds) are less of a concern during the winter.
>
> Part of the severity of the water quality problem associated with [snowmelt] is that it occurs when [many stormwater practices and

> receiving waters are] least able to deal with it. Routine assumptions on biological activity, aeration, settling, and pollutant degradation are altered by the cold temperatures, cold water and ice covered conditions that [in Vermont] prevail for many months. [A late winter] rain-on-snow event often presents the worst-case scenario when rain falls onto a deep, possibly saturated snowpack. The movement of a well-defined, rapidly moving wetted front through the snowpack results in the mobilization of soluble constituents, plus the energy associated with the rainfall is sufficient to mobilize the fine-grained or possibly larger solids and associated contaminants. This wave of melt also washes over urban surfaces and picks up material that has been deposited on these surfaces all winter.[69]

B. Soil Infiltration Capacity

Immediately after the last ice age, forty percent of Vermont was underwater, including much of the Champlain Valley.[70] The soils underlying this previously flooded land are rich in fine-grained clays and silts and these soils hold moisture better, are less acidic, and are more fertile than unflooded soils.[71] These fine-grained soils are often thought of as a challenge for stormwater management in that infiltration rates are minimal and therefore stormwater management BMPs are often thought to be limited to store-and-release practices such as ponds. On the contrary,

> There are many stormwater management practices that are appropriate on sites with low . . . . permeability soils.[72] The final selection of practices [depends] on many other factors including space availability, site topography, aesthetics, cost, maintenance, pollutant removal goals, and stormwater design criteria.[73]

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69. *Minnesota Stormwater Manual: Cold Climate Impact on Runoff Management*, MINN. POLLUTION CONTROL AGENCY, http://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management [https://perma.cc/8RBZ-W3MY] (last modified Dec. 2, 2015).

70. Chuck Wooster, *Vermont & New Hampshire: There's Something in the Soil*, N. WOODLANDS (Mar. 17, 2002), http://northernwoodlands.org/outside_story/article/vermont-new-hampshire-theres-something-in-the-soil [https://perma.cc/EKB3-3ZPW].

71. *Id.*

72. GREEN INFRASTRUCTURE CMTY. PARTNER & PITTSBURG UNITED, CLAY SOILS: GREEN INFRASTRUCTURE: OPPORTUNITIES FOR PITTSBURGH 1 (2013), http://www.3riverswetweather.org/sites/default/files/Clay%20Soils%20White%20Paper.pdf [https://perma.cc/K6ZL-HSK5].

73. *Id.*

C. Technical Capacity

In addition to the climate and landscape factors identified above, which present challenges in managing stormwater—and in particular in deploying GSI techniques—there is also a perceived lack of clarity in how GSI could be successfully employed to meet site needs and regulatory requirements and, in particular, compliance with the Vermont Stormwater Management Manual.[74] Vermont has worked to increase technical capacity within the design community over the past five years through its Green Infrastructure Initiative, but much work remains to be done in order for GSI techniques to become the preferred stormwater management approach.[75] It is anticipated that forthcoming revisions to the Vermont Stormwater Management Manual will help clarify how GSI techniques can be used to comply with Vermont's stormwater regulations.

D. Role of Stormwater Management in the Lake Champlain TMDL

Stormwater management is essential to achieving many of Vermont's water quality goals, including the successful implementation of the Lake Champlain TMDL. While other sources of phosphorus pollution within the basin are unlikely to see significant increases in the future, land development will continue as will attendant increases in stormwater runoff from those newly developed lands. EPA acknowledges this by assigning an allocation for future growth only to loads for stormwater runoff from developed lands in its draft revised Lake Champlain Phosphorus TMDL.[76]

The Lake Champlain Watershed's land area currently includes 3% impervious surface, which translates to roughly 140,000 acres of impervious surface in the Vermont portion of the basin.[77] Only 6% of Vermont's impervious surface area in the Lake Champlain Basin is currently subject to regulation under a state operational stormwater permit and an additional 12% of the impervious area is covered by the MS4

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74. VT. DEP'T OF ENVTL. CONSERVATION, THE VERMONT GREEN INFRASTRUCTURE INITIATIVE STRATEGIC PLAN: 2011-2013 (2011), http://dec.vermont.gov/sites/dec/files/wsm/erp/docs/sw_greeninfrastructureSP11-13.pdf [https://perma.cc/W7ZM-HZ4S].

75. *Id.*

76. U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 37 (2016).

77. Ryan Knox, Vt. Agency of Nat. Res., Lake Champlain NDVI Impervious Surface Project: Impervious Surface Layer for the Lake Champlain Basin (2012), http://anrmaps.vermont.gov/websites/vgisdata/layers_anr/metadata/LandLandcov_IMPERVLCB08.txt [https://perma.cc/FF4Z-JTBF].

permit.[78] This leaves approximately 115,000 acres of impervious surface that are not currently subject to any regulatory requirements for stormwater management. Runoff from impervious surfaces contributes nearly 20% of the total phosphorus delivered to Lake Champlain annually and the draft Lake Champlain Phosphorus TMDL will require the overall contribution from existing developed lands to be reduced by more than one-fifth (20.9%). In order to achieve this level of treatment, a significant number of impervious acres will need to be retrofitted with stormwater management practices.[79] The exact form these retrofits will take is not settled. While traditional stormwater management designs have provided treatment for both water quality and water quantity, there are newer approaches to stormwater management that may achieve a high level of nutrient reduction while providing little in the way of quantity management. Although space- and cost-effective for reducing nutrient loads, it is less clear if these approaches will be successful in achieving the ultimate water quality goals that have been established for Lake Champlain.

Many LID and GSI approaches have significant co-benefits, particularly in facing the challenges posed by climate change. Increasingly, climate models suggest Vermont's future will include more frequent and intense storm events, more precipitation as rain, and less snow in the winter[80]. More frequent and intense storm events in the future could lead to higher runoff volumes and more pollutants entering our waterways.[81]

In light of a changing climate, sound stormwater management adaptation strategies can preserve and strengthen the health of Lake Champlain and its watershed. More precipitation is expected, but the timing of precipitation events is less clear.[82] Though GSI techniques tend to have lower capacities for flood control, they can be effective in managing stormwater during small to moderate storm events. For larger events, LID principles including floodplain and wetland protection play an important role in reducing the impacts of increased high flows on the built and natural environments.

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78. STATE OF VT., VERMONT'S CLEAN WATER INITIATIVE 14 (2014), http://legislature.vermont.gov/assets/Legislative-Reports/303279.pdf [https://perma.cc/RT8P-6JTX].

79. APPENDIX A, *supra* note 45, at 8.

80. PETER C. FRUMHOFF ET AL., CONFRONTING CLIMATE CHANGE IN THE U.S. NORTHEAST: SCIENCE, IMPACTS, AND SOLUTIONS 8, 10, 31, 82 (2007), http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf [https://perma.cc/D9YL-43F9].

81. MARIKA DALTON, STEPHANIE CASTLE & ERIC HOWE, CLIMATE CHANGE AND STORMWATER MANAGEMENT IN THE LAKE CHAMPLAIN BASIN: AN ADAPTATION PLAN FOR MANAGERS 6 (2015), http://www.lcbp.org/wp-content/uploads/2013/03/80_LCBP_ClimateChange_StormwaterMangement.pdf [https://perma.cc/EXW6-7MUR].

82. *Id*. at 17, 19.

Building properly sized stormwater infrastructure throughout the landscape can help spread out runoff, improving the quality and reducing the quantity of runoff that reaches receiving waters. Getting technical and financial assistance to towns and stormwater managers and helping them identify the most important areas to protect are another way to reduce the risk of overwhelming stormwater infrastructure. Reducing stormwater runoff through the implementation of GSI practices may help limit the anticipated impacts of flooding resulting from potential climate change. Though individual GSI practices tend to have lower individual runoff detention capacities, they can be effective when dispersed throughout the landscape close to where that runoff is generated. These strategies can all help reduce the volume of untreated stormwater that flows into waterways during small to moderate storm events. For larger events, LID techniques, including floodplain and wetland protection, coupled with consistent permitting guidelines, relocation of existing infrastructure outside flood hazard areas, and properly-sized, well-maintained stormwater drainage networks will reduce the impacts of increased high flows on the built environment and Lake Champlain.

CONCLUSION

Site-scale stormwater management will play an integral role in achieving Vermont's ultimate water quality goals for Lake Champlain, but encouraging the widespread adoption of LID techniques and GSI retrofits remains challenging. This adoption requires fundamental and widespread changes in how we approach land use, development, and the centuries-old paradigm of moving stormwater away as quickly as possible in order to address a source of pollution that has produced huge chronic effects in Lake Champlain, but often less dramatic acute effects. "Therein lies the rub, or part of it, for stormwater [management]: as a species we seem hardwired to guard against the immediate, visible, localized threat, but we also seem wired to discount or even dismiss the longer term, less visible, generalized threat, even if it's ultimately [] substantial . . . ."[83] Ultimately, the stormwater management effort we must now engage is concerned with these longer-term, less-visible, generalized threats. Achieving the phosphorus load reduction for developed lands will be one of the more difficult and challenging aspects of implementation of the Lake Champlain Phosphorus TMDL.

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83. Richard B. Whisnant, *How Did Stormwater Control Get so Complicated? The Coastal Stormwater Chapter, Part 2*, U.N.C. SCH. GOV'T ENVTL. L. IN CONTEXT (Feb. 16, 2015), http://elinc.sog.unc.edu/how-did-stormwater-control-get-so-complicated-the-coastal-stormwater-chapter-part-2/ [https://perma.cc/MN8D-R693].

CONTROLLING POLLUTED STORMWATER RUNOFF FROM ROADS

Beverley Wemple[1]

INTRODUCTION

Transportation networks are a critical component of society's infrastructure, providing access to move goods and people through the landscape, but with environmental impacts that affect a range of ecosystem processes, including animal migration patterns, exotic plant propagation, and the production of runoff and water quality contaminants.[2] The linear nature of roads and their tendency to collect, concentrate, and route water and pollutants along the road corridor and roadside-ditch network result in

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1. The author gratefully acknowledges the important contributions of University of Vermont graduate students Joanne Garton, Scott Hamshaw, and Catherine Webster who conducted data gathering and analysis for the research described here. Support for this research was provided by grants from the Lake Champlain Basin Program through the U.S. Environmental Protection Agency, the Vermont Water Resources and Lake Studies Center through the U.S. Geological Survey's National Institutes of Water Resources, the Vermont Agency of Natural Resources Ecosystem Restoration Program, and the Vermont Experimental Program to Stimulate Competitive Research through a grant from the National Science Foundation (EPS1101317).

2. Richard T. T. Forman & Lauren E. Alexander, *Roads and Their Major Ecological Effects*, 29 ANN. REV. ECOLOGY & SYSTEMATICS 207 (1998).

impacts to watershed processes on a scale far greater than one might expect from the small fraction of land area they occupy.[3] The effects of roads on water quality are linked to the ways in which roads, as impervious surfaces, influence runoff (or stormwater) production and redistribution.[4] Within mountainous or upland[5] settings, where unimproved, gravel or native-surfaced roads are common, these runoff and water quality dynamics involve changes to the processes of rainfall infiltration, groundwater percolation, and delivery of stormwater to streams. The scientific work to document unpaved road impacts on runoff and water quality has been driven by a need to understand land management impacts and the need to mitigate these to comply with federal and state clean water regulations and other environmental regulations.[6]

Within the Lake Champlain Basin, much of the attention on water quality has focused on understanding the important contributions of agricultural runoff to water quality degradation. This has resulted in important new insights from field and modeling studies, helping to identify critical source areas for pollutant production.[7] Within the last two decades, attention in Vermont has also focused on the important role of unstable river channels and adjusting to a legacy of historical land use practices, including deforestation, agricultural production, and urbanization, that result in extensive river bank and floodplain erosion and the contribution of

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3. Charles H. Luce & Beverley C. Wemple, *Introduction to the Special Issue on Hydrologic and Geomorphic Effects of Forest Roads*, 26 EARTH SURFACE PROCESSES & LANDFORMS 111, 111 (2001).

4. Charles H. Luce, *Hydrological Processes and Pathways Affected By Forest Roads: What Do We Still Need To Learn?*, 16 HYDROLOGICAL PROCESSES 2,901, 2,901 (2002).

5. I define "uplands" here generally as areas of higher elevation, as compared to "lowland" settings (used later in this article). In Vermont, the "uplands" are generally located above 1,500 feet, where steeper slopes have led to pattern of landuse and landcover dominated by forests and rural housing. Most of the land cleared for agriculture in Vermont is located in what I refer to as "lowlands," those settings below 1,500 feet, including the Lake Champlain Valley and floodplains of major rivers.

6. Julia A. Jones et al., *Effects of Roads on Hydrology, Geomorphology, and Disturbance Patches in Stream Networks*, 14 CONSERVATION BIOLOGY 76, 78 (2000); COMM. ON HYDROLOGIC IMPACTS OF FOREST MGMT., HYDRAULIC EFFECTS OF CHANGING FOREST LANDSCAPE 67 (2008).

7. *See, e.g.*, VT. AGENCY OF NAT. RES. ET AL., FACT SHEET #1: AGRICULTURAL LANDS MANAGEMENT: VERMONT LAKE CHAMPLAIN PHOSPHOROUS REDUCTION PLAN: TAKING ACTION TO RESTORE LOCAL STREAMS AND LAKE CHAMPLAIN, http://dec.vermont.gov/sites/dec/files/wsm/erp/Champlain/docs/2014-11-10%20Lake%20Champlain%20TMDL%20Factsheet_Agriculture.pdf [https://perma.cc/529Z-ZGHK] (last visited July 3, 2016) (discussing the efforts taken by Vermont farmers, businesses, municipalities, and other stakeholders to reduce phosphorous into the lake); JOHNATHAN R. WINSTEN ET AL., POLICY OPTIONS FOR REDUCING PHOSPHOROUS LOADING IN LAKE CHAMPLAIN 4–12 (2004), http://www.northernlakechamplain.org/wp-content/uploads/2013/08/An-Analysis-of-Policy-Options-for-P-Control-in-the-Lake-Champain-Basin-2.pdf [https://perma.cc/Z69G-GK6E] (discussing and assessing current policy and programs attempting to control phosphorous runoff from agricultural lands).

sediment and sediment-bound nutrients to waterways.[8] Within this context, the uplands of Vermont are largely viewed as protectors of water quality due to extensive forests that blanket the mountain landscape and the important role that forests play in regulating water quality by absorbing rainfall into highly pervious soils and routing it more slowly to receiving waters.[9] However, one need only travel into the uplands of Vermont along any of the unpaved road corridors to see clear indications of water quality impacts associated with the transportation network in this setting, including extensive erosion of road surfaces and roadside ditches and direct discharges of storm water to otherwise pristine mountain streams (Figure 1). This article seeks to outline what we know about the impacts of unpaved roads on water quality in the Lake Champlain Basin and similar settings of the northeastern United States. Section I below lays out the ways in which roads alter processes of stormwater production and routing, with impacts on erosion and water quality. This is followed in Section II by a general description of transportation networks in mountainous landscapes to provide context for both the local reader and for those interested in parallels to landscapes elsewhere. Section III provides a summary of empirical work in Vermont to examine the role of unpaved roads on water quality. Section IV summarizes experimental and retrospective assessments used to evaluate the effectiveness of practices to mitigate against these impacts. Section V ends with comments aimed to place the "road impact" into broader perspective, for those concerned with water quality management, and with comments on barriers to implementation of practices to address road impacts on water quality.

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8. VT. AGENCY OF NAT. NAT. RES., RESILIENCE: A REPORT ON THE HEALTH OF VERMONT'S ENVIRONMENT 8–9 (2011).

9. COMM. TO REVIEW THE NEW N.Y. C. WATERSHED MGMT. STRATEGY, MANAGEMENT FOR POTABLE WATER SUPPLY: ASSESSING THE NEW YORK CITY STRATEGY 76, 386 (2000).

Figure 1: Evidence of water quality impacts associated with unpaved roads in Vermont's uplands: erosion of rills and gullies on impervious road surface (left panel), eroded roadside ditch resulting from channelized stormwater runoff (middle panel), direct discharge of road runoff to receiving stream from road culvert (right panel).

I. PRIMER ON UNPAVED ROAD IMPACTS TO WATERSHED PROCESSES IN UPLAND MOUNTAINOUS SETTINGS

Roads located in rural upland and mountainous settings influence watershed processes through a number of mechanisms. The relatively impervious surface of the roadbed, even when unpaved, reduces the infiltration of precipitation, generating stormwater, which is otherwise rare in these settings.[10] The network of roadside ditches is designed to collect stormwater and route it efficiently to discharge points, but this concentration and discharge of stormwater represents an artificial extension to the natural drainage network and a direct conduit for discharges of sediment, nutrients, or other pollutants to receiving waters.[11] In addition, when roads are constructed on steep slopes in mountainous terrain, shallow groundwater can be intercepted along road cuts and transferred from slow moving pathways in the subsurface to more rapid and concentrated pathways along roadside ditches,[12] resulting in extensive erosion of the road and ditch and discharge of eroded material in to streams (Figure 1). The concentration of water on roads, roadside ditches, and the discharge points

10. *See generally* Charles H. Luce & Terrance W. Cundy, *Parameter Identification for a Runoff Model for Forest Roads*, 30 WATER RESOURCES RES. 1057, 1057–69 (1994); Alan D. Ziegler & Thomas W. Giambelluca, *Importance of Rural Roads as Source Areas for Runoff in Mountainous Areas of Northern Thailand*, 197 J. HYDROLOGY 204, 205, 213–25 (1997).

11. Beverley C. Wemple et al., *Channel Network Extension By Logging Roads in Two Basins, Western Cascades, Oregon*, 32 WATER RESOURCES BULL. 1195, 1195 (1996).

12. Beverley C. Wemple & Julia A. Jones, *Runoff Production on Forest Roads in a Steep, Mountain Catchment*, 39 WATER RESOURCES RES. 8, 8 (2003).

below roads has been shown to destabilize slopes, causing gullying,[13] shallow land sliding,[14] and failure of drainage or stream-crossing culverts under-designed to accommodate the volume of water generated during extreme storm events.[15] Through these various mechanisms, roads generate stormwater and erode soils at levels significantly greater than the undisturbed or lightly disturbed terrain they occupy. An important consequence of these changes in watershed processes is that any solute carried in stormwater and any particulate associated with soils eroded from road surfaces and roadsides may end up discharging to receiving waters and impacting water quality.[16] Salt and sand commonly used in northern latitudes during winter, particulate phosphorus that is naturally associated with soils, and dissolved nutrients (e.g., phosphorus and nitrogen) along with other pathogens (*E. coli* bacteria) move with stormwater and are discharged to receiving waters.[17]

An underappreciated aspect of road impacts on watershed processes relates to the ways in which roads function to connect portions of the landscape they drain, effectively extending natural stream networks. This impact has received more attention recently within the scientific literature[18] as road studies have documented the magnitude of channel network extension and its effects, including consequences for pollutant discharges and impacts on downstream flood production.[19] A recent study in New

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13. Beverley C. Wemple, Hydrological Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon 59 (Jan. 21, 1994) (unpublished master's thesis, Oregon State University) (on file with Vt. J. Envtl. L.); I. Takken et al., *Thresholds for Channel Initiation at Road Drain Outlets*, 75 CATENA 257 (2008).

14. D. R. Montgomery, *Road Surface Drainage, Channel Initiation, and Slope Instability*, 30 WATER RESOURCES RES. 1,925, 1,925 (1994).

15. Beverley C. Wemple et al., *Forest Roads and Geomorphic Process Interactions, Cascade Range, Oregon*, 26 EARTH SURFACE PROCESSES & LANDFORMS 191, 191 (2001).

16. JOANNE S. GARTON, MASTER'S PROJECT: EVALUATING THE EFFECTIVENESS OF BEST MANAGEMENT PRACTICES ON RURAL BACKROADS OF VERMONT: A RETROSPECTIVE ASSESSMENT AND COST ANALYSIS 1 (2015), http://scholarworks.uvm.edu/cgi/viewcontent.cgi?article=1005&context=rsmpp [https://perma.cc/6AXF-QM6B].

17. *Typical Pollutants in Stormwater Runoff*, SOIL & WATER CONSERVATION SOC'Y METRO HALIFAX, http://lakes.chebucto.org/SWT/pollutants.html [https://perma.cc/VC4K-A2GN] (last updated Aug. 14, 2015).

18. *See* Christopher D. Arp & Trey Simmons, *Analyzing the Impacts of Off-Road Vehicle (ORV) Trails on Watershed Processes in Wrangel-St. Elias National Park and Preserve, Alaska*, 49 ENVTL. MGMT. 751, 752–53 (2012) (addressing off road trail impact on watersheds in an Alaskan national park); *see generally* DREW COE, THE IMPACT OF FOREST ROADS ON HYDROLOGICAL PROCESSES AND PATHWAYS: A REVIEW OF PUBLISHED LITERATURE (overview of various impact roads have on water pathways with extensive reference to scientific literature).

19. *See generally* Jacky Croke et al., *Sediment Concentration Changes in Runoff Pathways from a Forest Road Network and the Resultant Spatial Patter of Catchment Connectivity*, 68 GEOMORPHOLOGY 257 (2005) (using forest roads to examine the effect of runoff on pathways in stream networks); Louise J. Bracken & Jacky Croke, *The Concept of Hydrological Connectivity and Its Contribution to Understanding Runoff-Dominated Geomorphic Systems*, 21 HYDROLOGICAL PROCESSES

York state showed that a vast majority of the road network in the agricultural landscape discharged directly to streams.[20] This "connectivity" of roads and streams, associated with both unpaved and paved roads across the landscape, may be among the most important design elements of the transportation network to consider in managing impacts to water quality.

To address the adverse impacts of unpaved roads on water quality, a range of best management practices ("BMPs") are recommended. These practices generally include guidelines for locating roads to minimize impacts at stream crossings, recommendations for sizing, spacing, and installing drainage structures (such as culverts and water bars), and strategies for stabilizing roadsides and road drainage points (i.e., culvert outlets) using vegetation or energy dissipating structures, such as check dams or other stone work and turn-outs to direct runoff into vegetated areas along the roadside.[21] Within Vermont, these recommendations are codified in guidance documents provided to municipalities and supported by grants that promote small-scale road improvements and drainage practices executed by municipalities.[22]

II. A DEMOGRAPHY OF ROADS IN THE LAKE CHAMPLAIN BASIN AND SIMILAR MOUNTAIN SETTINGS

The Lake Champlain Basin is typical of the northern New England landscape in that topography has largely dictated land use patterns and the development of the transportation network. Throughout the basin and much of northern New England, land has been cleared for agriculture in the lowlands and the floodplains of major rivers, leaving the steeper terrain of the uplands covered today primarily by forests.[23] Major transportation corridors follow the river valleys a result of these settings having some of the only flat terrain for locating roads and railroads in this otherwise steep,

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1,749 (2007) (using a road network as an example of a landscape feature that enhances hydrological connectivity).

20. B. P. Buchanan et al., *Hydrological Impact of Roadside Ditches in an Agricultural Watershed in Central New York: Implications for Non-Point Source Pollutant Transport*, 27 HYDROLOGICAL PROCESSES 2,422 (2012).

21. *See generally* BEVERLEY C. WEMPLE, ASSESSING THE EFFECTS OF UNPAVED ROADS ON LAKE CHAMPLAIN WATER QUALITY (2013), http://www.lcbp.org/wp-content/uploads/2013/07/74_Road-Study_revised_June2013.pdf [https://perma.cc/574Z-LYCE] (discussing pollution into Lake Champlain via unpaved roads and assessing the effectiveness of BMPs suggested to reduce sediment runoff).

22. *See generally* N. VT. & GEORGE D. AIKEN, VERMONT BETTER BACKROADS MANUAL: CLEAN WATER YOU CAN AFFORD (2009) (discussing best practices for backroads in Vermont

23. *Agriculture*, FROM THE LAND TO THE LAKE, http://www.henrysheldonmuseum.org/land_to_lake/articles/agriculture.html [https://perma.cc/AK52-WHDR] (last visited July 3, 2016).

mountainous landscape.[24] Roads within the few urban centers and along the major federal and state highway corridors are paved, but many of the roads managed by small municipalities in the region are unpaved and traverse steep land.[25]

The mountainous terrain of the region and location of the transportation infrastructure gives rise to a set of interactions among rivers and roads that have implications both for infrastructure integrity and for water quality (Figure 2). Roads located in the lowlands, especially in the narrow valleys of the region, travel parallel to rivers, occupying floodplains once carved by rivers that moved laterally to accommodate floods but are now constrained by transportation infrastructure. During Tropical Storm Irene in August of 2011, these transportation corridors suffered tremendous damage as roads were undermined by rivers seeking to dissipate the energy of intense flood waters and the debris transported by them.[26] Over the long term, lateral constriction by transportation infrastructure limits the natural migration of rivers that provide important aquatic habitat and allow rivers to use their floodplains to dissipate energy and cleanse floodwaters of sediment and sediment-bound nutrients.[27] Roads located in the uplands traverse steep slopes with frequent crossings of small stream channels. In this upland setting, the mostly forested landscape is covered by soils with high infiltration rates, but steep topographic gradients give rise to higher precipitation rates in the uplands, thus, more water to accommodate. Water concentrated on impervious road surfaces and intercepted along road cuts is routed through a network of roadside ditches and typically discharged to receiving streams. This creates a chronic sourcing of stormwater and pollutants to these otherwise pristine streams but also an episodic risk to infrastructure during extreme storms, when the volume of runoff often exceeds the design capacity of ditches and culverts, leading to the types of infrastructure failure seen so commonly during Tropical Storm Irene and more recent floods in the region (Figure 2).

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24. *Construction of the Railroad (1846-1886)*, LANDSCAPE CHANGE PROGRAM, UNIV. OF VT., https://www.uvm.edu/landscape/dating/railroads/construction.php [https://perma.cc/VFB6-V25M] (last visited July 3, 2016).

25. WEMPLE, *supra* note 21, at ii, 1–3.

26. VT. NAT. RES. COUNCIL, READING VERMONT'S RIVERS 3 (2013), http://vnrc.org/wp-content/uploads/2013/07/Reading-Rivers-reduced.pdf [https://perma.cc/RV9L-NUKK] (last visited May 2, 2016).

27. Paul Blanton & W. Andrews Marcus, *Railroads, Roads, and Lateral Disconnection in the River Landscapes of the Continental United States*, 112 GEOMORPHOLOGY 212, 222–24 (2009).

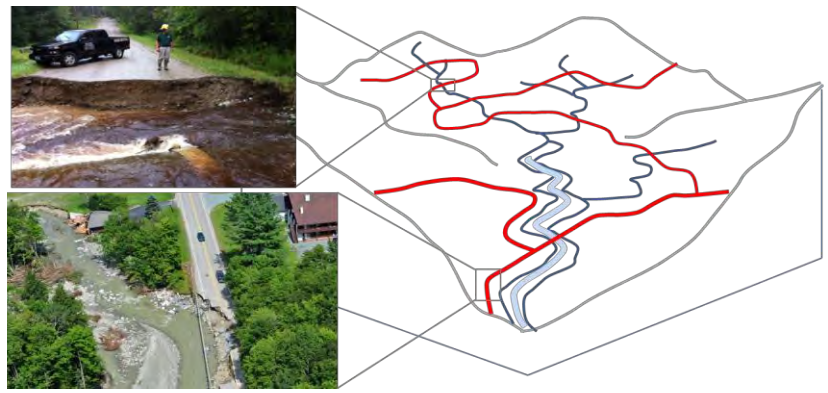

Figure 2: Right: block diagram illustrating characteristic location of roads in the northern New England and other mountain landscapes. In the lowlands, roads are preferentially situated in floodplains. In the uplands, roads traverse steep slopes and cross small-stream channels. Photos at the left show damage sustained on Vermont roads during Tropical Storm Irene in August of 2011 at a road-stream crossing in the uplands (top) and along a river corridor in the lowlands (bottom).

Within the Vermont portion of the Lake Champlain Basin, records of road surfacing included in the state Agency of Transportation's digital data layers show that roughly sixty percent of the road network is unpaved, with a greater fraction of unpaved roads (relative to paved road length) in the rural mountainous towns of the state.[28] These roads are largely managed by small municipalities who devote considerable taxpayer resources to annual maintenance and repairs, including snow removal during winter, grading following the snow melt season to provide a safe driving surface, and on-going maintenance of drainage structures and storm damages. Steep gradients on the unpaved road network amplify the drainage and maintenance challenges experienced by municipalities. Within the Winooski River Watershed of Vermont, for example, roughly fifty percent of the road length is five percent grade or steeper, a threshold commonly used to recommend road stabilization measures such as stone lining of ditches to reduce erosion by stormwater.[29]

III. EXAMINING IMPACTS OF UNPAVED ROADS ON WATER QUALITY IN MOUNTAINOUS SETTINGS IN THE LAKE CHAMPLAIN BASIN

Despite the recognition of the impact of roads on stormwater production and water quality, based on studies cited above and others, little heretofore has been known about the relative importance of roads within

28. WEMPLE, *supra* note 21, at 27.
29. N. VT. & AIKEN, *supra* note 22, at 3.

the context of efforts to address Lake Champlain's water quality. To this end, we initiated a study in 2011 to quantify stormwater and pollutant production on rural roads within the Lake Champlain Basin.[30] Our focus was on unpaved roads in upland settings because of an interest in looking beyond the lowland agricultural landscape for other factors that contribute to water quality degradation and because unpaved roads represent the larger share of the transportation network in the uplands. Results of that work are conveyed in a technical report[31] and summarized here for policy makers and legal scholars.

To quantify stormwater production and the associated sediment and sediment-bound phosphorus generated on unpaved roads during storm events, we studied a set of twelve unpaved road segments in the Mad River Valley of Vermont where an on-going community water monitoring program allowed us to estimate watershed loadings of sediment and phosphorus, placing our estimates from roads in context.[32] Our monitoring involved continuous measurements of runoff during storm events and sampling for water quality analysis using automated water samplers located at each of the road sites. Our observations show that the volume of stormwater generated on roads is influenced by the length of the road draining to a discharge point and that the concentration of sediment carried in that storm water is influenced by the gradient of the road (Figure 3). Longer segments of road generated more runoff during storm events and steeper segments of roads generated higher concentrations of eroded sediments. Measurements of this type, made over successive storm events at each of the monitored road sites then scaled to a unit estimate of annual suspended sediment production, shows the general pattern of higher rates of sediment production on steeper roads (Figure 4). Although the explanatory power of road gradient is modest at best (R2 = 0.35), suggesting that other factors such as the occurrence of shallow groundwater interception, presence of roadside vegetation, condition of the road surface, storm intensity, and vehicle traffic during storm events influence the concentration of sediment in stormwater generated on unpaved roads, this relationship to road gradient provides a means for extrapolating site-scale observations to the watershed scale, as described below.

30. WEMPLE, *supra* note 21.
31. *Id.* at ii.
32. *Id.*

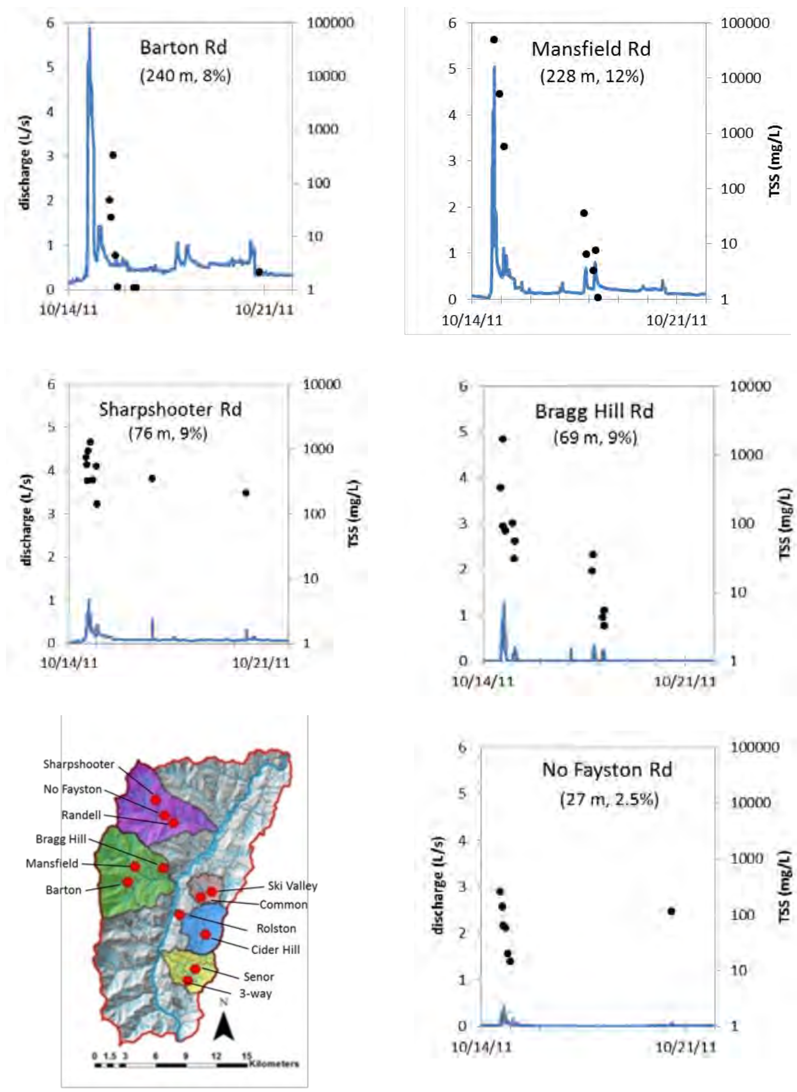

Figure 3: Measurements of stormwater production and suspended sediment concentrations in stormwater on five unpaved road segments in the Mad River Valley, monitored during an October 2011 storm event. Sites are displayed from upper left to lower right in order of decreasing road length (indicated in parentheses as meters of road draining to the measurement station). Road grade for each segment is also displayed in parentheses. Monitored site locations within the Mad River Valley for this and other storm events are shown in the inset map in the lower left panel within the small watersheds they are located. See Figure 5 for watershed names and loading estimates derived from these and other measurements.

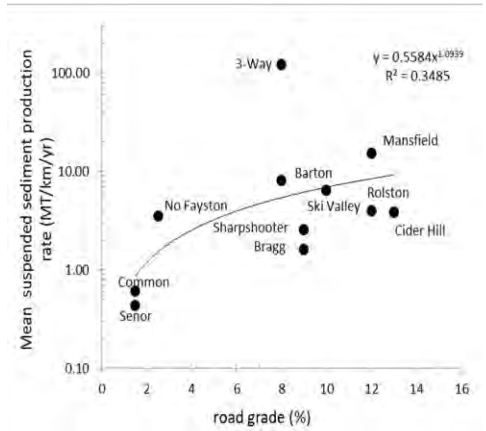

Figure 4: Plot of total phosphorus concentration verses total suspended sediment concentration in samples collected on roads in the Mad River Valley in 2011 and 2012. TSS to TP relationship was used to estimate total phosphorus loads from roads in the Mad River Watershed. W*EMPLE*, supra *note 21.*

Sediment eroded from unpaved roads serves as a water quality contaminant in two ways. Fine particulates discharged to receiving waters degrade water clarity and fills interstitial spaces of streambeds, impacting the quality of aquatic habitat for biota macroinvertebrates and fish that spawn in coarse bedded mountain streams, an effect that has been well documented in the western United States.[33] In addition, because phosphorus tends to adhere in particulate form to soils, soil erosion from roads will be accompanied by particulate phosphorus.[34] Stormwater will also have a component of dissolved phosphorus, sourced from groundwater seeps along road cuts or stormwater that entrains phosphorus as it flows over land adjacent to the road corridor.[35] Our samples collected from roads during storm events show a strong positive relationship between total suspended sediment and total phosphorus concentration in road stormwater (Figure 5). It is this particulate and dissolved phosphorus contribution from unpaved roads that leads to concerns regarding water quality impacts within the Lake Champlain Basin where phosphorus has been identified as the pollutant of concern to be managed under the TMDL.[36] Nevertheless, the reader should be aware that sediment is a key water quality contaminant in surface waters

33. William S. Platts et al., *Changes in Salmon Spawning and Rearing Habitat from Increased Delivery of Fine Sediments to the South Fork Salmon River, Idaho*, 118 TRANSACTIONS AM. FISHERIES SOC'Y 274, 274 (1989); Stephen C. Trombulak & Christopher A. Frissell, *Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities*, 14 CONSERVATION BIOLOGY 18, 22 (2000).

34. Lowell Busman et al., *The Nature of Phosphorus in Soils*, U. MICH., http://www.extension.umn.edu/agriculture/nutrient-management/phosphorus/the-nature-of-phosphorus/ [https://perma.cc/LY72-XY8R] (last updated July 2009).

35. Joseph L. Domagalski & Henry Johnson, *Phosphorous and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams*, U.S. GEOLOGICAL SERV., http://pubs.usgs.gov/fs/2012/3004/ [https://perma.cc/8SSW-RT2L] (last updated Jan. 9, 2013).

36. ENVTL. PROT. AGENCY, PHOSPHOROUS TMDLS FOR VERMONT SEGMENTS OF LAKE CHAMPLAIN 7 (2016), https://www.epa.gov/sites/production/files/2016-06/documents/phosphorus-tmdls-vermont-segments-lake-champlain-jun-17-2016.pdf [https://perma.cc/8RJ8-BLTZ] (last visited May 2, 2016).

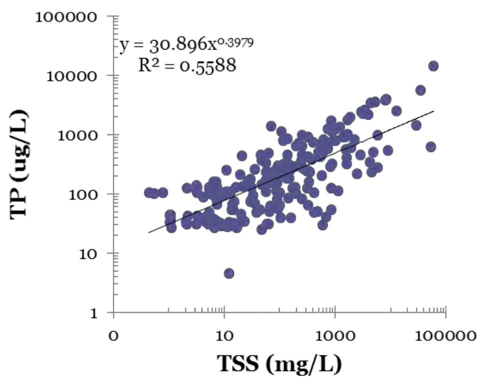

Figure 5: Plot of site estimated annual sediment production on monitored road segments in the Mad River Watershed of Vermont versus site road gradient. See W*EMPLE*, supra *note 21.*

of the United States[37] and of particular concern in mountain streams where inputs of fine sediment from erosion degrade aquatic habitat and negatively impact fish and other biota.

To estimate the pollutant loading from roads as a fraction of that flushed from small watersheds of the Mad River, we used a modeling approach as follows and described in a technical report on this work.[38] Water quality monitoring data (measuring suspended sediment and total phosphorus concentrations) provided by the local watershed association were used to develop concentration-discharge relationships for each of the five watersheds in which our road sites were located (Figure 3). These relationships were then used to estimate an annual load of sediment and phosphorus from each of these watersheds. To estimate loadings from roads, we used the relationship displayed in Figure 4 to derive estimates of annual sediment flux from the road network in the five watersheds and the relationship between total suspended sediment and total phosphorus concentration displayed in Figure 5 to estimate annual phosphorus load from road erosion. This approach yields estimates of sediment and phosphorus sourcing from roads of roughly ten to thirty percent of the loads estimated from the watersheds in which they are located (Figure 6). These are the first event-based estimates of pollutant production from unpaved roads in Vermont and provide a basis for evaluating the importance of addressing this pollutant source. Important uncertainties in these estimates warrant consideration and are discussed in the final section of this article.

37. ENVTL. PROT. AGENCY, THE INCIDENT AND SEVERITY OF SEDIMENT CONTAMINATION IN SURFACE WATERS OF THE UNITED STATES 1–3 (2004).

38. WEMPLE, *supra* note 21.

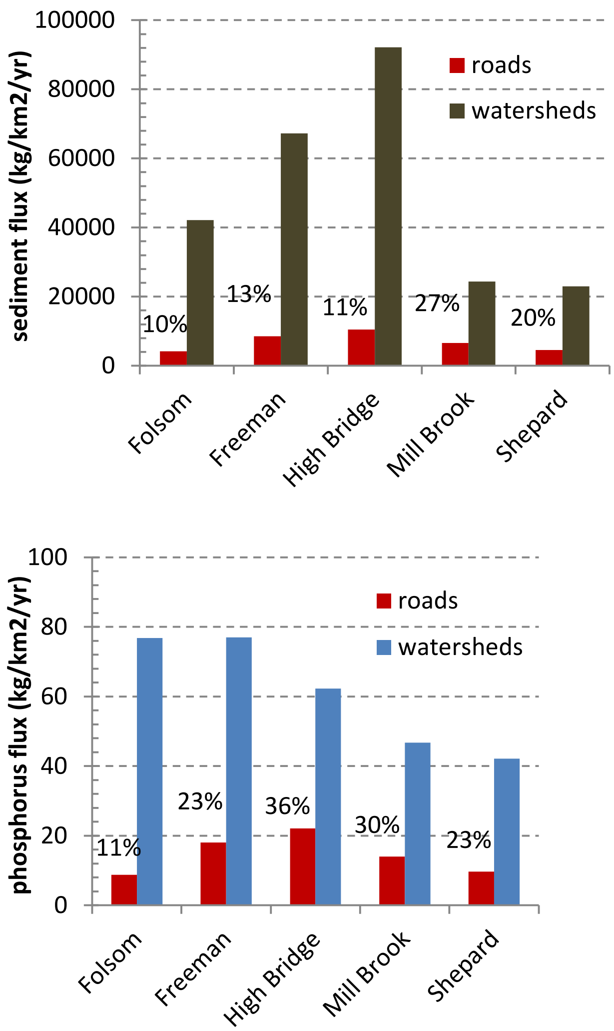

Figure 6: Comparison of estimated pollutant loads from unpaved roads (red bars) and small watersheds for suspended sediment (left panel) and total phosphorus (right panel). Percentage values above red bars are estimates of pollutant loads from roads as a fraction of estimates from watersheds.

IV. EVALUATING THE EFFECTIVENESS OF BEST MANAGEMENT PRACTICES ON GRAVEL ROADS

To mitigate the effects of unpaved roads on pollutant production and water quality degradation, a number of BMPs have been developed and evaluated.[39] Studies of BMP implementation on forested lands in the

39. James A. Lynch et al., *Best Management Practices for Controlling Nonpoint-Source Pollution on Forested Watersheds*, 40 J. SOIL & WATER CONSERVATION 164, 164–65 (1985); Walter F.

Northeastern United States have shown highly variable compliance with recommendations, pointing particularly to instances when the failure to use BMPs on roads resulted in significant hydrologic and erosion impacts.[40] Much of this work is limited to application of BMPs on roads built for logging operations. Although unpaved municipal roads in Vermont are in many ways similar to the low volume, unpaved roads built for large-scale logging operations, little information exists on the efficacy of practices employed by small municipalities, such as those in Vermont and elsewhere in northern New England, to manage their transportation networks and no retrospective assessments have been conducted to evaluate road drainage improvements that have been funded by federal, state, and local investments. To provide insight into these issues, we conducted a study of BMP effectiveness involving two components: an experimental study to evaluate effectiveness of several recommended BMPs used on municipal unpaved roads to control erosion and improve road drainage and a retrospective assessment of BMPs funded by Vermont's Better Backroads Program[41] to determine current condition and efficacy of those practices.

Figure 7: Silt fence constructed of plastic sheeting to retain sediment and filter fabric to pass stormwater, installed at culvert outlets to trap material eroded from roads and roadside ditches.

Our experimental study was conducted in the Mad River Watershed, leveraging observations made and relationships built from the water quality study described above. For this work, we selected nine road segments identified by town officials as needing drainage improvements. For each of these, we prepared applications for installation of one of three practices as

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Megahan et al., *Best Management Practices and Cumulative Effects from Sedimentation in the South Fork Salmon River: An Idaho Case Study*, *in* WATERSHED MANAGEMENT: BALANCING SUSTAINABILITY AND ENVIRONMENTAL CHANGE 401 (Robert J. Naiman ed., 1992) (explaining how proper implementation of management practices had potential to reduce sediment yields by forty-five to ninety-five percent); J. N. Kochenderfer et al., *Hydrologic Impacts of Logging an Appalachian Watershed Using West Virginia's Best Management Practices*, 14 N.J. APPLIED FORESTRY 207, 207 (1997).

40. David J. Brynn & John C. Clausen, *Postharvest Assessment of Vermont's Acceptable Silvicultural Management Practices and Water Quality Impacts*, 8 N.J. APPLIED FORESTRY 140, 140–43 (1991); Jamie L. Schuler & Russell D. Briggs, *Assessing Application and Effectiveness of Forestry Best Management Practices in New York*, 17 N.J. APPLIED FORESTRY 125, 133–34 (2000).

41. N. VT. RES. CONSERVATION & DEV., VERMONT BETTER BACKROADS PROGRAM REPORT 2010, http://www.nvtrcd.org/2010_BBR_Report.pdf [https://perma.cc/LED7-RJWP] (last visited May 2, 2016).

experimental treatments: (1) stone lining ditches to reduce erosion and incision along the road margin; (2) check dams and turnouts to dissipate stormwater energy and divert water and sediment into road-adjacent forest; and (3) compost socks (fabric bales of organic material) placed in ditches to act as energy dissipaters and traps for sediment.[42] For each of the experimental sites, we also selected a nearby road segment to use as an experimental control that would be monitored throughout the study period, but not manipulated.[43] Monitoring involved installation of silt fences at the outlets of culverts draining both the treatment and control sites. The silt fences were designed to pass stormwater but trap sediment, allowing us to return to the study sites following storms and excavate material eroded and deposited at the fence during storms.[44] We measured the entire volume of material trapped in the silt fence following storms and then returned a subsample to the lab where we dried and weighed it to convert a volume collected to mass and analyzed subsamples for grain size analysis and concentration of total phosphorus in eroded sediments.[45]

Results from this work provide insights both into the magnitude of material eroded from unpaved roads we studied and the effectiveness of these recommended practices. Depending upon conditions of the site, roads selected by town officials for drainage improvements commonly eroded between 100 – 300 kilograms of dry soil during storm events, with some sites yielding even greater amounts.[46] As expected, sites selected as controls generally had lower erosion rates when compared to the treatment sites in the pre-treatment period.[47] Following installation of BMPs, erosion at the treated sites was substantially reduced in most cases, resulting in sediment runoff that more closely matched the lower rates measured at control sites.[48] In some cases, installation of BMPs proved ineffective.[49] For example, the Grout Road site in Duxbury experienced considerable erosion (up to and in excess of 150 kilograms of material per monitored storm) in the post-treatment period and the check dams and turnouts installed there were insufficient to control erosion of this magnitude (Figure 8). Phosphorus concentrations in eroded soil captured at the silt fences averaged 500 milligram of phosphorous per kilogram of dry soil (Figure 9). A reduction

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42. BEVERLEY C. WEMPLE & DONALD C. ROSS, EVALUATING EFFECTIVENESS OF BMP IMPLEMENTATION ON GRAVEL ROADS TO REDUCE SEDIMENT AND PHOSPHORUS RUNOFF 6 (2014).
43. *Id.* at 3.
44. *Id.* at 5.
45. *Id.* at 6.
46. *Id.* at 4.
47. *Id.* at 3.
48. *Id.* at 10.
49. *Id.*

in sediment eroded from unpaved roads will accomplish the added benefit of reducing phosphorus eroded and discharged in to receiving waters.

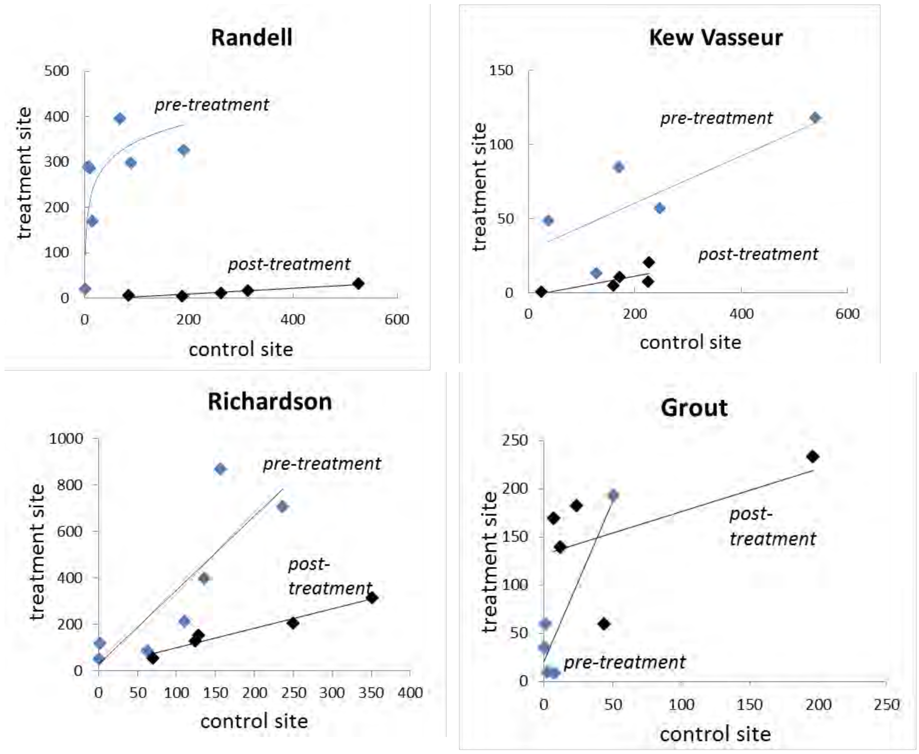

Figure 8: Examples of results from experimental installations of BMPs on select road segments in the Mad River watershed. Plots summarize mass (in kilograms) of dry sediment collected at silt fences (see Figure 7) at each site for individual storm events and compare a control site, plotted on the x-axis, to a treated site, plotted on the y-axis, for both the pre-treatment and post-treatment period. A downward shift in the relationship between treated and control site, as evidenced at the Randell, Kew Vasseur and Richardson Road sites, demonstrates success of the BMP following installation of the experimental "treatment."

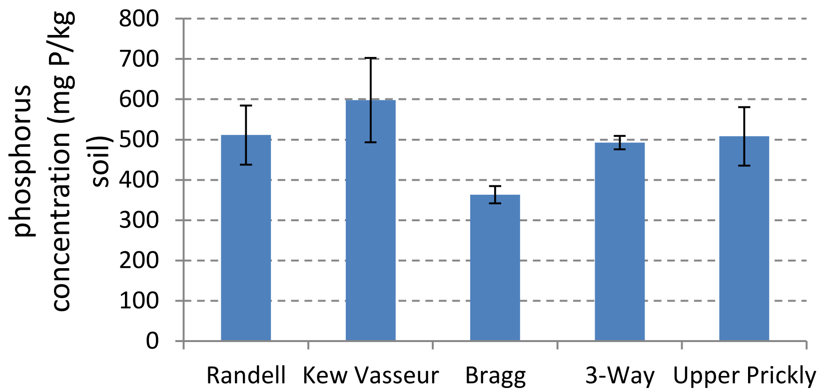

Figure 9: Total phosphorus concentration in bulk sediment samples collected in silt fences at five road sites in the Mad River Watershed. Bars are means of samples analyzed. Error bars are sample standard deviations.

To complement this experimental work, we also assessed 100 BMP installations at 43 sites funded by the Vermont Better Backroads Program over the past 8 years (the period for which records of project design and installation have been retained). The assessed sites were located in rural towns of northwestern and north-central Vermont, allowing us a broader geographical view across the state of practices employed and their efficacy. Our assessments involved review of the project design notes and a site visit to inspect conditions. For each BMP installation documented in the project notes and located in the field, we made a qualitative evaluation of condition, rating each as "intact" if the BMP appeared to be functioning to improve drainage and reduce on-site erosion, "compromised" if was some evidence of reduced performance to drain water and prevent erosion and "failed" if the BMP as recorded on the project file had been undermined or destroyed (Figure 10).

Figure 10: Examples of assessed BMPs—left: intact stone lined ditch; middle: culvert compromised by debris partly plugging inlet; right: failed BMP installation showing evidence that stone and stabilization fabric have been undermined.

Results of this assessment showed that BMPs funded through Vermont's Better Backroads Program are largely intact and functioning to provide the drainage improvements and water quality benefits for which they were designed (Figure 11). For example, among the one-hundred BMPs assessed, only ten had failed. Thirty percent of the BMPs assessed were compromised in their performance (most of these were stonework projects in the three to five years-since-installation range), but the maintenance required to restore function of these installations can be, and generally is, incorporated into regular activities of municipal road crews. Our assessment showed no longer-term tendency toward failure, even up to eight years after installation of BMPs, suggesting that these practices provide benefits for up to a decade (and perhaps longer) after installation.[50] Among the most vulnerable BMPs were those installed on the steepest roads. Failure rate increased from zero percent of those assessed on the lowest gradient roads, to approximately fourteen percent on roads with grades between five to nine percent to twenty-two percent on roads steeper than nine percent grade.[51]

50. WEMPLE, *supra* note 21, at 2, 63.
51. Wemple et al., *supra* note 11, at 1,204.

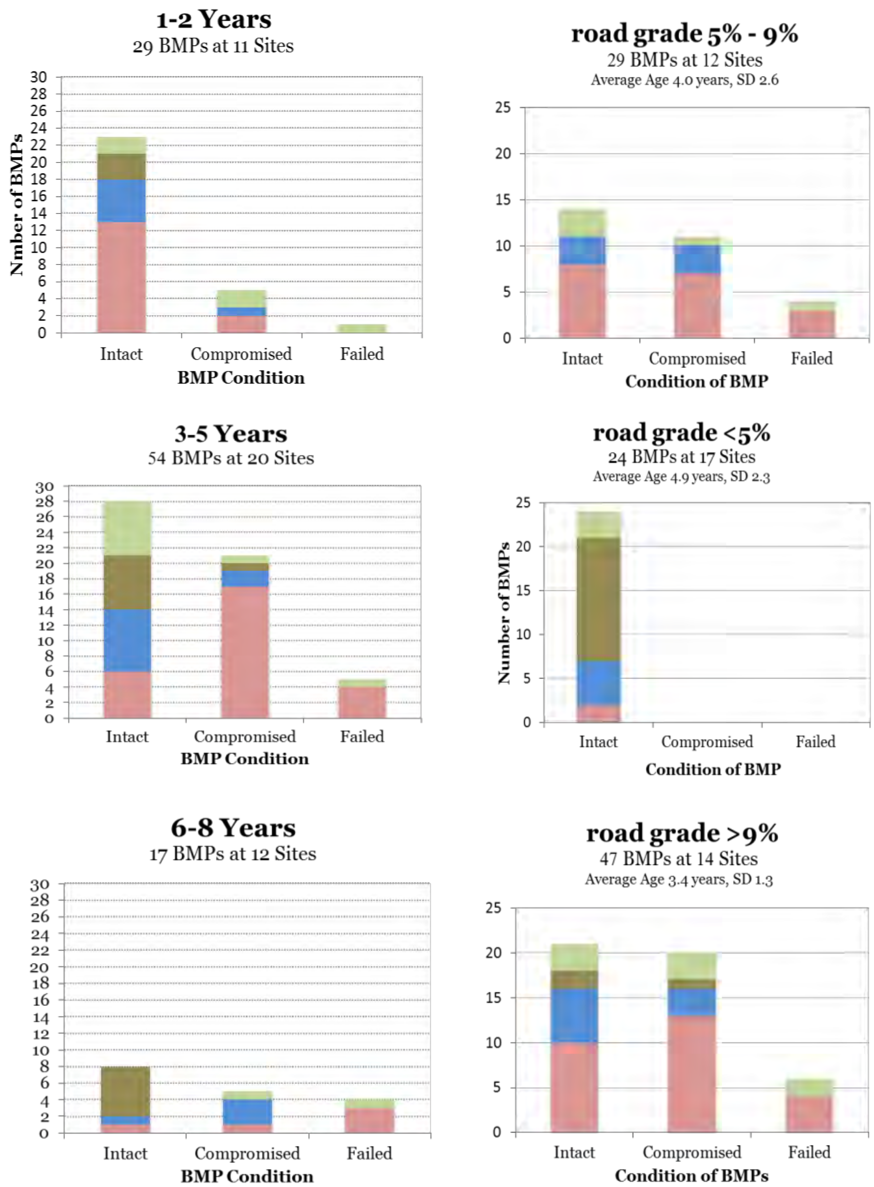

Figure 11: Condition of BMPs assessed grouped by age of project (left panel) and road grade (right panel). Bar colors are pink = stonework, blue = culverts, dark green = revetments, and light green = vegetative controls.

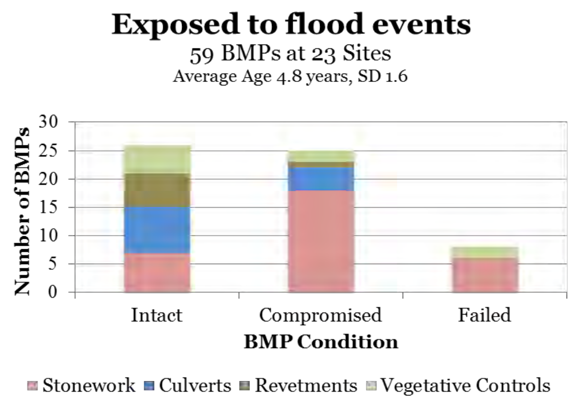

Figure 12: Condition of assessed BMPs exposed to flood events, as documented in the database of Castle et al, supra *note 53.*

Our retrospective assessment also showed that BMPs funded through the Vermont Better Backroads Program weathered extreme storms with considerable success (Figure 12).[52] We coded sites according to whether they had been exposed to an extreme flood since BMP installation by using the database of historical floods in Vermont described in *Flood Resilience in the Lake Champlain Basin and Upper Richelieu River*.[53] Among those BMPs we assessed that had been exposed to flood events documented in this data base, only about fourteen percent had failed.[54] The nearly fifty percent of BMPs exposed to flood events that showed evidence of compromised condition underscores the importance of regular road maintenance to ensure design performance of these structures.[55]

Collectively, these experimental and retrospective results show that BMPs of the type employed on rural, unpaved roads in Vermont can be highly effective in reducing erosion of soil and associated phosphorus. These practices persist over time and largely withstand the conditions of extreme floods experienced in the last decade. In addition to the water-quality benefits achieved by implementation of these practices, an important benefit is improved flood resilience where roads can withstand extreme events and towns reduce expenditures on costly flood damage repair. These results suggest that within the upland, mostly forested landscape of the Lake Champlain Basin and similar settings, efforts to improve water quality can be achieved by addressing erosion on roads using these types of relatively low-cost practices, effectively targeted at the most vulnerable and highly eroding sites, with important added benefits for

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52. GARTON, *supra* note 16, at 23 (states that only a minority of BMPs failed after flooding).
53. STEPHANIE S. CASTLE ET AL., FLOOD RESILIENCE IN THE LAKE CHAMPLAIN BASIN AND UPPER RICHELIEU RIVER 15 (2013).
54. GARTON, *supra* note 16.
55. *Id.*

rural communities who bear the cost of transportation-infrastructure maintenance and repair. In the following section, perspectives on this work are offered based on work conducted with a set of Vermont towns broadly representative of rural communities in the region.

V. THE ROLE OF GRAVEL ROADS ON WATER QUALITY AND RURAL COMMUNITY RESILIENCE IN VERMONT

The need to maintain rural transportation networks is a key concern of municipalities and one in which they invest considerable resources. Decisions regarding allocation of resources to ongoing maintenance and upgrading of structures to address storm damage are made continually by highly capable road crews and informed by priorities set by municipal governing bodies and the tax payers of those municipalities. Over the period spanning the research described here, I heard many accounts relayed by town staff, select board members, and residents of the challenges they faced in meeting these demands, particularly in light of extreme storms experienced by many of mountain communities in recent years. To explore these decisions and tradeoffs, we conducted interviews and a simple budget analysis with the town administrator or clerk and the road foreman of five Vermont towns who agreed to participate. Our goal was to examine how road budgets were being spent and to consider how these might be balanced against investments in future BMP implementation.

The towns that participated in these interviews were not randomly selected, but are broadly representative of rural upland towns in Vermont with a small taxpayer base, a network of mostly gravel roads they maintain, and a road crew of three to five full- and part-time employees.[56] We reviewed a single year's budget with the town administrator to understand the types of expenses and staffing in the town's road budget then interviewed the road foreman with a set of questions to understand how staff time and materials were distributed throughout the year. We aimed to identify the share of salary and materials spent on unpaved roads during the non-winter period because this would be the time during which expenditures might be directed toward road drainage and water quality improvements either currently or in the future. We asked the road foreman to broadly categorize expenditures into one of five activity types: (1) routine maintenance; (2) mud-season repairs; (3) fixing "problem" roads[57];

56. GARTON, *supra* note 16, at 27.

57. "Problem roads" were defined here as road segments repaired by road crews in response to property owner or resident complaints or in response to on-going evidence of erosion or storm damage that compromised the integrity of the driving surface, ditch or drainage structures.

(4) constructing BMPs; or (5) maintaining BMPs. For each month of the year, we asked the road foreman to estimate the percentage of crew time spent on each of these activities in the budget year we examined. For the materials budget, we asked the road foreman to estimate those materials and the percentages of each allocated to unpaved roads during the non-winter season for each of the five task groups above.

Table 1: Towns participating in surveys and budget analysis of road maintenance and BMP implementation

	Corinth	Huntington	Hyde Park	Waitsfield	West Windsor
Total Road Miles	93.74	43.96	63.45	29.67	51.28
% Unpaved	77	75	61	75	85
Population[58]	1,367	1,938	2,954	1,719	1,099
Road Budget (Year)[59]	$1,076,891 (FY 2014)	$867,717 (FY 2013)	$677,707 (FY 2014)	$431,615 (CY 2013)	$876,088 (CY 2013)
Budget $/mile	$11,488	$19,739	$10,680	$14,547	$17,084
Road crew Employees[60]	3 FT 1 PT	4 FT	4 FT 1 PT	3 FT	3 FT 1 PT

58. U.S. CENSUS BUREAU, VERMONT: 2010 POPULATION AND HOUSING UNIT COUNTS 12, 20, 24 (2012).
59. Refers to budget year reviewed in this analysis
60. Includes full-time (“FT”) and part-time (“PT”) employees.

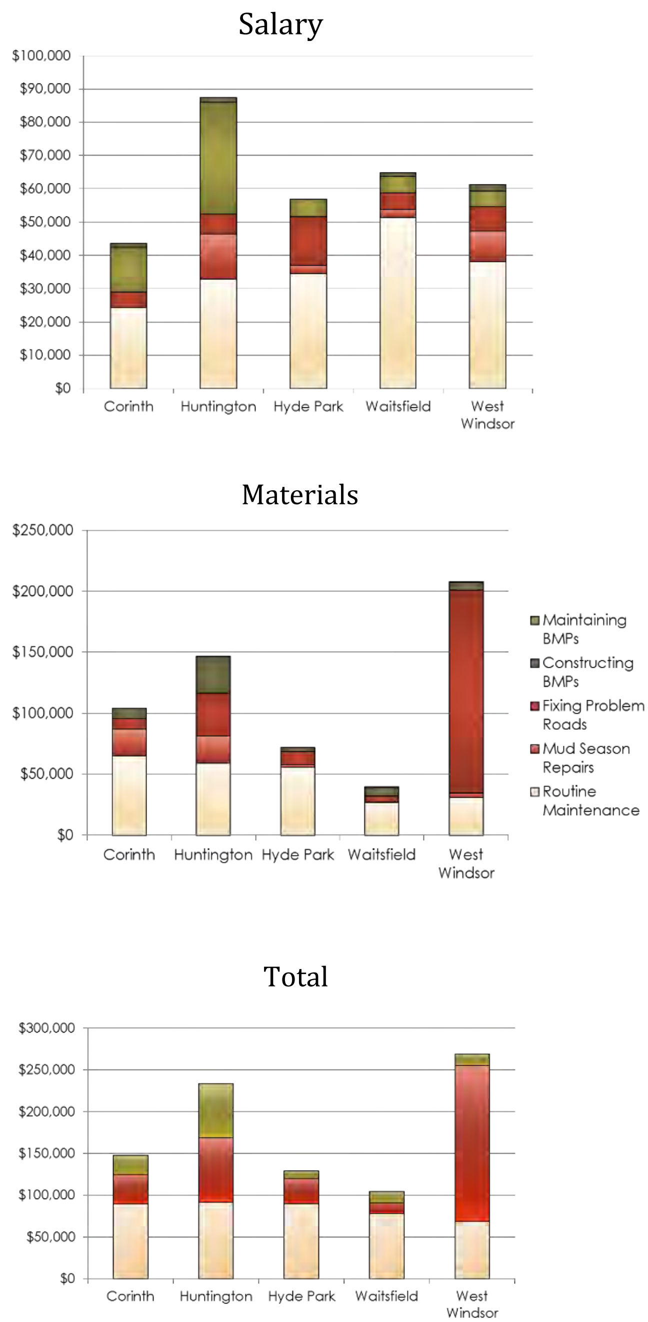

Figure 13: Graphs of estimated salary expenditures on staff salary (upper panel) and materials (middle panel) for non-winter work on gravel roads based on interview responses for five towns interviewed for this study. Lower panel is total of salary and materials with five expenditure categories summarized into routine maintenance (tan), repairs (red), and BMPs (green).

Interviews indicated that routine maintenance comprised the largest share of both salary and material expenditures for each of the towns studied (Figure 13). Four of the five towns studied had invested a smaller share of resources in the previous year on repair efforts following the snow-melt period ("mud season") and storm events. One of the towns interviewed, West Windsor, had allocated more than three times the amount spent on routine maintenance to damage repairs in the previous year, an outcome of extensive storm damage that the town had experienced. West Windsor's experience has likely been shared by other Vermont mountain towns impacted by severe storms in recent years based on statewide news reports of storm damage to road infrastructure.[61] Interviews also showed that each of the towns was allocating resources to BMP construction and maintenance, though this represented the smallest share of resource allocation (Figure 13). Huntington reported that they were investing more funds than in the past on BMP implementation in response to drainage improvements and reduced storm damage they had experienced following installation of Better-Backroads funded projects in recent years.[62] In total, the towns interviewed had spent in the budget year analyzed an average of $70,000 on routine maintenance, less than $15,000 to nearly $200,000 on repairs, and between $10,000 and $60,000 on BMP construction and maintenance.[63]

Although the scope of need for BMP implementation on gravel roads in the state is not well known, a recent mapping analysis provides some means of estimating where investments may be best made to improve road drainage and address water quality concerns. The Road Erosion Risk Ranking, developed under contract for the Vermont Agency of Natural Resources, uses a set of risk factors, including road gradient, proximity to streams, and discharge into receiving waters, to rank erosion risks on roads as a means of prioritizing projects that would address water quality concerns.[64] For the five towns interviewed, a summary of high-priority

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61. *Storms Wash Out Bridges, Damage Roads in Vermont*, USAToday (June 30, 2006), 10:51 AM), http://usatoday30.usatoday.com/weather/storms/2006-06-30-vermont-flooding_x.htm [https://perma.cc/92JP-HQYB]; *Vermont Flood / Irene Hi-Res Gallery – September 12, 2011*, MANSFIELD HELIFLIGHT (Sept. 12, 2011), http://www.mansfieldheliflight.com/flood/index2.html [https://perma.cc/UA4A-3UCK]; Jack Thurston, *No Holiday for Some in Storm-Beaten Vt.*, WPTZ (July 4, 2014, 11:29 PM), http://www.wptz.com/news/vermont-new-york/burlington/no-holiday-for-some-in-stormbeaten-vt/20847334 [https://perma.cc/6GP8-JTZL]; *Storms Wreak Havoc on Central Vermont*, Times ARGUS ONLINE (July 20, 2015), *Storms Wreak Havoc on Central Vermont*, Times Argus Online.

62. GARTON, *supra* note 16, at 35.

63. *Id.* at 31.

64. VT. DEP'T OF ENVTL. CONSERVATION, VERMONT BETTER BACKROADS: ROAD EROSION INVENTORY ASSESSMENT MANUAL (2015), https://anrmaps.vermont.gov/websites/pdfs/Road%20Erosion%20Risk%20Manual.pdf [https://perma.cc/ZV38-VNTT].

roads is shown in Table 2 along with an estimate of the cost to implement BMPs. When amortized over eight years (the lifetime of many intact BMPs we assessed and described earlier in this paper), the cost of BMP implementation approaches the cost of annual expenditures on ongoing repairs typical in these towns, as shown in Figure 13.

Table 2: Summary of road length classified as at high risk of eroding and degrading water quality taken from recent statewide analysis conducted for Vermont Agency of Natural Resources and estimated treatment costs of BMPs taken from this study.

Town	High risk road length (miles)[65]	Treatment cost[66]	Treatment cost over 8 years[67]
Corinth	2.02	$425,675	$53,209
Huntington	1.34	$282,816	$35,352
Hyde Park	1.47	$311.452	$38,932
Waitsfield	1.23	$260,529	$32,566
West Windsor	2.59	$546,174	$68,272

CONCLUSIONS

Results of this study demonstrated that erosion from discrete segments of unpaved rural roads generate substantial quantities of sediment and sediment-bound particulate phosphorus during storm events, particularly as the length and gradient of the road segment increases. Experimental results show that the implementation of BMPs on unpaved roads significantly reduces erosion and impairments that threaten water quality of receiving waterways. Retrospective assessment of past practices showed that BMPs employed on Vermont's backroads have remained largely intact for up to nearly a decade after installation, achieving long term benefits for water quality while protecting the integrity of the road way. Costs analysis for a select set of towns showed that addressing erosion control on gravel roads and fixing the types of problems that occur following storm events

65. *ANR Natural Resource Atlas*, VT. AGENCY OF NAT. RESOURCES, http://anrmaps.vermont.gov/websites/anra/ [https://perma.cc/965N-54WQ] (last visited Mar. 7, 2016) (under the "Watershed Protection" category).

66. Treatment costs are estimated at $40/foot using the standard $10,000 Vermont Better Backroads grant amount and assuming a standard treated length of 250 feet. Actual treated road lengths on these projects vary and road length effectively treated in a $10,000 project may exceed this 250 foot estimate. Values are given here for illustrative purposes only.

67. Treatment costs are amortized over eight years to reflect the lifetime of intact BMPs assessed in this research, given availability of project data files. Actual BMP life may exceed this length of time.

constitute a substantial portion of the non-winter expenditures. These expenditures can be particularly straining in the wake of extreme storms. Taken together, these results suggest that a reallocation of resources from repair of damaged road segments to proactive implementation of BMPs will achieve water quality improvements and long-term cost savings for towns.

Although the empirical observations described in this paper were limited by the set of sites and towns selected for study, the sites examined are typical of upland settings in towns with populations, resources, and road networks that span conditions of the rural settings of the state. The results described here should be broadly applicable across the state and useful for directing resources and policies toward back road improvements.

Within the broader context of water-quality management in Lake Champlain, where control of biologically available phosphorus is needed to reduce the occurrence of harmful algal blooms, controlling erosion on unpaved roads may contribute only incrementally to meeting this regional challenge because phosphorus yielded from unpaved roads is likely less bioavailable than the yields from agricultural lowlands and must be transported over longer distances than from those settings closer to the lake. Nevertheless, mitigating water-quality impacts to our waterways is a broad challenge that requires adaptive interventions across the landscape. Addressing erosion and water-quality impairments on rural, upland road networks will make important contributions to reducing sediment input to our mountain streams, a pro-active measure that will undoubtedly forestall future water quality concerns in this setting. In addition, shoring up unstable and vulnerable segments of the upland road network will ensure the integrity of the infrastructure while building communities that are more resilient to the extreme events affecting Vermont and other settings in the face of climate change.

AGRICULTURAL SOURCES OF WATER POLLUTION: HOW OUR HISTORY INFORMS CURRENT DEBATE

Chuck Ross and Marli Rupe*

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INTRODUCTION

Humans have been present in Vermont and the Champlain Valley for thousands of years and have relied upon the bounty of its ecology for support and sustenance. Prior to the colonization of the United States, human activity was small in scope and characterized by hunting and gathering in dense woods and small-scale agricultural activities consistent with their small population and impermanent locations.[1] The ecological footprint of Native Americans was small and their impact negligible in terms of fundamentally changing or altering the ecology of the region.[2]

Things changed with European colonization of North America and a human population that arrived with a distinctive set of cultural beliefs, strategies and practices for engaging with the natural environment. These strategies relied upon the restructuring of the existing agrarian relationship and human impact on the landscape with a focus on turning natural resources into food and goods for their immediate needs and marketable products beyond their immediate needs.[3] The enormous forests that covered Vermont's landscape at the time provided a range of products needed by the emerging state and markets to the south.[4] The dramatic clearing of these forests and the many fertile soils that then became available for agricultural pursuits made the region a rich resource for its inhabitants and to the growing population of the United States.[5] The bounty of this ecological system and the resources of water, soil, sun, and proximity to the early cities and population centers enabled Vermont to become a prominent provider of resources to support our new country.[6]

Vermont's history was like many other states and countries where its early development and success depended upon maximizing the potential of the environment. Unfortunately, intensive use and exploitation of that environment created negative consequences, which seemed minor given the vast wealth of the land, but which were eventually recognized and slowly understood as creating an array of costs and impacts that would need to be addressed at a future time.[7] In the 1800s, Vermont recognized that actions were needed to ameliorate or reverse these negative consequences. While people expressed concern and took actions during that century, George

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1. CHARLES W. JOHNSON, THE NATURE OF VERMONT: INTRODUCTION AND GUIDE TO A NEW ENGLAND ENVIRONMENT 50–51 (New & Expanded ed. 1998).
2. *Id.* at 51.
3. *Id.* at 50–52.
4. *Id.* at 51–54.
5. *Id.* at 52–53.
6. *Id.* at 53.
7. *See id.* at 52–53, 55–56, 64 (recounting Vermont's history of poor faming and logging practices and environmental degradation).

Perkins Marsh, the most enduring voice to focus on these issues, wrote about the significance of the damage to the environment.[8] The 1900s saw policies put in place to address soil erosion, establish national agricultural policy to improve farm profitability, and assure food was affordable.[9] In the 1970s, the federal government passed landmark legislation like the Clean Water Act, Safe Drinking Water Act, and the National Environmental Policy Act. These acts represent key elements of the "environmental" movement beginning in the 1970s and leading to further action and involvement on the part of citizens, including Vermont.

In the last ten years, Vermont's efforts have been characterized by an increasingly collaborative effort between federal and state regulatory agencies, landowners and citizens, and technical experts and scientists. Much of this effort has been aimed at identifying sources, reducing source levels to assimilative levels, and changing practices throughout society to achieve goals for water quality including Lake Champlain.

I. HISTORY

Vermont's forested landscape in the early 1800s was so vast and valuable and the demand for wood products was so strong that the lumbermen of the day established Vermont as a premier source of logs and lumber. One of the most important activities that characterized the early years of colonial settlement was the harvesting of trees for the production of potash and pearl ash, greatly in demand to the British market,[10] and the creation of charcoal, a fuel source increasingly in demand by the colonial towns and cities.[11] By 1873, Burlington, Vermont, was the third largest lumber port in the world.[12] With the cutting of trees came the clearing of the land for agricultural cultivation necessary to support the settlement lifestyles being sought and established by the colonists and modeled upon countries from which they came.[13] The clearings became gardens, pastures, and fields to raise crops and livestock necessary to sustain the growing population and markets to the south.

The mid-1800s also saw the rise of a sheep industry that dominated Vermont agriculture. By 1840, the demand for wool was at a peak and 1.5

8. *Id.* at 56–57.

9. *See id.* at 58 (describing the conservation forestry practices championed by Theodore Roosevelt and others).

10. FROM POTASH TO READY CASH: VERMONT'S FIRST CASH CROP, http://vermonthistory.org/images/stories/articles/greenmountaineer/frompotashtoreadycash.pdf [https://perma.cc/U75A-7HB2] (last visited Apr. 18, 2016).

11. JOHNSON, *supra* note 1, at 53.

12. *Id.* at 54.

13. *Id.* at 52–53.

million Merino sheep thrived on the Vermont landscape.[14] Sheep helped clear the Vermont hillside as trees were felled for the potash markets, including its use as a fertilizer and an ingredient in soap for cleaning raw wool.[15] The clearing of trees amplified the value of Vermont's water and waterways, which were used as a means of transporting wood to markets to the south, an activity increased by the construction of canals, which enhanced the ease of transportation.[16]

These activities permanently altered the landscape of the region. By the 1850s, seventy to seventy-five percent of the land in Vermont was open due to sheep pastures, croplands, and cleared forests.[17] Vermonters used this open land to support an agricultural economy that served the greater United States through the raising and exporting of wool and forest products demanded by southern markets.[18]

As Vermont reached its peak in wool and timber production, changes in national trade policy and expansion of settlements in the western United States began to drive a change in Vermont's agricultural sector. Wool prices dropped in the mid-1800s when the tariffs on imported wool were eliminated and lower production costs in western states hurt the Vermont producers.[19] New transportation methods and infrastructure opened farming options in other parts of the United States where land degradation had not yet occurred, rivers were not muddy from erosion, and land was flatter and more productive.[20] Over time, as sheep farming declined, dairy became a stronger factor in Vermont agriculture where the cool growing season allowed for good grazing and hay production. By the 1900s, few farms did not have milk cows.[21]

At first, the transition to butter and cheese production was not smooth, mainly because of poor dairy cow genetics. Over time, production quality and volume improved in part due to the importation of Jersey breed cattle

14. *Id.* at 53.
15. *Id.*
16. *Id.*
17. JOHNSON, *supra* note 1, at 53.
18. *Id.*
19. Roger Albee, *The Sheep Craze in Vermont's Agricultural History*, WHAT CERES MIGHT SAY (Mar. 24, 2011), http://whatceresmightsay.blogspot.com/2011/03/sheep-craze-in-vermonts-agricultural.html [https://perma.cc/JF5K-KN63].
20. JOHNSON, *supra* note 1, at 55.
21. Bob Parsons, *Vermont's Dairy Sector: Is There a Sustainable Future for the 800 lb. Gorilla?* 2–3 (Univ. of Vt. Ctr. for Rural Studies, Food Sys. Research Collaborative, Opportunities for Agriculture Working Paper Series Vol. 1, No. 4), http://www.uvm.edu/crs/reports/working_papers/WorkingPaperParsons-web.pdf [https://perma.cc/R9JV-U4WY].

by Fredrick Billings.[22] Individual farmers produced most of the butter on the farm until the mid-1800s when commercial production began and the Vermont legislature supported the establishment of the Vermont Dairymen's Association (1872), the first in the nation.[23] By the 1920s, Vermont had about 14,000 dairy farms, 166 creameries, and 66 cheese factories and St. Albans was known as the "butter capital" of the world.[24] Vermont was a major supplier of milk to regional markets and about 50% of the milk purchased in Boston originated in Vermont.[25] Still, diversified agriculture existed with apples, potatoes, poultry, and maple all contributing to the Vermont farm economy.

The mid-1800s also saw the beginning of systematic education for farmers when Vermont Senator Justin Morrill oversaw the creation of the Land Grant System in 1862.[26] The Board of Agriculture that began in 1872 was later responsible for the Vermont Agricultural Experiment Station (1886) that was charged with working on soil fertility and farm practices.[27] During this time, commercially processed fertilizers were being used extensively to increase soil fertility. In 1882, the State of Vermont began to regulate and license fertilizer sales and authorized the University of Vermont ("UVM") to test fertilizer samples.[28] The Board of Agriculture also began to hear about and discuss environmental concerns. Their first annual report in 1872 acknowledged that early settlers had believed soil was inexhaustible. Several speakers, including Jonathan Lawrence of St. Johnsbury, a farmer himself, spoke to the Board of how to improve soil fertility and the need to plant trees to decrease erosion.[29]

II. CONSERVATION'S BEGINNINGS IN VERMONT

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22. Roger Albee, *The Slow Movement to Commercial Butter Production*, WHAT CERES MIGHT SAY (Apr. 12, 2011), http://whatceresmightsay.blogspot.com/2011/04/slow-movement-to-commercial-butter.html [https://perma.cc/D5RT-EP4P].

23. Roger Albee, *Timeline of Changes in Vermont*, WHAT CERES MIGHT SAY (Mar. 1, 2011), http://whatceresmightsay.blogspot.com/2011/03/timeline-of-changes-in-vermont.html [https://perma.cc/6VXK-AY28].

24. Albee, *The Slow Movement to Commercial Butter Production*, *supra* note 22.

25. Roger Albee, *Lessons Learned from the Past: Looking to the Future After a Major Disaster—The Vermont Story*, WHAT CERES MIGHT SAY (Oct. 11, 2011), http://whatceresmightsay.blogspot.com/2011/10/lessons-learned-from-past-looking-to.html [https://perma.cc/6PQA-U5L2].

26. Roger Albee, *Historical Importance of Agriculture Education in the United States and in Vermont*, WHAT CERES MIGHT SAY (Aug. 1, 2011), http://whatceresmightsay.blogspot.com/2011/08/historical-importance-of-agricultural.html [https://perma.cc/2G4U-87VP].

27. Roger Albee, *Brief History of Agriculture, the Environment, and Land Use in Vermont*, WHAT CERES MIGHT SAY (June 30, 2012), http://whatceresmightsay.blogspot.com/2012/06/brief-history-of-agriculture.html [https://perma.cc/DN2K-NNXM].

28. *Id.*

29. *Id.*

In 1847, well-known author, conservationist, and Vermont Congressman George Perkins Marsh called for recognition of environmental stewardship and "zealous efforts" toward farming improvements.[30] In 1864, Marsh wrote of environment challenges in his book *Man and Nature* when he stated, "the operation of causes set in action by man has brought the face of the earth to a desolation almost as complete as that of the moon," a reference to the deforestation and sheep farming that were eroding the soils of Vermont's fields into its rivers and streams.[31] But it was not until the Dust Bowl of the early 1930s that the American public's attention was captured. For years, farmers had plowed up the deep rooted Midwest grasses to grow wheat. Persistent drought in Oklahoma, Texas, Kansas, Colorado, and New Mexico left land bare to blowing winds and resulted in dust storms.[32] In 1934 and 1935, the dust storms darkened the skies across the country—including Washington, D.C.—devastating human and animal health and causing long-term agricultural effects.[33] This public and environmental health challenge emphasized the severity of the situation enough to create the first major national effort toward natural resource protection.[34]

As a result, soil and water conservation were priorities in the Franklin D. Roosevelt administration. Federal funds were first allocated through the Soil Conservation Act for demonstration projects in the most critically eroded areas of the country to show the value of soil conservation.[35] Hugh Hammond Bennett, who became the first Chief of the Soil Conservation Service ("SCS"), influenced this with his early writings and later urged the creation of a permanent federal agency that would address soil conservation.[36] In 1935, SCS was established as part of the U.S. Department of Agriculture ("USDA").[37] While created to address erosion concerns, watershed planning and related water quality and quantity issues were also priorities of SCS.[38] As a result, the USDA saw the benefits of locally led action to educate and bring farmers together. The Standard State

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30. George Perkins Marsh, Address Delivered Before the Agricultural Society of Rutland County (Sept. 30, 1847), *in* U. OF VT. LIBRARIES: CTR. FOR DIG. INITIATIVES, http://cdi.uvm.edu/collections/item/pubagsocaddr [https://perma.cc/KR4C-754G] (last visited Apr. 19, 2016).

31. GEORGE PERKINS MARSH, MAN AND NATURE 42 (1864).

32. *80 Years Helping People Help the Land: A Brief History of NRCS*, U.S. DEP'T OF AGRIC. NAT. RESOURCE CONSERVATION SERV., http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/about/history/?cid=nrcs143_021392 [https://perma.cc/YJD7-QHGY] (last visited Apr. 4, 2016).

33. *Id.*

34. *Id.*

35. *Id.*

36. *Id.*

37. *Id.*

38. *Id.*

Soil Conservation Districts Law in 1937 created the Soil and Water Conservation Districts, with the first District created in Vermont in 1942.[39] The Natural Resources Conservation Service ("NRCS"), as the SCS was renamed in 1994, and the Natural Resources Conservation Districts ("NRCDs") have been pivotal in Vermont agricultural history for development and implementation of critical conservation and pollution control practices.[40]

In 1933, the Roosevelt Administration created the first Farm Bill, known as the Agricultural Adjustment Act, to compensate farmers for not using their land for crop production.[41] During the Depression, farm incomes had decreased by more than 50%[42] and the purpose of the act was primarily to support farmers through higher grain prices. This act was formalized in 1938 and, at that time, required to be updated every five years.[43] In 1995, federal legislation responsible for incentivizing comprehensive conservation practice implementation was introduced and passed.[44] It was called the "Environmental Quality Incentives Program" ("EQIP") and it was championed by a bipartisan group of Senators led by Vermont Senator Patrick Leahy, a member of the Senate Agriculture Committee.[45] By 2002, the Farm Bill, retitled the Farm Security and Rural Investment Act, increased EQIP funding from $400 million dollars to over $1 billion, with the emphasis on environmental protection and less on market stabilization.[46] The EQIP allocation in the most recent Farm Bill, now known as the Agricultural Reform, Food and Jobs Act of 2013, allocated approximately $9 million in 2015 to Vermont.[47]

From the outset, the Farm Bill has initiated many agricultural programs. Unfortunately, many of the agricultural activities done in the early 1900s

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39. *Id.*
40. *Id.*
41. Gilbert C. Fite, *Farmer Opinion and the Agricultural Adjustment Act, 1933*, 48 MISS. VALLEY HIST. REV. 656, 659 (1962).
42. Rosemary D. Marcuss & Richard E. Kane, *U.S. National Income and Product Statistic: Born of the Great Depression and World War II*, 87 SUR. CURRENT BUS. 32, 32 (2007).
43. CAF DOWLAH, INTERNATIONAL TRADE, COMPETITIVE ADVANTAGE AND DEVELOPING ECONOMIES: HOW LESS DEVELOPED COUNTRIES ARE CAPTURING GLOBAL MARKETS 54 (2016).
44. Otto Doering, *An Overview of Conservation and Agricultural Policy: Questions from the Past and Observations About the Present* 6 (Am. Farm & Tr. Ctr. for Agric. in the Env't Working Paper, 1998), http://www.farmlandinfo.org/sites/default/files/AGRICULTURAL_AND_CONSERVATION_POLICIES_2002_AND_BEYOND_1.pdf [https://perma.cc/U7SF-FFSX].
45. Press Release, U.S. Senator Patrick Leahy of Vermont, Vermont Highlights of 2008 Farm Bill (May 14, 2008), https://www.leahy.senate.gov/press/vermont-highlights-of-2008-farm-bill [https://perma.cc/7SNH-7HQF].
46. MEGAN STUBBS, CONG. RESEARCH SERV., R40197, ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP): STATUS AND ISSUES 3 (2010).
47. Personal communication with Obediah Racicot, Vt. Nat. Res. Conservation Serv. (Feb. 15, 2016).

that were seen as beneficial for increasing farm production and profitability ultimately proved detrimental to conservation and protection of water and natural resources. Wetlands, which are critical to water quality and flood resiliency, were routinely drained (sometimes with state and federal funding support) to increase crop production on marginal lands.[48] Trees and shrubs were cleared along riverbanks to allow for planting row crops in the rich, alluvial soils. Farming turned from mostly perennial grass-based practices to annual crop production and deep and continuous tillage—again exposing bare soils to fall and winter erosion. In Vermont, the 20th century was a time of dramatically changed crop production on farms coupled with increased negative impacts on the environment and natural resources of the state. Eroding soils carried phosphorus-laden soils to rivers, streams, and lakes. The lack of wetlands affected flood resiliency as more intense rainfall events occurred and non-forested buffers left streambanks without strong root systems to keep them secure.

The federal programs of the 1930s provided the architecture for the future of agriculture in the United States. Vermont's farming economy evolved through the mid-1900s and was characterized by a diversified farm economy with an increasing presence and focus on dairy.[49] The farms were typically small family operations with subsistence activities and products aimed at the New England and New York dairy markets.[50] These farms covered Vermont's diverse landscape and maintained much of the open land created in the 1800s, supporting the village countryside pattern of land use that has become the state's hallmark. Those farms produced the maple and dairy products that have become the marquee-brand food products for which Vermont is renowned. Dairy became the primary agricultural product in terms of revenue and land use and, by the 1960s, there were more than 6,000 dairies in Vermont averaging 6,000 pounds of milk per year,[51] achieving production rates that were never thought possible by the early subsistence farmers. These family farms are what helped create the self-reliant, independent Vermonter that cared about community and understood that their livelihood depended upon their natural environment. These farmers and the business people who supported them were also the people who served as community leaders, selectmen, and legislators. These small, grass-based, diversified dairy farms and supporting businesses were the

48. FARM DRAINAGE IN THE UNITED STATES. HISTORY, STATUS, AND PROSPECTS 8–9 (George A. Pavelis ed., 1987), http://files.eric.ed.gov/fulltext/ED295043.pdf [https://perma.cc/HS3A-RGXE].

49. Parsons, *supra* note 21, at 2.

50. Email from Roger Albee to Chuck Ross, Secretary, Vt. Agency of Agric., Food & Mkts., & Marli Rupe, Assistant Program Manager, Clean Water Initiative Program, Vt. Dep't of Envtl. Conservation (Jan. 31, 2016) (on file with authors).

51. Parsons, *supra* note 21, at 3.

economic and cultural bedrock of Vermont in the 1940s and early 1950s. They were the "essence of Vermont" at that time, but Vermont was changing and so would the face of agriculture.

III. CHEAP FERTILIZER, CHEAP FOOD, AND SAFE FOOD

The change that was afoot included a march toward greater productivity and efficiency supported by national cheap food policies advanced during the Great Depression and World War II. The national dairy policies developed during and after the Depression were of particular importance because they influenced the evolution of dairy farming and the prices received by farmers and paid by consumers.[52]

The federal government's support for agricultural productivity grounded in scientific analysis encouraged the farmers to become more efficient and productive, exemplified by the importation of freight trains of phosphorus fertilizer paid for by the federal government—a program implemented nationally, including in Vermont.[53] The cheap phosphorus was aimed at increasing soil fertility and crop yields and was applied liberally by farmers all over the state. At the same time, federal funds through the former USDA Agricultural Stabilization and Conservation Service helped farmers drain wet fields, often wetlands, to increase the acreage available for annual crop production.[54] These early practices encouraged by government policy and subsidies and supported by academic research contributed to—and now conflict with—the water quality anti-degradation and phosphorus reduction policies of today.

Ironically, federal policy aimed at a bountiful and safe food supply required dairy farmers to install bulk milk tanks and cement floors in their barns to protect the quality and safety of the milk they were shipping.[55] These infrastructure improvements were often difficult or impossible to implement because the cost was beyond economic capacity of many of the Vermont farms that were located on rocky hillsides with low acreage and marginal or wet soils.

The confluence of these policies and the economics of the time dramatically accelerated changes on the farm and thereby the economy,

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52. ERIC M. ERBA & ANDREW M. NOVAKOVIC, THE EVOLUTION OF MILK PRICING AND GOVERNMENT INTERVENTION IN DAIRY MARKETS 9–10 (1995), http://dairy.wisc.edu/pubPod/pubs/EB9505.pdf [https://perma.cc/9NVF-AWM3].

53. Email from Roger Albee, *supra* note 50.

54. FARM DRAINAGE IN THE UNITED STATES, *supra* note 48, at 8.

55. Curt A. Gooch, *Considerations in Flooring*, DELAVAL MILKPRODUCTION.COM (Nov. 28, 2005), http://www.milkproduction.com/Library/Scientific-articles/Housing/Considerations-in-flooring/ [https://perma.cc/R3YV-9TJ8]; *Historical Timeline: History of Cow's Milk from the Ancient World to the Present*, PROCON.ORG, http://milk.procon.org/view.timeline.php?timelineID=000018 [https://perma.cc/W6LZ-SW24] (last updated July 10, 2013).

communities, and environment of Vermont. While the bulk tank and cement floor requirements were significant change agents in Vermont, they were manifestations of the unrelenting push for efficiency and productivity that characterized the United States after World War II, from which Vermont agriculture was not immune. The result was a steady increase in production driven by efficient techniques and economies of scale that rewarded larger farms with the financial ability to invest.[56] The federal government's support for commodity programs assured that farmers received enough money for their products. These programs and various subsidies coupled with education and technical assistance helped farmers to modernize, stay in business, and continue to increase production.

In Vermont, smaller farms (less than 100 cows) had traditionally emphasized pasturing and smaller herds, but the development of larger farms, soon over 1,000 cows, changed the landscape, with more annual crops and less ground cover of grasses and trees. It also changed animal management. Both had water quality effects. As herd size increased, pasturing was more difficult and land was needed for crops that produced more feed per acre. Animals were contained in barns full-time, with limited access outside, usually on a small, concrete or beaten down dirt barnyard.[57] The resulting concentration of manure led to further pollution concerns. Manure's value as a fertilizer was a key reason for animals to be part of early agriculture. Today, manure increases in quantity on a per cow basis as milk production increases; these increasing volumes of manure need to be moved, managed, and distributed efficiently around the farm.[58]

The on-farm changes were matched by changes in the businesses and industries supporting agriculture. Up and down the supply chain of the United States food system, business and industry (and the political system, in partnership with the farmers) made changes that enabled American agriculture to significantly increase the quantity of food available for domestic use and export.[59] Like the rest of the nation's economy, the food system did not always assess or penalize the production of negative externalities, especially intangible values not easily captured in the market place. Agriculture was part of the same economic system that allowed industry to discharge wastes to the air, water, and soil—the system that allowed the Cuyahoga River to catch fire, acid rain to sterilize lakes in the

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56. CAROLYN DIMITRI ET AL., THE 20TH CENTURY TRANSFORMATION OF U.S. AGRICULTURE AND FARM POLICY 2 (2005), http://www.ers.usda.gov/media/259572/eib3_1_.pdf [https://perma.cc/RM7C-RB4K].

57. Gooch, *supra* note 55.

58. JAMES M. MACDONALD ET AL., MANURE USE FOR FERTILIZER AND FOR ENERGY iii, 1, 4, 18 (2009), http://www.ers.usda.gov/media/377377/ap037fm_1_.pdf [https://perma.cc/8U3V-UYTZ].

59. DIMITRI ET AL., *supra* note 56, at 2.

Adirondacks, and the Love Canal to poison groundwater. American agriculture as part of the American economy was part of a system that used pesticides that poisoned our birds, plowed and tilled fields in ways that eroded our soils, tiled and filled our wetlands, and allowed excess nutrients and chemicals to run-off our farms and pollute our waters.

Vermont agriculture reflected this national system. Farm productivity increased dramatically and farms consolidated. For example, in Franklin County the number of farms declined from 2,500 in the late 1800s to less than 800 in 1990.[60] As the declining number of farms demonstrates, many farmers could not sustain their businesses in the changing economic climate and chose—or were forced—to go out of business. To better navigate this economy in which corporations exercised economic strength in the market, farmers banded together to initiate and lead cooperatives that exercised the legal power of the Capper-Volstead Act of 1922.[61] Cooperatives provide farmers greater leverage in the market place by combining their economic power and enabling them to negotiate with other players in the supply chain. The strength cooperatives provided farmers increased in importance as the size and strength of the other businesses in the supply chain increased.[62]

Initially, the dairy cooperatives were dealing with many companies that bought and processed raw milk and retailers who sold the finished product to the consumer.[63] These businesses were ubiquitous within the supply chain and competitive with one another. But over the years, cooperatives, like the farms, consolidated and became or have nearly become oligopolistic enterprises. They have been accused of exercising leverage in the market place to suppress prices and/or to increase their profitability at the expense of the farmers.[64] Low prices and low margins constrain profitability and increase stress on farms already working on small margins. This is further exacerbated by a federal milk pricing system that few people understand, or can explain, and which has amplified price swings. The result has been a dairy economy in which margins are low, prices are highly volatile, and profitability is inconsistent and accompanied by long periods

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60. KAREN HYDE ET AL., HISTORY OF PHOSPHORUS LOADINGS TO ST. ALBANS BAY, 1850-1990 9 (1994), http://www.lcbp.org/wp-content/uploads/2013/03/7B_History-of-Phosphorus-Loading-to-St.-Albans-Bay-1850_1990.pdf [https://perma.cc/Q7YM-9XY7].

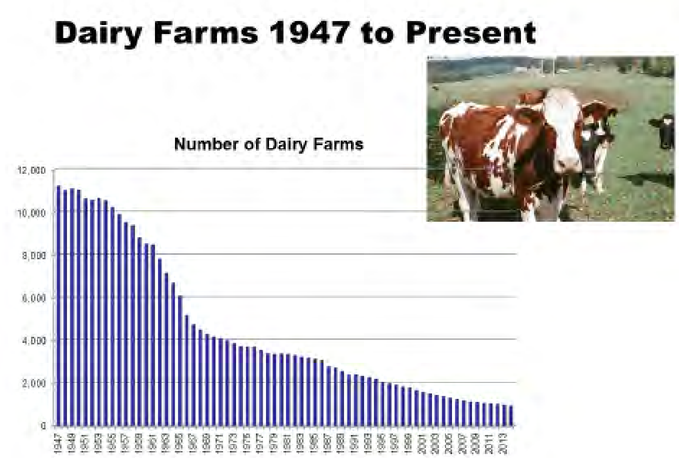
61. Donald M. Barnes & Christopher E. Ondeck, The Capper-Volstead Act: Opportunity Today and Tomorrow (Aug. 5, 1997) (unpublished manuscript), http://www.uwcc.wisc.edu/info/capper.html [https://perma.cc/LPY5-7DEM].

62. *Id.*

63. *Id.*

64. Complaint at 2, 12, United States v. Dean Foods Co. (E.D. Wis. 2011) (No. 10-C-0059).

of low-profit or below-cost-of-production operations.[65] This has created a nearly irresistible need to decrease cost, increase revenues, increase efficiency, and build economies of scale through expansion. The result over time has been the dramatic decline in the number of dairy farms in Vermont. Nationally, this includes the ongoing pressure to consolidate and get big to compete, the loss of small and medium sized farms, and the loss of good agricultural land.[66] The forces that accompanied the modernization of Vermont agriculture and dairying and the changes they induced can be seen in the charts below:



> The structure of Vermont agriculture changed over time with a large reduction in farm numbers as many small and inefficient farms went out of business and those that remained got larger and more efficient.[67]

A. National Response to Low Prices and Decline in Farms

Society has responded to the problem of low milk prices by passing a range of new public policies. In 1986, the federal government established a program called the "Whole Herd Buyout," which bought farmers' herds in

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65. *See* JEFFREY WEISEL, THE NEED FOR CHANGE IN THE DAIRY INDUSTRY, www.justice.gov/atr/public/workshops/ag2010/001/AGW-00006-a.doc (last visited Apr. 4, 2016) (describing how the complex pricing system for dairy has created ranges in production costs and consumer prices).

66. DIMITRI ET AL., *supra* note 56, at 3.

67. Presentation by Dan Scruton, Dairy Section Chief, Vt. Agency of Agric., Food & Mkts., to Vt. Agency of Agric., Food & Mkts. staff (data on file with Vermont Journal of Environmental Law), (the date of the presentation is not available).

an effort to reduce production and thereby increase prices.[68] More recently, the federal government has included the Milk Income Loss Contract ("MILC") and the Dairy Security Act ("DSA") provisions. The MILC program was designed to augment poor prices after they fell to a certain level.[69] The DSA provision was designed to replace MILC with an insurance program that provides coverage when profitability margins become too small.[70]

In the early 1990s, following the Whole Herd Buyout and prior to the MILC, Vermont also helped by leading the effort to pass the New England Interstate Dairy Compact. This program, passed as part of the 1996 Farm Bill, allowed the six New England states to band together to set prices for Class 1 fluid milk[71] sold in the region and thereby increase the financial returns to producers.[72] Because the operation of the New England Interstate Dairy Compact triggered the Interstate Commerce Clause, this program required Congressional approval.[73] Senator Leahy, who sat on both the Agriculture and Judiciary committees in the U.S. Senate, led a coalition of senators and representatives of both parties to get Congress to take the necessary action to support this program. In 2006, Vermont also passed legislation that provided direct support from Vermont taxpayers to supplement the income of dairy farmers.[74] This program only lasted one year and paid out approximately $11 million.[75]

B. The Vermont Response to Farm and Farmland Losses

In 1988, Vermont established policies impacting land use that in turn had dramatic effects on agricultural economics and sustainability. In 1986, concern about the development pressure and sprawl on valuable agricultural

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68. Scott Brown, Food & Agric. Policy Research Inst., Univ. of Mo., History of Federal Dairy Programs: Presentation to the Dairy Industry Advisory Committee 17 (Apr. 13–15, 2010), http://www.fsa.usda.gov/Internet/FSA_File/1_2_overview_brown.pdf [https://perma.cc/RRR7-5GUZ].

69. *Id.* at 20.

70. LINNEA CARLSON, MILKING THE TRUTH: THE FACTS ABOUT DAIRY FARMING IN THE UNITED STATES, https://apps.carleton.edu/curricular/posc/assets/Carlson_Milking_the_Truth.pdf [https://perma.cc/4RZ6-ZLWL] (last visited July 22, 2016).

71. NE. DAIRY COMPACT COMM'N, http://dairycompact.org/ [https://perma.cc/RF7G-DWDK] (last visited Apr. 11, 2016).

72. ED JESSE & BOB CROPP, BASIC MILK PRICING CONCEPTS FOR DAIRY FARMS 19 (2008), http://future.aae.wisc.edu/publications/basic_milk_pricing.pdf [https://perma.cc/WKS4-3WK6].

73. RALPH M. CHITE, CONG. RESEARCH SERV., 96-814 ENR, THE NORTHEAST INTERSTATE DAIRY COMPACT 2 (Oct. 7, 1996), http://dairy.wisc.edu/PubPod/Reference/Library/Chite.10.1996.pdf [https://perma.cc/ECS9-B5K7].

74. H.406, 2005-2006 Leg. Sess. (Vt. 2005).

75. Email from Diane Bothfeld, Deputy Secretary, Vt. Agency of Agric., Food & Mkts., to Marli Rupe, Assistant Program Manager, Clean Water Initiative Program, Vt. Dep't of Envtl. Conservation (Feb. 17, 2016) (on file with authors).

lands and availability of affordable housing caused the legislature to enact the Vermont Housing and Conservation Trust Fund Act and fund it with $3 million.[76] Since then, the Vermont Housing and Conservation Board ("VHCB") has used state and federal funds to buy development rights from farmers, thereby paying the farmland owner for their equity while conserving the land and restricting its future use to agriculture through conservation easements.[77] This program has enabled VHCB to conserve almost 400,000 acres of land, but it has also made land acquisition a possible option for new farmers who could never afford to purchase agricultural land at development value.[78]

In 1978, Vermont passed the state-funded Use Value or "Current Use" program. This program provided substantial tax benefits to farmers and forest landowners to keep their land in agriculture and forest production.[79] The land is then taxed at its "current use" rather than its highest market value rate.[80] Enrollment in the Current Use program saved thousands of dollars every year in abated property tax dollars for those farmland owners who enrolled and many considered it to be Vermont's most important farmland conservation program.[81]

While these programs have helped to bolster income at various times and provided property-tax breaks to reflect the broader societal importance of farming and farmland to Vermont, they did not stop the loss of farms and farmland or the devastating price swings experienced by dairy farmers. These programs did not address the emerging issue of Vermont's declining water quality or the role of agriculture's contribution or responsibility as part of the solution.

IV. RECOGNITION OF WATER QUALITY CHALLENGES

Programs have been developed to assist farmers in their manure management, including the installation of manure pits to collect and manage the liquid manure being generated by an increasing number of farms. Many of these farmers were increasing grain inputs and

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76. *VHCB Conservation Programs*, VT. HOUSING & CONSERVATION BOARD, http://www.vhcb.org/conservation.html [https://perma.cc/V8SF-SSKJ] (last visited Apr. 5, 2016).

77. *Id.*

78. *Id.*

79. VT. STAT. ANN. tit. 32, §§ 3750–3777 (2016).

80. *Current Use*, RURAL VERMONT, http://www.ruralvermont.org/issues-main/current-use/ [https://perma.cc/6ZQA-Z6RC] (last visited Mar. 29, 2016); VT. STAT. ANN. tit. 32, § 3756.

81. JAMEY FIDEL ET AL., COMMUNITY STRATEGIES FOR VERMONT'S FORESTS AND WILDLIFE: A GUIDE FOR LOCAL ACTION 19–20 (2013), http://vnrc.org/wp-content/uploads/2013/08/VNRC-Forestland-Conservation-10-1-links.pdf [https://perma.cc/AV5R-3NF5]; *Current Use*, *supra* note 80.

concentrating cows onto larger farms in order to increase efficiency and production and, in many cases, greater revenues and profitability.[82] The increased milk production also required increased grain use, resulting in increased manure generation and a need for new management systems and equipment.[83] The need to feed high-energy grain containing corn imported from outside the region incentivized farmers to raise their own corn in order to reduce costs. This led to further water quality impacts as perennial grassland was turned over into annual corn ground. In Franklin County alone, acreage in corn increased from between 4,000 and 6,000 acres (1900–1930) to over 17,000 acres in 1980.[84] Heavy applications of manure and commercial fertilizers were applied to assure the fertility required for high corn yields, which were necessitated by the market demand for increases in efficiency and production.[85]

In early agriculture, manure was a relatively dry product, combined with bedding in cow stalls and removed from barns by scrapers that cleaned the gutters behind the cow stalls and carried the manure to a mechanical spreader outside the end of the barn. It was distributed around fields during the growing season and often in winter too, spread on snow and frozen ground, with no chance to infiltrate soil and causing winter runoff to streams and lakes. Some winter manure was stacked in fields to be used in the spring as soon as the ground thawed.

As farms grew in size, changes in dairy feed management that greatly increased protein intake and barn designs that required less bedding, resulted in a more liquid manure and that transition from stackable bedding manure to a contained slurry-like waste marked a dramatic change in water quality impacts. Liquid manure flows more easily across the sloped fields of Vermont and wastes in barnyards that were built for short daily animal exercise became problematic as they ran to nearby small ditches and brooks.[86]

V. LAKE CHAMPLAIN BASIN PROGRAM—A MULTI-JURISDICTIONAL EFFORT

82. DIMITRI ET AL., *supra* note 56, at 2.

83. *See generally* Mary Beth de Ondarza, *Manure Evaluation*, DELAVAL MILKPRODUCTION.COM (Oct. 10, 2000), http://www.milkproduction.com/Library/Scientific -articles/Nutrition/Manure-evaluation/ [https://perma.cc/8VX7-J9EU] (explaining how grain affects cow manure).

84. HYDE ET AL., *supra* note 60, at 9.

85. *Id.* at 8–9 (explaining how changes in agricultural practices led to increased phosphorus yield on farms).

86. Author's personal knowledge.

The decade of the 1990s would see an increase in concern and efforts to address what was becoming understood as a real challenge to the water quality of Lake Champlain, specifically to its smaller sub-watersheds of the South Lake, Missisquoi Bay, and St. Albans Bay. In 1990, Lake Champlain was designated as a resource of national significance[87] by a law drafted by Senators Jeffords and Leahy and supported as co-sponsors by New York Senators Moynihan and D'Amato. The goal of this law was to bring together the varied interests concerned with Lake Champlain to develop a comprehensive pollution prevention, control, and restoration plan for the lake.[88] The Lake Champlain Basin Program ("LCBP") was created and composed of representatives from many stakeholder groups and citizens including the Vermont Secretary of Agriculture and other agriculturally oriented representatives.[89] The stakeholder representatives governed the operations of the LCBP and subsequently developed Memoranda of Understanding ("MOUs") with the United States and Canadian governments.[90] In 1996, the LCBP wrote the first water quality plan coordinating the efforts of Vermont, New York, and Quebec around their shared waterbody. The collaborative plan was called *Opportunities for Action* ("OFA").[91] It examined the water quality problem, helped identify the significance of the problem, and proposed an array of mitigating actions that could be taken by various stakeholders in the two states and Canada.[92] The most recent update to OFA was in 2010, but the plan is maintained on LCBP's website as an interactive and dynamic site where chapters, goals, actions, and tasks are listed and continuously updated.[93]

The Vermont Statehouse also voiced public and scientific concern about water quality. The first conservation laws were passed in 1967, including the Soil Conservation Act and the Conservation and Development statute under Title 10, which established policies of the NRCDs.[94] Other related policies on wetlands, land conservation, and watershed protection, largely administered by the Agency of Natural Resources ("ANR"), were also included. It was under Title 6, however, where the first agricultural

87. Lake Champlain Special Designation Act of 1990, 33 U.S.C. § 1324(d)(2) (2012).

88. *Id.* § 1270(a)(1).

89. *Mission*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/about-us/mission/ [https://perma.cc/MX63-C3BQ] (last visited Apr. 19, 2016).

90. *Id.*

91. *Lake Champlain Opportunities for Action Management Plan*, LAKE CHAMPLAIN BASIN PROGRAM, http://plan.lcbp.org/ [https://perma.cc/AMN6-KJ85] (last visited Apr. 19, 2016).

92. *Opportunities for Action: An Evolving Plan for the Future of the Lake Champlain Basin: A Strategy for Implementing the Plan*, LAKE CHAMPLAIN BASIN PROGRAM, http://plan.lcbp.org/ofa-database/chapters/a-strategy-for-implementing-the-plan [https://perma.cc/NTJ5-DV94] (last updated Mar. 18, 2015).

93. *Lake Champlain Opportunities for Action Management Plan*, *supra* note 91.

94. VT. STAT. ANN. tit. 10, § 701 (2016).

water quality regulations were created and administered by the Agency of Agriculture.[95] This separation established in the law impacts how agricultural policy is developed, administered, and enforced separately than other sectors (even today) and reflects the strong historic support for agriculture by lawmakers in Vermont. Title 6 requires inspection of farms for sanitation and public health concerns.[96] However, environmental concerns were not addressed until 1991, when the Vermont Commissioner of Agriculture was first given a mandate to require certain agricultural land use practices to protect water quality.[97] Four years later, Vermont's first agricultural water quality regulations were created.

VI. THE ACCEPTED AGRICULTURAL PRACTICES AND STATE WATER QUALITY REGULATION

In 1995, the Accepted Agricultural Practices ("AAPs") were first adopted.[98] As written in the AAPs,

> Recognizing the need to protect and improve water quality through improved agricultural practices, the Vermont legislature charged the Agency of Agriculture, Food and Markets with creating a comprehensive Agricultural Nonpoint Source Pollution Reduction Program including Accepted Agricultural Practices and Best Management Practices. The legislature also recognized the need to balance water quality improvements with the need to sustain a healthy, economically viable agricultural industry.[99]

This desired balance of public health, agricultural viability, and the requirement that practices be both technically feasible and cost effective for farmers to implement became a point of contention when future regulations were developed. The AAPs were not designed, nor intended, to eliminate pollutants entering surface water, but were expected to decrease practices that would pollute or impact water quality. Nonetheless, the AAPs served as the regulatory floor with respect to water quality protection for all Vermonters engaged in agricultural practices and this constituted the first

95. VT. STAT. ANN. tit. 6, § 4810 (2016).

96. *Id.* § 4851(h).

97. VT. STAT. ANN. tit. 10, § 1679(c).

98. *Required Agricultural Practices (RAPs): Current Accepted Agricultural Practices*, VT. AGENCY OF AGRIC. FOOD & MKTS., http://agriculture.vermont.gov/water-quality/regulations/rap [https://perma.cc/R4UR-7QEJ] (last visited Apr. 19, 2016).

99. VT. AGENCY OF AGRIC., FOOD & MKTS., ACCEPTED AGRICULTURAL PRACTICE REGULATIONS § i (Apr. 24, 2006) (updating the language from the 1995 AAPs), http://agriculture.vermont.gov/sites/ag/files/ACCEPTED%20AGRICULTURAL%20PRACTICE%20REGULATIONS.pdf [https://perma.cc/Y2VP-SBW8].

major regulatory effort focused on agriculture to conserve and protect water quality.

At this time, there were approximately 2,000 dairy farms, ensuring dairying was still by far the dominant farming activity in the state and the sector of agriculture most affected by the AAPs.[100] These new rules dramatically changed the landscape of agricultural practices. The AAPs established that spreading of wastes (manure) was prohibited between December 15 and April 1.[101] This increased the number of farms that needed to install manure storage pits. Many smaller farms continued to stack manure with the intention of creating storage away from waterways. The AAPs also required the establishment of vegetative buffers between annual cropland and streams to filter nutrients and sediment from field erosion.[102] The rules also established minimum distances between stacking sites and water and required that waste management systems did not discharge into water.[103] Farms were now required to do soil tests, apply nutrients only according to crop needs, and manage soil erosion.[104]

These regulatory standards required farmers to change how they farmed and, in many circumstances, make substantial investments in order to comply, such as building manure storage pits and improving barnyard areas and silage storage systems. The AAPs were intended to reduce agriculture's adverse impact on water quality. While the intentions were well-founded, and many farmers did change how they farmed and made investments to mitigate their impacts, the knowledge and adoption of these regulations was not uniform and waned overtime.

A key part of the AAPs was the clarification of roles for the Vermont Agency of Agriculture, Food and Markets ("VAAFM") and ANR, which were, as mentioned, distinctly identified in separate titles of state statutes.[105] ANR is the agency delegated by the federal Environmental Protection Agency ("EPA") as the lead state water quality agency, thereby responsible for the management and enforcement of all water quality and water pollution control.[106] The Vermont legislature required that VAAFM cooperate with ANR in developing the Agricultural Nonpoint Source Pollution Reduction Program.[107] In 1999, the first MOU was developed between the two agencies to outline agricultural water quality oversight and

100. Authors' personal knowledge.
101. ACCEPTED AGRICULTURAL PRACTICE REGULATIONS, *supra* note 99, § 4.03.
102. *Id.* §§ ii, 4.06.
103. *Id.* § 4.02.
104. *Id.* §§ i, 4.04.
105. *Id.* § iii (explaining the roles of the agencies in implementing the AAPs).
106. *Vermont Agency of Natural Resources*, ENVTL. COUNCIL STATES, http://www.ecos.org/section/states/?id=VT [https://perma.cc/84LZ-ZTLQ] (last visited Apr. 4, 2016).
107. VT. STAT. ANN. tit. 6, § 4810.

enforcement.[108] While ANR retained its overall water quality authority, it clearly delegated responsibility for agricultural water quality and enforcement to VAAFM.[109]

A. Large Farm Permits

Nationally, EPA focused attention on the dramatic increase in large agricultural operations. Vermont followed suit with the creation of the Large Farm Operations ("LFO") program in 1995 and LFO rules in 1999.[110] The Vermont LFO initiative provided a distinct alternative to the Confined Animal Feeding Operation ("CAFO") permit process being advanced nationally by EPA. The LFO permit was more restrictive than the CAFO permit but allowed farmers to avoid publicly sharing their nutrient management plans as required of CAFO permit holders.[111] The LFO program required all farms with more than 700 mature cows (or comparable numbers of other species) to be individually permitted by VAAFM, have no nutrient discharges, be regularly inspected, and meet a higher standard of water quality protection than smaller farms by including lower soil erosion tolerance and wider stream buffers.[112] LFOs also had to request permission to build new structures from the Secretary of Agriculture, who then had the authority to call for a public informational meeting addressing the request.[113] This process addressed a dramatic change in authority of farm management in a state where landowners historically cherished their personal rights and privacy. In 2016, there are twenty-six LFOs in Vermont.[114]

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108. Memorandum from Roger Albee, Sec'y, Agency of Argic., Food & Mkts., to George Crombee, Sec'y, Agency of Nat. Res., Act 78 Memorandum of Understanding (Sept. 17, 2007), http://legislature.vermont.gov/assets/Documents/2016/WorkGroups/Senate%20Natural%20Resources/Bills/S.49/Witness%20Testimony/S.49~ANR-Department%20of%20Environmental%20Conservation~2007%20AAFM%20-%20Large%20Farm%20MOU%20with%20DEC~4-9-2015.pdf [https://perma.cc/Z3R3-FR2A].

109. *Id.*

110. VT. STAT. ANN. tit. 6, §§ 4849–4852; VT. AGENCY OF AGRIC., FOOD & MKTS., LARGE FARM OPERATION REGULATIONS (1999), http://agriculture.vermont.gov/sites/ag/files/LFO%20Rules.pdf [https://perma.cc/8YVU-9XJS]; *Regulations for Large Farm Operations (LFOs)*, VT. AGENCY OF AGRIC., FOOD & MKTS., http://agriculture.vermont.gov/water-quality/regulations/lfo [https://perma.cc/A77H-NR96] (last visited Apr. 19, 2016).

111. *Regulations for Large Farm Operations (LFOs)*, *supra* note 110.

112. *Id.*

113. *Id.*

114. Email from Nathaniel Sands, Vt. Agency of Agric., Food & Mkts., to Marli Rupe, Assistant Program Manager, Clean Water Initiative Program, Vt. Dep't of Envtl. Conservation (Oct. 9, 2015) (on file with authors).

In 2006, when dairy farm numbers had declined to 1,182 farms,[115] but the size of the remaining farms continued to grow, the AAPs were revised to recognize changes in farm management and amendments to Title 6 statutes.[116] The AAP regulations were then amended to include requirements related to the management of streambanks, animal mortalities, groundwater contamination, and setbacks for manure storage and land application.[117] It was at this time that the Medium Farm Operations ("MFO") program was passed in state law creating a general permit for medium sized farms, which for dairy was between 200 and 700 mature cows.[118] The MFO law also allowed for covering smaller farms identified as contributors to water quality impairment, but no small farms were ever brought under this rule.[119]

A major concern following the passage of these MFO and LFO rules was the lack of funding to support their implementation. LFOs were inspected annually and MFOs at least once every five years.[120] VAAFM was able to meet these requirements and address citizen-driven complaints on smaller farms, but the agency had little capacity to provide additional outreach and technical assistance to small farms. Because of the clear scientific link between ongoing water quality impairments and increasing intensity of agricultural activities, policy makers, scientists, farmers, and water quality practitioners all agreed additional measures were needed on the farm. Best management practices ("BMPs") were developed and consisted of a range of farming practices and infrastructure improvements that could be used on farms to mitigate or eliminate negative impacts on water quality. As a result, the 1990s and 2000s saw the start of the extensive collaborative partnerships between state agencies and non-governmental organizations ("NGOs") that have since brought millions of dollars of assistance to farmers and built the capacity of important non-profit organizations.

It was understood that BMPs would likely cost farmers more money to implement than the simpler, cost effective AAPs. Consequently, additional funding was appropriated through federal and state budgets. The federal Farm Bill appropriated resources to NRCS and deployed both financial and

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115. Dan Scruton, The Number of Dairy Farms in Vermont (on file with Vermont Journal of Environmental Law), (last updated 2016).

116. ACCEPTED AGRICULTURAL PRACTICE REGULATION, *supra* note 99.

117. *Id.*

118. *Regulations for Medium Farm Operations (MFOs)*, VT. AGENCY OF AGRIC., FOOD & MKTS., http://agriculture.vermont.gov/water-quality/regulations/mfo#A2 9 [https://perma.cc/8RXS-DWYV] (last visited Apr. 3, 2016).

119. VT. STAT. ANN. tit. 6, § 4858(a), (d).

120. *Regulations for Medium Farm Operations (MFOs)*, *supra* note 118.

technical assistance through their EQIP program.[121] By 2000, the EQIP program was funding $2.5million of BMPs per year in Vermont, and the allocations increased over time.[122] These funds were contracted on a voluntary basis, but state regulatory oversight helped encourage farmers to apply for and take advantage of the technical and financial assistance being offered through EQIP. The state and federal programs worked together with other partner non-profit organizations to allocate funding to the highest priority and most cost-effective projects. While the assistance and resources led to effective on-farm conservation practice implementation, the complexity associated with the multiple programs, processes, and funding at times made it difficult for the applicants to access the funds and for the organizations to allocate the funding in the most effective way. The partnerships and collaborations with NGOs remained critical to addressing these concerns.

Another challenge to on-farm improvement is the variability between farms. Every farm in the state is different with respect to management, layout, infrastructure, and finances and application of these resources required individual evaluation. Production areas (main barnyard, housing, and feeding areas) were the first targets for BMP implementation, as VAAFM staff began required inspections in the 1990s on MFOs and LFOs.[123] For many farms, installation of in-ground or above-ground manure storage tanks or pits were a necessary investment to comply with the winter spreading ban, costing as much as $500,000 for the larger lined manure pit.[124] As livestock moved inside and off pasture, hay and corn had to be harvested and preserved (ensiled) for efficient feed management. The ensiling process produces a high quality feed for animals, but it can also result in liquid seepage as the silage "cooks." The seepage, known as leachate, is a highly concentrated brew of nutrients with high biological oxygen demand ("BOD") that quickly consumes oxygen when it hits

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121. *Environmental Quality Incentives Program*, NAT. RESOURCES CONSERVATION SERV., http://www.nrcs.usda.gov/wps/portal/nrcs/main/vt/programs/financial/eqip/ [https://perma.cc/J88R-7KWT] (last visited Apr. 5, 2016).

122. Personal communication with Obediah Racicot, Vt. Nat. Res. Conservation Serv. (Oct. 20, 2015).

123. *Regulations for Large Farm Operations (LFOs)*, *supra* note 110; *Regulations for Medium Farm Operations (MFOs)*, *supra* note 118.

124. *See, e.g.*, U.S. DEP'T OF AGRIC., NAT. RES. CONSERVATION SERV., COSTS ASSOCIATED WITH DEVELOPMENT AND IMPLEMENTATION OF COMPREHENSIVE NUTRIENT MANAGEMENT PLANS: PART I—NUTRIENT MANAGEMENT, LAND TREATMENT, MANURE AND WASTEWATER HANDLING AND STORAGE, AND RECORDKEEPING 82 (2003), http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012131.pdf [https://perma.cc/HX4M-3EJ3] (explaining the cost per gallon of a lined storage pond).

surface water, dramatically affecting living organisms in the water.[125] Because of the significant impact of leachate on water quality, BMPs are often installed at a significant cost to manage and treat the leachate. BMPs varied from containment in manure pits or independent structures or in-field treatment areas where leachate was absorbed by growing vegetation. Barnyards that eroded dirt and manure to ditches or water sources needed to be managed and controlled with concrete infrastructure where manure could be scraped and collected. Heavily used animal walkways that quickly turned into mucky, manure-rich mud that ran off into ditches needed to be graded, elevated, and surfaced with gravel for stability. Between 1996, when the program began, and 2000, $1.7 million was spent on BMP improvements to bring these primary production areas into regulatory compliance.[126] Because these improvements were so widely needed and costly to implement, the need far exceeded the available funding. Consequently, not all farms received the financial assistance needed to install and implement the necessary BMPs. This shortfall in BMP implementation was further exacerbated by the ongoing shortage of funding and personnel necessary to reach out to the hundreds of small dairy operations (smaller than 200 milk cows) and beef and horse farms also in need. Consequently, only about 50% of the dairy cows in Vermont fell under proactive regulation with attendant outreach, education, and technical assistance. The remaining dairy cows and tens of thousands of other animals only received attention on a complaint driven basis from VAAFM.

B. Clean and Clear and Collaboration

The technical and financial assistance required by the agriculture industry were only part of the water quality problem and other sectors found similar challenges. A new era of collaboration began in 2003 with the creation of the Clean and Clear Program, which had the goal to accelerate the reduction of phosphorus pollution in Lake Champlain.[127] In 2008, a Clean and Clear coordinator was hired and worked with both secretaries of Natural Resources and Agriculture. Funding for water quality improvement increased by coordinating activities and using increased state funds to

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125. *See CAFO Glossary*, SIERRA CLUB, http://www.sierraclub.org/michigan/cafo-glossary [https://perma.cc/7DYM-2FAA] (last visited Apr. 19, 2016) (explaining how BOD affects oxygen levels in water).

126. Email from Jeff Cook, Vt. Agency of Agric., Food & Mkts., to Marli Rupe, Assistant Program Manager, Clean Water Initiative Program, Vt. Dep't of Envtl. Conservation (Feb. 17, 2016, 3:43 PM EST) (on file with Vermont Journal of Environmental Law).

127. Vt. Governor James H. Douglas, Clean and Clear Water Action Plan (Sept. 30, 2003) (transcript available at https://votesmart.org/public-statement/23255/clean-and-clear-water-action-plan-remarks-of-governor-james-h-douglas [https://perma.cc/A54W-GKLU]).

leverage additional federal resources. Opportunities for farmers and their partners also increased. While organizations like NRCDs and the University of Vermont Extension System had a long history of working with farmers, the breadth of the technical-assistance need and opportunity for allocation of new funding increased the capacity and activities of many new groups into agricultural assistance. Many of these groups have since become critical to the ongoing implementation of agricultural improvements. Some were watershed groups who increased their technical ability and with funding from state and federal programs, passed funding directly to farmers for BMP installation. In some cases, farmers who chose not to use governmental cost-share programs were able to get assistance through various non-profit groups to help with expensive project installations. The abilities of these watershed groups have increased greatly in the past ten years and, with state budget restrictions on increasing staff, their assistance and ability to receive funds to provide technical assistance is immeasurable. These groups also face the challenge of continuing to support themselves with limited administrative dollars. Both ANR and VAAFM work closely with these partners to help address these concerns as much as possible.

C. Critical Source Areas and Prioritization

An agreement between the governments of the United States and Canada in 2008 resulted in funding to the International Joint Commission to conduct the *Missisquoi Bay Critical Source Area Study*, a pivotal study that, for the first time, quantified the value of a targeted approach to BMP implementation.[128] Previously, NRCS funds were allocated primarily on a first-come, first-served basis and state dollars funded the most critical priority issues. This study showed that far greater improvements would be made by focusing resources on the critical source areas (the highest areas of phosphorus contribution to the lake). The study, conducted by Stone Environmental for LCBP, demonstrated that by addressing twenty percent of the problem (implementing practices on the areas of highest potential

128. *Missisquoi Bay Critical Source Area Study*, INT'L JOINT COMM'N, http://ijc.org/missisquoibayreport/ [https://perma.cc/Y8TL-KVLR] (last visited Apr. 19, 2016). The International Joint Commission prevents and resolves disputes between the United States of America and Canada under the 1909 Boundary Waters Treaty and pursues the common good of both countries as an independent and objective advisor to the two governments. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes. Find more information at *IJC Mission and Mandates*, INT'L JOINT COMM'N, http://www.ijc.org/en_/IJC_Mandates#sthash.sk8ET58B.dpuf [https://perma.cc/82H6-KUKJ] (last visited Apr. 19, 2016).

phosphorus runoff), 80% of the agricultural water quality problem could be addressed in the Missisquoi River basin.[129] This study started a state-wide effort to find these "hot spots" on farms and provide assistance to address these concerns first.[130] Stone Environmental and NRCS used Geographical Information Systems ("GIS") to map the Missisquoi River Basin throughout the rest of the state over the next eight years.[131] This, coupled with the new Light Detection and Ranging ("LIDAR") mapping technology, gave state agencies and partners access to this new data, thus increasing the understanding in the farming community of the impacts of agriculture and the specific benefits that could be gained by targeted improvements.[132] By 2015, this focus influenced federal funding sources, which for the first time were allocated to priority watersheds and the highest benefit practices.

In 2011, in response to a lawsuit brought by the Conservation Law Foundation, EPA disapproved the Vermont portion of their prior approved 2002 Lake Champlain Total Maximum Daily Load ("TMDL") and required the state agencies to look at new options, new research, and new ideas to meet the phosphorus reduction needs of the Lake.[133] The State had already attempted to address these concerns with the creation of the Clean and Clear Program and new collaborations with partners, but the updated TMDL modeling showed the phosphorus problem was greater than before and additional reductions were needed. Governor Shumlin's administration had just begun and new leaders of both AAFM and ANR/Department of Environmental Conservation ("DEC") took office in early 2011. The first conversation between new Secretary Chuck Ross and new DEC Commissioner David Mears focused on the challenges of water quality, but neither knew that extreme weather events would increase their need for intensive collaboration and communication.

On April 13, 2011, Lake Champlain reached flood stage (100 feet above mean sea level) and remained above this level for 67 days, causing extensive impacts on the upper Lake Champlain Basin.[134] In August of

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129. MICHAEL WINCHELL ET AL., IDENTIFICATION OF CRITICAL SOURCE AREAS OF PHOSPHORUS WITHIN THE VERMONT SECTOR OF THE MISSISQUOI BAY BASIN 78 (2011), http://www.lcbp.org/techreportPDF/63B_Missisquoi_CSA.pdf [https://perma.cc/7C4G-TVF7].

130. *Id.* at xvi.

131. *Id.* at 5.

132. *Id.* at 47.

133. Press Release, Envtl. Prot. Agency, EPA Takes Steps to Improve Lake Champlain Water Quality (Jan. 24, 2011), https://yosemite.epa.gov/opa/admpress.nsf/0/73DB2705E25A948B85257822006EEF39 [https://perma.cc/835P-RN7A].

134. *2011 Flooding*, LAKE CHAMPLAIN BASIN PROGRAM, http://www.lcbp.org/water-environment/water-quality/flooding/2011-flooding/ [https://perma.cc/72WD-22PS] (last visited Apr. 19, 2016).

2011, Tropical Storm Irene devastated parts of Vermont, including the southern Lake Champlain Basin, where small streams destroyed property and infrastructure and resulted in untold damage to water quality.[135] Both events brought the concept of "flood resiliency" to the forefront of agency planning and discussions. Both the Secretary of Agriculture and the Commissioner of DEC forged a partnership that was recognized throughout the state—by farmers and water quality partners—as a pivotal change needed for water quality improvement.[136]

The Shumlin administration quickly took an "all in" approach, directly and honestly recognizing the challenges ahead, but also acknowledging the value of previous efforts and the major improvements currently underway. The agencies began to integrate their efforts to break down historic silos and divergent cultures. The agencies worked jointly with over thirty groups and established the Agricultural Work Group to provide advice on the best methods to address the dramatic phosphorus reductions needed for agriculture in many Lake Champlain watersheds.[137] Many of the Agricultural Work Group recommendations were incorporated into the implementation plan for the pending EPA TMDL for Lake Champlain. These recommendations were included in 2015 in Vermont's Clean Water Act, Act 64.[138] The goal was to support sensible, cost-effective, innovative, and highest-priority practices to reduce agriculture's phosphorus pollution.

Other farmer-led efforts were also initiated around this time. In Franklin County, the Farmer's Watershed Alliance ("FWA") was established by farmers to help other farmers understand opportunities for water quality improvement, to help facilitate more on-farm research in coordination with the UVM Extension System, and to facilitate the transfer of funds to farmers for small, discrete projects.[139] Over several years, FWA funded grants of almost $500,000 to farmers, implementing 72 different

135. NAT'L OCEANIC AND ATMOSPHERIC ADMIN., SERVICE ASSESSMENT, HURRICANE IRENE, AUGUST 21–30, 2011 iv, 12 (2012).

136. Jacob Park & Christopher Brooks, *Local Flood Resiliency in an Era of Global Climate Change: Understanding the Multisectoral Policy Dimensions,* 17 VT. J. ENVTL. L. 160, 173 (2015).

137. VT. AGENCY OF AGRIC. ET AL., FINAL REPORT OF THE AGRICULTURAL WORKING GROUP 4 (2013), http://www.emcenter.org/wp-content/uploads/2012/10/Final-Report-of-the-AWG.pdf [https://perma.cc/W3CW-74G9].

138. *Id.*; U.S. ENVTL. PROT. AGENCY, PHOSPHORUS TMDLS FOR VERMONT SEGMENT OF LAKE CHAMPLAIN 60 (2015), http://winooskinrcd.org/wp-content/uploads/phosphorus-tmdls-vermont-segments-lake-champlain.pdf [https://perma.cc/MM7K-4BMY]; VT. STAT. ANN. tit. 10, § 1386.

139. *Mission of the Farmers' Watershed Alliance*, FARMER'S WATERSHED ALLIANCE (Apr. 3, 2011), http://farmerswatershedalliance.com/?p=33 [https://perma.cc/997T-KXSE].

water quality improvement projects.[140] In 2012, the Champlain Valley Farmer Coalition formed as an advocacy group for farmers, providing testimony at the statehouse and input to agencies and doing extensive farmer outreach and education.[141] In 2015, another farmer-led group, the Connecticut River Farmers' Watershed Alliance, was created with the primary goal of providing technical and mentoring assistance to other farmers on the eastern side of the state.[142]

These organizations, along with state agencies, UVM, and non-profits, recruited millions of dollars in grant funds to help with farmer projects and education. NRCS Conservation Innovation Grants funded at least three agricultural research projects each year. Other federal funding, provided by the National Institute of Food and Agriculture, offered extensive technical assistance. Furthermore, the Great Lakes Fishery Commission funded the LCBP in 2010 to hire three agronomists to work one-on-one with farmers in the Lake Champlain basin.[143]

In 2014, U.S. Secretary of Agriculture Tom Vilsack and Vermont Senator Patrick Leahy announced new and re-allocated funding of $45 million to NRCS to be used for Lake Champlain water quality improvement efforts over the next five years.[144] In their announcement, they said, "not just agriculture, but landscape, and sewage treatment . . . have impacted and affected the health of this great lake . . . we at USDA, we in Vermont and across the country have to do a better job of investing in this extraordinary piece of Mother Nature."[145] Six months later, the State of Vermont received an additional $16 million dollars through the USDA's Regional

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140. Email from Susan Brouillette, Farmer's Watershed All., to Marli Rupe, Assistant Program Manager, Clean Water Initiative Program, Vt. Dep't of Envtl. Conservation (Feb. 11, 2016) (on file with authors).

141. *About CVFC Inc.: Farmers Working Together for a Clean Champlain & Thriving Agriculture in Vermont*, CHAMPLAIN VALLEY FARMER COALITION INC., http://www.champlainvalleyfarmercoalition.com/about-us.html [https://perma.cc/RWW4-3HBT] (last visited Apr. 4, 2016).

142. Press Release, New England Dairy Promotion Board, Farmers Launch Connecticut River Farmers' Watershed Alliance (Dec. 30, 2015), http://vtdigger.org/2015/12/30/farmers-launch-connecticut-river-farmers-watershed-alliance/ [https://perma.cc/R3KT-QTTK].

143. LAKE CHAMPLAIN BASIN PROGRAM, 2015 STATE OF THE LAKE AND ECOSYSTEM INDICATOR REPORT (2015), http://sol.lcbp.org/images/State-of-the-Lake_2015.pdf [https://perma.cc/DH7N-GFPA].

144. Press Release, U.S. Dep't of Agric., USDA to Invest $46 Million to Improve Water Quality in Lake Champlain (Aug. 28, 2014), http://www.usda.gov/wps/portal/usda/usdahome?contentid=2014/08/0190.xml [https://perma.cc/ZY8Q-KL86].

145. *Vilsack Announces Water Quality Funding for Lake Champlain*, NE. PUB. RADIO (Aug. 28, 2014), http://wamc.org/post/vilsack-announces-water-quality-funding-lake-champlain#stream/0 [https://perma.cc/9YVT-YTT4].

Conservation Partnership Program ("RCPP").[146] This grant was written jointly by DEC and VAAFM to provide additional EQIP dollars for the next five years to fund BMPs in the Lake Champlain Basin and also wetland restoration, forestry improvements, and land conservation practices.[147] The $16 million of RCPP funding were also matched by over $20 million from Vermont sources.[148]

The RCPP, a new effort in the 2014 Farm Bill, was a grant opportunity specifically designed to leverage new partners, new funds, and new creative ways to address agricultural water quality using traditional NRCS funding programs.[149] Vermont was awarded the second largest RCPP national grant in the country in 2015 and is coordinating with the Vermont Association of Conservation Districts, which was awarded a state grant of $700,000. Connecticut is also coordinating a $10 million Long Island Sound grant that will provide over $1.5 million to Vermont.[150] In 2016, NRCS awarded the Orleans County Natural Resources Conservation District the 2016 Vermont State RCPP for $674,000 for the Memphremagog watershed.[151]

D. TMDL and Act 64

The challenge in 2016 and going forward is to reach out to all Vermonters to explain expectations by virtue of the 2016 TMDL for Lake Champlain and Act 64. Vermonters from all sectors of society, including forestry, developers, municipalities, waste water treatment plants, and agriculture, are required to comply with new rules and regulations. Many of the new regulations are based upon the EPA's Phase I TMDL plan, which establishes significant new phosphorus reduction goals for each section of the lake.[152] These goals and the plan of action set forth in the TMDL have been operationalized in Act 64. Act 64 provides the state laws and resources necessary to successfully implement the TMDL and improve water quality in Vermont.

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146. *Regional Conservation Partnership Program*, U.S. DEP'T AGRIC., http://www.nrcs.usda.gov/wps/portal/nrcs/main/vt/programs/farmbill/rcpp/ [https://perma.cc/PBA7-8VHZ] (last visited Apr. 5, 2016).

147. *Id.*

148. *Id.*

149. *Id.*

150. *RCCP 2014/15 All Projects*, U.S. DEP'T AGRIC., http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/farmbill/rcpp/?cid=stelprdb1267978 (last visited Apr. 4, 2016).

151. 2016 RCPP Projects by State, U.S. DEP'T AGRIC., http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/farmbill/rcpp/?cid=nrcseprd598407 [https://perma.cc/L52U-5ZNP] (last visited July 28, 2016).

152. PHOSPHORUS TMDLS FOR VERMONT SEGMENT OF LAKE CHAMPLAIN, *supra* note 138, at 51.

Of particular importance to agriculture are the revisions to the AAPs that are required as part of Act 64. The AAPs will be renamed the Required Agricultural Practices ("RAPs") and the performance standard revision will be filed as Final Proposed Rule by September 15, 2016. The RAPs are intended to increase performance on farms with respect to water quality by mandating a higher level of agricultural practice. Many of the required practices emanate from the recommendations of the Agricultural Work Group.

The new RAPs will increase restrictions on manure application, require higher standards for nutrient management plans, increase livestock exclusion and conservation field practices, and require small farms to self-certify that they are in compliance with the RAPs.[153] The certification of small farms and the enhanced regulatory capacity of VAAFM will, for the first time, enable VAAFM to proactively and regularly engage and inspect small farm operations.[154] The RAPs will also require certification of manure applicators and training of technical service providers.[155]

E. Conservation Law Foundation ("CLF")

In addition to the federal and state decisions to raise the bar on water quality issues, environmental groups have also had an impact on agricultural water quality programs. In the summer of 2014, CLF submitted a petition to the Secretary of Agriculture to require mandatory implementation of BMPs, above the required AAPs, in the Missisquoi Bay watershed.[156] In July of 2014, the Secretary held a public hearing on the petition in St. Albans and, in November of that year, denied CLF's petition. The Secretary cited three basic reasons for the denial:

- the petitions provided insufficient data demonstrating where BMPs were necessary or what BMPs should be implemented;
- the implementation of the petition conflicted with the ongoing TMDL process; and
- there was insufficient funding available for farmers to implement the BMPs, as required by law.

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153. VT. AGENCY OF AGRIC., FOOD & MKTS., REQUIRED AGRICULTURAL PRACTICE RULE FOR THE AGRICULTURAL NONPOINT SOURCE POLLUTION CONTROL PROGRAM 13, 20, 24–25 (Feb. 23, 2016), http://agriculture.vermont.gov/water-quality/regulations/rap#Q5 [https://perma.cc/9A5T-Q2XQ].

154. *Id.* at 10.

155. *Id.* at 24–25.

156. *Conservation Law Foundation (CLF) Petition*, VT. AGENCY OF AGRIC. FOOD & MKTS., http://agriculture.vermont.gov/water-quality/news-events/clf-petition [https://perma.cc/VH75-WBYE] (last visited Apr. 19, 2016).

In December of 2014, CLF appealed the denial.[157] While this appeal was being considered, Act 64 was passed into law, which changed the regulatory and legal landscape.[158] Most significantly was the passage of Act 64 requiring the RAPs to be established and eliminating the prior statutory provision that funding must be available to help a farm implement a BMP before it can be required by the Secretary of Agriculture. In addition, the TMDL plan and Act 64 both called for the use of more BMPs and additional resources became available through the RCPP and NRCS to support the implementation of BMPs.[159] After nine months of negotiation between VAAFM and CLF and a public hearing on a proposed settlement, VAAFM and CLF filed an agreement with the court for approval.[160] The agreement was approved and on February 3, 2016, Vermont's Secretary of Agriculture, Chuck Ross, issued his revised decision regarding the CLF petition to require mandatory BMPs for farms in the Missisquoi Bay Basin. The Secretary's Revised Decision makes a threshold determination that BMPs are necessary in the basin to achieve compliance with Vermont's water quality goals.[161]

The Revised Decision provides a framework for outreach, education, and assessment of farms in the watershed and a process for farm-specific development and implementation of a Farm Plan to address identified water quality resource concerns, where needed. Farm assessments may conclude that practices required by the RAPs are sufficient to protect water quality and that BMPs may not be required due to a farm's specific characteristics or management.[162]

The final agreement will require VAAFM to:

- educate all the farms within the Missisquoi River Basin of the new regulations;
- assess all farms in the basin to identify water quality issues;
- require water quality implementation plans to be developed and filed with VAAFM;
- require farmers to identify funding sources needed for implementation; and
- implement necessary BMPs within six years on all LFOs, MFOs, and certified small farms and within ten years on all other farms.

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157. *Id.*
158. *Id.*
159. *Id.*
160. *Id.*
161. *Id.*
162. *Id.*

These activities, practices, and outcomes align with the VAAFM work plan and goals as outlined in Act 64.

F. Organic Farming

In the background of this ongoing discussion of the many forces, issues, and actions affecting water quality in Vermont has been the emergence of another production system—organic agriculture. Some might say it is a "back to the future" system that incorporates many production practices utilized prior to the ubiquitous availability of commercial fertilizers, pesticides, mechanization, and other practices considered part of "modern or conventional" agriculture. Regardless of how it is characterized, it is now a significant and growing component of the agriculture economy governed by a set of national standards with sales of greater than $39 billion per year.[163] It is also a system of particular interest to Vermonters because it was U.S. Senator Leahy who worked with Vermont organic farmers and consumers to establish the national organic standards, which distinguish it from other forms of agriculture.[164] This system and economy continues to grow because of consumer demand and because it can reward producers with higher prices. It also can have beneficial attributes for water quality when practiced correctly because it focuses on cropping, tillage, and manure management practices as a way to build soil health. Organic's focus on soil health has helped raise the awareness of the importance of soil health to all forms of agriculture and to the public at large. Some of the practices required as part of organic farming are being incorporated into policies statewide, not only because of the benefits to water quality, but also the co-benefits of flood resiliency and climate change adaptation. In Vermont, organic agriculture continues to grow and with it so do soil practices and awareness supported by consumers in Vermont and in markets beyond.

G. The Final Factor—The Rising Voice of the Citizen Consumer

A final set of factors may now be at play, which could have the most profound and influential impact on the speed and degree of the agriculture community's approach to water quality concerns. This force is the

163. Press Release, Organic Trade Ass'n, U.S. Consumers Across the Country Devour Record Amount of Organic in 2014 (Apr. 15, 2015), https://www.ota.com/news/press-releases/18061 [https://perma.cc/QU5R-6KX6].

164. Press Release, U.S. Senator Patrick Leahy of Vt., Leahy Announces Farm Bill Funds To Help Small Farmers With Organic Certification Costs (July 17, 2014), http://www.leahy.senate.gov/press/-leahy-announces-farm-bill-funds-to-help-small-farmers-with-organic-certification-costs [https://perma.cc/HK5E-U93L].

emerging power of the citizen consumer. Their collective individual preferences are operationalized by their purchases in the marketplace and are sending economic signals to farmers and processors alike. These signals reward farmers and other players in the food system supply chain who produce what consumers want.

These consumers are increasingly interested in knowing what they are buying, where it comes from, how it is produced, and who produced the products. Their demand is building economy, community, new awareness in the food system, and supporting new businesses. Its roots may be traced back to the start and evolution of the organic farming movement and is now expressed through "buy local" activities like Community Supported Agriculture ("CSA"), farmer's markets, and farm stands. It also shows up through consumer preferences for local/regional food that is safe, healthy, and sustainably harvested. These same consumers are also demonstrating additional preferences for things such as humane handling, free range, and fair trade, to name a few. It has manifested itself in the growth of local markets all over the country by dramatic growth in companies like Whole Foods and the adoption of organic food products by companies like Walmart.

If and when these same consumers focus their attention on the environmental characteristics of the products they buy, they may become the most transformative force in changing the farm and food system to more effectively address water quality concerns. They may have the power to create a culture of land and water quality stewardship underwritten by their preferential purchases. Their power has already been demonstrated by the marketing of BST-free milk, the nationwide conversation about GMO labeling, the presence of local food in regional and national groceries, and the catering of local foods to college students. Twenty-five years ago organic farming did not have national standards, Whole Foods did not exist, and groceries bragged about California lettuce. Today, the conversation is about food safety, buying local, buying healthy, and the strength and opportunities of regional markets to support local and regional economies and communities. The market is fundamentally different and evolving rapidly with major businesses making calculations and adjustments to ensure they end up on the correct side of consumers' evolving preferences.

Large-scale agriculture will continue to play an enormous role in producing foodstuffs for Americans and people across the world, but as water quality concerns have become community discussions and climate change has increased the frequency and severity of precipitation events, farmers and communities are starting to look at these challenges through the same lens. This lens may give more attention to soil health, an increase of which can benefit the farmer, increase the ability of land to absorb the greater quantities of water, and increase the ability of our communities to be more flood resilient. Perhaps it may be the new and emerging diversified farmers focused on building soil heath and the consumers in the local and regional markets leading the farm and food system conversation that is restorative for both people and the environment. These new voices may be establishing the farm and food system culture of the future, in which environmental and human health are critical drivers of the economy and stewardship practices on farms and within the supply chain. If and when this happens, a new culture around agricultural water quality that cares about and rewards water quality stewardship may rapidly emerge. When that day comes, we may see the most rapid, systemic, and sustainable change in our farm and food systems benefiting water quality.

CONCLUSION: THE VERMONT PERSPECTIVE

Agriculture as practiced by most people is not part of the natural ecosystem, but is rather an adaptation of our ecological system to fit the needs of humankind and our evolution in this place we have named Vermont. In Vermont, agriculture and its practitioners have responded to the changing needs of the purchasing public, evolving and adapting their practice of agriculture on top of and integrated with the underlying foundation of Vermont's natural resources and ecological systems. In so doing, they have also discovered the collective impact of the pricing markets and society's policy directives constrain, confuse, and limit their profitability and ability to adapt to the emerging ecological imperatives of our time. However, dairy, the largest agricultural industry in Vermont, is challenged to adapt due to the pricing structures and limitations of larger farms and infrastructure. During much of history, our needs have driven our actions with little concern and, in some cases, little knowledge of the impact on these ecological systems. Over time, our sensitivity and responsiveness to our influence on these systems has ebbed and flowed. At times, we have heard the clarion calls of people like George Perkins Marsh to change our ways. Only a few times have we altered course and even fewer of these changes have been sustained through time. Instead, we have soldiered on, doing what we needed to do to meet our immediate needs and almost unwittingly relied upon the strength and resiliency of our natural systems to sustain us, assimilate our waste, and accommodate our excesses. But now, with blue green-algae choking our bays and Lake Champlain's ecological balance at risk, it is time that we as a society: begin to recognize our over-reliance on these natural systems; react in ways that might reduce or ameliorate the stress we impose on them; and attempt to remedy the damage we have done.

Our agricultural history in Vermont is rich. We are part of the United States, a system that is considered by many to be the most productive, lowest cost, and safest farm and food system in the world. We rely upon it to feed us, to employ us, and to be a marketable resource for international trade and relations. At times, it has been one of the strongest elements of our economy and, over the decades and centuries, this system has imbued our culture with characteristics that have served us well, such as independence, self-reliance, a strong work ethic, physical strength, and a belief in ourselves. Many of our society's leaders have learned the lessons of life behind a plow, in the hay loft, or in the barn at 4:30 A.M. These, and many others, are the attributes our farm and food system has provided to our society. Without doubt and without hesitation, it is the farmers who we must recognize for the work they have done and continue to do that bring these values and attributes to our society and our communities.

But our agricultural history as a country, as a state, and as a people has not always been perfect. We have followed the lead and directions of our government policies, our academic leaders, our industry experts, and the needs, wants, and desires of our citizen consumers. This, in many cases, has not served us as well.

The creation, evolution, and operation of this system has also created our own society-wide dilemma: we have created an incredible system upon which we depend for our sustenance and growth, but that in too many circumstances erodes the very ecological system upon which we and that system depend. We have put in place markets, policies, subsidies, and practices that sometimes prevent the changes we need, where we need them, and at the rate we need them. This "catch 22" is exemplified by our own Lake Champlain—a natural resource we have used, abused, and exploited through ignorance and neglect—to serve our needs, which we now are trying to save through the implementation of a plan that will meet the pollution budget of the TMDL, the passage of state laws, and the creation of a new culture of clean water—a culture of which agriculture must be an integral part. The time has come for all of us to stand together to adapt our agricultural system once again. We must develop the new policies, incent the new practices, and develop the culture to enable the profitability that will help farmers to do the right thing on their farms and in their businesses. Most farmers understand their environment, their dependency upon our natural resources, and the importance of stewardship. They know and work with the natural environment and understand the importance of long term planning. They want to do the right thing. It is our collective responsibility to provide the cultural support and economic framework to enable them to succeed as farm businesses, which support their families and protect the natural systems upon which we all depend. It is also our responsibility to address those who choose to not protect our natural systems with an effective, consistent, and respected enforcement system. All of these responsibilities and opportunities bring resource needs and challenges.

In Vermont, we have built and continue to build a community-based agricultural system. It is a system that connects our farms to our communities, helps our farms build our local economies, and enables our people to connect to the agricultural values and work ethic that undergird our collective culture. We celebrate agriculture's contribution to our quality of life. By and large, we continue to hold agriculture in high regard as a noble pursuit. The degrees of separation between farmer, friend, neighbor, and community are small to non-existent.

This closeness and proximity allows us the opportunity to have conversations and to be heard. If willing, it empowers us to be sensitive to our individual and collective needs. If we can commit ourselves to the challenges before us, it affords us the chance to chart a course together and do the work necessary. And as part of this process, the farming community can listen, take ownership for their part, take action to contribute to the solution, and take great pride in their role as part of this society-wide effort. In Vermont, our personal, economic, and environmental proximity allow us to understand that we are ALL IN THIS TOGETHER and therein lies the hope and opportunity for our future.

AFTER THE TMDLS

Dave Owen

INTRODUCTION

In March 2015, the United States District Court for the Western District of Washington decided *Sierra Club v. McLerran*, a case involving something known as a total maximum daily load ("TMDL").[1] TMDLs are pollution budgets for impaired waterways, and they are, in theory, a key mechanism for bringing those water bodies into compliance with water quality standards.[2] They are also mandatory. Clean Water Act section 303(d) leaves little doubt that states must prepare TMDLs for water bodies that do not meet water quality standards, and that the U.S. Environmental Protection Agency ("EPA") must step in should a state fail to act.[3]

1. 2015 WL 1188522 (W.D. Wash. 2015).

2. *See* JOHN HORNBEEK ET AL., IMPLEMENTING TOTAL MAXIMUM DAILY LOADS: UNDERSTANDING AND FOSTERING SUCCESSFUL RESULTS 13 (2008) ("The federal TMDL program plays a central role in the nation's water quality management efforts."); Memorandum from Robert Perciasepe, Assistant Adm'r U.S. Envtl. Prot. Agency, to Reg'l Adm'rs and Reg'l Water Div. Adm'rs, U.S. Envtl. Prot. Agency on New Policies for Establishing and Implementing Total Maximum Daily Loads, http://www.epa.gov/sites/production/files/2015-10/documents/2003_10_21_tmdl_ratepace1997guid_0.pdf [https://perma.cc/MX9U-29WF] ("The TMDL program is crucial to success because it brings rigor, accountability, and statutory authority to the process.").

3. 33 U.S.C. § 1313(d)(1)(C) (2012) (beginning with "each state shall").

For the Spokane River, however, the Washington Department of Ecology and EPA honored that mandate only through what might appear to be a blatant breach. The department had begun a TMDL for polychlorinated biphenals, a group of pollutants impairing the river. But then, and with EPA's acquiescence, it suspended the TMDL writing process indefinitely.[4] That suspension did not derive from a lack of interest in responding to the river's pollution problems—or, at least, the department admitted no such thing. Instead, the department asserted that its resources would be best spent on developing a plan to restore the river.[5] The TMDL, in other words, would be a sideshow, a distraction, and the best course would be to skip the TMDL and go straight to implementation planning, which normally is the next step in the regulatory sequence. This was not the first time regulators had preferred this course of action, or expressed skepticism about the value of TMDLs.[6] Similar things have been said in many ways, perhaps none more concise than the brief words a guest speaker—a municipal stormwater manager and committed environmentalist—once offered to my environmental law class: "TMDLs suck."[7]

This article considers whether my guest speaker, and the Washington Department of Ecology, might have been right. It asks what tens of thousands of TMDLs have actually done to protect the environment. And while the most accurate answer to that question would be, "we don't know," the evidence we do have is somewhat discouraging. Twenty years ago, TMDLs were, in some quarters, the great hope of water quality law.[8] Now, however, the water quality problems that spurred so much interest in TMDLs still persist.[9] And despite some positive individual examples—one

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4. *McLerran*, 2015 WL 1188522, at *2–*4 (describing the administrative process, which involved a draft TMDL that never was finalized).

5. *Water Quality Improvement Project Spokane River: PCBs*, WASH. DEP'T ECOLOGY, http://www.ecy.wa.gov/programs/wq/tmdl/spokaneriver/SpokPCBTMDL.html [https://perma.cc/25PD-K9CT] (last visited Apr. 5, 2015). The Department of Ecology explains, "Rather than develop a TMDL for PCBs, Ecology is pursuing direct actions to lower PCB loading into the Spokane River. Because establishing a TMDL with wasteload allocations can take many generations to meet and may take a decade or more to establish, Ecology feels that taking steps to reduce toxics immediately is more effective at achieving the desired water quality goal." Id.

6. *See* Dave Owen, *Urbanization, Water Quality, and the Regulated Landscape*, 82 U. COLO. L. REV. 431, 453–54 (2011) (describing Maine regulators' frustrations with TMDLs for urban stormwater).

7. I will not name names, so readers will just have to trust in the accuracy of my memory.

8. *See, e.g.*, Robert W. Adler, *Integrated Approaches to Water Pollution: Lessons from the Clean Air Act*, 23 HARV. ENVTL. L. REV. 203, 204–05 (1999) (asserting the Clean Water Act's TMDL requirements "stand[] out as having sufficient promise to meet this challenge" of integrated water quality regulation); Memorandum from Robert Perciasepe to Reg'l Adm'rs and Reg'l Water Div. Adm'rs, *supra* note 2.

9. *See National Summary of State Information*, U.S. ENVTL. PROTECTION AGENCY, http://ofmpub.epa.gov/tmdl_waters10/attains_nation_cy.control [https://perma.cc/7BJU-SRR8] (last

of which is the focus of the rest of this symposium issue—there is little evidence that TMDLs can claim any credit for systemic pollution reductions.[10]

That dearth of demonstrated accomplishments raises uncomfortable questions. Why do we not have more evidence of success? Has a massive amount of effort been wasted? And what can we learn, at this still-preliminary stage, from TMDLs? Despite the informational deficits that prevent definitive answers, there are some lessons to be drawn. They just reflect basic common sense: construct your statutes well and, if you are an environmental group, pick your litigation battles carefully. But what these lessons lack in originality, they make up in importance.

These may all sound dark and pessimistic, particularly for a symposium celebrating TMDLs. And the conclusions do come with important caveats. Clearly, some TMDLs already have major accomplishments to their credit.[11] With others—including very important ones like the Lake Champlain TMDL—there is reason for cautious optimism. And, most importantly, there is a huge difference between the absence of evidence of success and affirmative evidence of failure. It may well be that the right studies just haven't been done yet, and that if we examine TMDLs in different ways, we will learn about undiscovered achievements.[12] But optimism, though somewhat justified, ought to be tempered. In fifty years, environmental lawyers may yet look back upon the United States' massive TMDL experiment as a success. But environmental advocates also should consider the possibility that the TMDL story is, more than anything else, a cautionary tale.

I. LAUNCHING THE TMDL PROGRAM

The obligation to prepare TMDLs springs from section 303 of the Clean Water Act.[13] Section 303 obligates states to set water quality standards, to identify water bodies that fail to meet those standards, and to create TMDLs for each non-attaining water body.[14] As its name suggests, the TMDL should function as a daily pollutant budget: it specifies the mass of each offending pollutant that a waterway can accommodate—with a

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visited Apr. 5, 2016) (summarizing water quality monitoring data, and showing widespread impairment).

10. *See infra* Section II.

11. *See, e.g.*, *infra* notes 97–98 and accompanying text (describing the Garcia River TMDL).

12. *See infra* note 58 and accompanying text (suggesting possible research projects).

13. 33 U.S.C. § 1313.

14. *Id.*

margin of safety—while still attaining water quality standards.[15] Section 303 also obliges states to adopt continuing planning processes designed, in theory, to turn the budgets contained in TMDLs into actual pollution controls.[16] The whole system exemplifies what some commentators refer to as an "ambient" approach to pollution control: the idea is to identify the level of pollution a system can tolerate and then reverse engineer that outcome through controls on individual sources.[17]

For many years, as Oliver Houck has explained in wonderful detail, this approach was the forgotten stepchild of the Clean Water Act.[18] The act also includes a permitting program, known as the National Pollutant Discharge Elimination System ("NPDES"), that employs technology-based controls on "point sources"—generally outfalls from factories, wastewater treatment plants, and municipal stormwater systems.[19] For decades, EPA devoted much of its attention to the monumental task of developing and enforcing those technology-based standards.[20] The results, by most accounts, were impressive.[21] Pollution loading from factories and wastewater treatment plants has been greatly reduced (stormwater is another story), and in some waterways, water quality has greatly improved.[22] But while EPA's attentions—and those of the states—were focused on the NPDES program, little happened with section 303. States did not even publish lists of impaired waterways, let alone write TMDLs, and EPA did not step into the void.[23] The agency had decided its efforts were better spent elsewhere.

In the 1990s, that all changed. Environmental groups filed a series of lawsuits challenging states and EPA for their failures to prepare 303(d) lists and TMDLs.[24] While some of the lawsuits initially failed, victories

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15. *Implementing Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/tmdl [https://perma.cc/LYT4-YKRD] (last visited Apr. 5, 2016).

16. 33 U.S.C. § 1313(e).

17. Sarah Birkeland, *EPA's TMDL Program*, 28 ECOLOGY L.Q. 297, 316–17 (2001).

18. OLIVER A. HOUCK, THE CLEAN WATER ACT TMDL PROGRAM: LAW, POLICY, AND IMPLEMENTATION (1999).

19. *National Pollutant Discharge Elimination System (NPDES): Permit Limits*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/npdes/npdes-permit-limits [https://perma.cc/J3HK-36MS] (last visited Apr. 12, 2016).

20. HOUCK, *supra* note 18, at 12–24.

21. *See, e.g.*, Johnathan Cannon, *A Bargain for Clean Water*, 17 N.Y.U. ENVTL. L.J. 609, 618–21 (summarizing debates over the NPDES program's performance).

22. *See, e.g.*, William L. Andreen, *Success and Backlash: The Remarkable (Continuing) Story of the Clean Water Act*, 4 J. ENERGY & ENVTL. L. 25, 26 (2013).

23. HOUCK, *supra* note 18, at 49–56; *e.g.*, Sierra Club v. Hankinson, 939 F. Supp. 865, 870–71 (N.D. Ga. 1996) (describing Georgia's progress, or lack thereof).

24. *E.g.*, Alaska Ctr. for the Env't v. Browner, 20 F.3d 981 (9th Cir. 1994); Scott v. City of Hammond, 741 F.2d 992 (7th Cir. 1984); Friends of the Wild Swan v. U.S. Envtl. Prot. Agency, 130 F. Supp. 2d 1184 (D. Mont. 2001); Kingman Park Civic Ass'n v. U.S. Envtl. Prot. Agency, 84 F. Supp. 2d

eventually came steadily, and the primary issue—often resolved in consent decree negotiations—was not whether 303(d) lists and TMDLs must be prepared, but how quickly.[25] And so a massive experiment was launched. Now, over a decade after that first litigation phase was largely completed, the states and EPA have tens of thousands of TMDLs, with more emerging every day.[26] In court cases, the primary issues now concern the content and implications of TMDLs rather than the necessity of their preparation.[27] The Spokane River litigation, which does address that latter question, is a throwback.[28]

All of this litigation reflected a hypothesis. The cases made strategic sense for their environmental plaintiffs only if EPA was wrong about TMDLs.[29] Perhaps EPA was wrong because it simply misjudged TMDLs' potential to produce environmental improvements. And perhaps EPA—or more likely, the states—had not misjudged TMDLs' potential, but lacked the political will to embark on a program that would antagonize powerful industries.[30] But if TMDLs really were just a distraction from more promising efforts to address water quality, then bringing those lawsuits was a mistake, no matter how winnable they were.

At the time, there were some good reasons to believe that hypothesis was correct. Environmental advocates had accumulated plenty of experience then—and have accumulated more since—in using litigation to instigate regulatory initiatives that eventually provided important

1 (D.D.C. 1999); Idaho Sportsman's Coal. v. Browner, 951 F. Supp. 962 (W.D. Wash. 1996); *Hankinson*, 939 F. Supp. 865.

25. When I interned at the Sierra Club's legal office in the summer of 2000, the club was involved in negotiating multiple consent decrees, and these timing questions were central.

26. As of April 5, 2016, EPA's TMDLs database puts the number of approved TMDLs at 69,289. That number is based on state reporting, however, and many of the state reports are quite dated. The actual number therefore is probably much higher. *National Summary of Impaired Waters and TMDL Information*, U.S. ENVTL. PROTECTION AGENCY, http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T#APRTMDLS [https://perma.cc/H877-GY2E] (last visited Apr. 5, 2016) [hereinafter *TMDL Database*].

27. *See, e.g.*, Am. Farm Bureau Fed'n v. U.S. Envtl. Prot. Agency, 792 F.3d 281, 310 (3d Cir. 2015) (rejecting multiple substantive challenges to the Chesapeake Bay TMDL); Friends of the Earth v. U.S. Envtl. Prot. Agency, 446 F.3d 140 (D.C. Cir. 2006) (holding that TMDLs must include daily load limits rather than using some other time increment).

28. *See supra* notes 1–5 and accompanying text.

29. An alternative hypothesis would be that the plaintiffs just brought the cases because they were hoping to secure attorneys' fees, with environmental improvements as a secondary goal. Having spent some time working with environmental groups during this time period, I am very skeptical of that claim. Even at that time, attorneys' fees were much less important than donations in supporting environmental groups' budgets. And an environmental non-profit is no place for an attorney that cynical. There is much more money to be made elsewhere.

30. *See generally* HOUCK, *supra* note 18 (describing many examples of political opposition to meaningful water quality regulation).

environmental protections.[31] And this use of litigation flowed from the basic premises and designs of environmental laws. The legislators who crafted those laws had not drafted citizen suit provisions by accident. They expected that sometimes litigation would be necessary to spur agencies to action, and prior experience had sometimes validated their foresight.[32] From the get-go, TMDL litigation had its skeptics; many commentators registered concerns about how efficacious Clean Water Act section 303 would ever really be.[33] But an attentive student of environmental law's then-short history might have expected that litigation was about to launch another important regulatory program.

II. 69,000 AND COUNTING

Decades later, the TMDL program is well past the launch phase. According to the most recent—but already dated—estimate from EPA, over 69,000 TMDLs have been written.[34] Many of those TMDLs are of very recent vintage, and more time will need to elapse before anyone can fairly evaluate their accomplishments.[35] But others are older, and studies of those older TMDLs provide some basis for preliminary judgments about what TMDLs have wrought.[36]

Initially, one of the most striking features of many of the TMDL implementation studies is not the answers they provide, but the questions they ask. EPA, for example, has produced multiple studies that focus on TMDL implementation.[37] The question many of these studies ask is not

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31. *See* Owen, *supra* note 6, at 483–84 (describing major watershed protection initiatives that litigation helped spur); ROBERT MELTZ, FEDERAL AGENCY ACTIONS FOLLOWING THE SUPREME COURT'S CLIMATE CHANGE DECISION IN *MASSACHUSETTS V. EPA*: A CHRONOLOGY (2014).

32. *See* JOSEPH L. SAX, DEFENDING THE ENVIRONMENT: A STRATEGY FOR CITIZEN ACTION (1971) (describing the theory behind citizen enforcement); Barton H. Thompson, Jr., *The Continuing Innovation of Citizen Enforcement*, 2000 U. ILL. L. REV. 185 (describing the origins, benefits, and problems associated with citizen suits and other citizen enforcement mechanisms).

33. *See, e.g.*, Birkeland, *supra* note 17, at 314 ("[T]he TMDL program is burdened with all of the problems inherent in any ambient-based regulatory system, with a few extra challenges tossed in for good measure.").

34. *TMDL Database*, *supra* note 26. As noted earlier, that number is almost certainly low.

35. *See* GEN. ACCOUNTING OFFICE, CLEAN WATER ACT: CHANGES NEEDED IF KEY PROGRAM IS TO HELP FULFILL THE NATION'S WATER QUALITY GOALS 14 (2013) [hereinafter GAO] (showing cumulative numbers of TMDLs).

36. *E.g.*, *id.*; JOHN HORNBEEK ET AL., MEASURING WATER QUALITY IMPROVEMENTS: TMDL IMPLEMENTATION PROGRESS, INDICATORS, AND TRACKING 6 (2011) (listing multiple earlier studies).

37. *See, e.g.*, U.S. ENVTL. PROT. AGENCY, FY2010 NATIONAL REPORT ON IMPLEMENTING TOTAL MAXIMUM DAILY LOADS (TMDLS) (2011); LAURA BLAKE ET AL., STATE APPROACHES AND NEEDS FOR MEASURING, TRACKING, AND REPORTING ON WATER QUALITY IMPROVEMENTS 8 (2010); DOUGLAS J. NORTON, WATER ENV'T FED'N, SAMPLING TMDL IMPLEMENTATION RATES AND PATTERNS IN THE NORTH CENTRAL US 1309 (2009); OFFICE OF WETLANDS, OCEANS, & WATERSHEDS,

whether TMDLs have improved water quality. Instead, it is whether something—anything—has been done implement the TMDL.[38] Particularly for TMDLs focused on nonpoint source pollutants, the answer to that question is often "no."[39] Additionally, EPA has surveyed its regional TMDL staff to find out about levels of awareness of, and interest in, TMDLs among staff at state and local planning offices, agricultural agencies, and other governmental entities that might partner in TMDL implementation. Those surveys revealed a widespread perception that the very people who ought to be implementing TMDLs instead lack understanding of, and commitment to, the TMDL program.[40] For other TMDLs, some type of implementation program exists, but many of the studies do not measure that implementation program against metrics designed to assess the likelihood of producing successful outcomes.[41] And, as EPA often notes, information gaps are pervasive.[42]

Other studies do provide that second layer of analysis. One of the most recent major studies is a General Accounting Office report from 2013.[43] The authors surveyed state agency staff responsible for TMDL implementation, and they also identified features thought to promote

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U.S. ENVTL. PROT. AGENCY, ANALYSIS OF TMDL IMPLEMENTATION RATES IN EPA REGION 5 (2009); THE CADMUS GRP., INC., TOTAL MAXIMUM DAILY LOAD (TMDL) IMPLEMENTATION TRACKING NEEDS ASSESSMENT: CURRENT STATUS AND FUTURE NEEDS FOR STATES IN REGION 5, 6, AND 10 (2008); INDUS. ECON., INC., DEVELOPING EFFECTIVE NONPOINT SOURCE TMDLS: AN EVALUATION OF THE TMDL DEVELOPMENT PROCESS (2007); Valentina Cabrera-Stagno, *Developing Effective TMDLs: An Evaluation of the TMDL Process*, PROC. WATER ENV'T FED'N, TMDL 2007 443 (2007); U.S. ENVTL. PROT. AGENCY, REGION 10, WATERSHED PROT. UNIT, IMPLEMENTATION OF WASHINGTON'S TMDL PROGRAM, 1998-2003 (2005).

38. *E.g.*, OFFICE OF WETLANDS, OCEANS, & WATERSHEDS, *supra* note 37, at iii; FY2010 NATIONAL REPORT ON IMPLEMENTING TOTAL MAXIMUM DAILY LOADS (TMDLS), *supra* note 37.

39. *See, e.g.*, HORNBEEK ET AL., *supra* note 36, at vi ("[E]xisting studies suggest that Total Maximum Daily Load implementation for point sources tends to occur more reliably than for nonpoint sources."); FY2010 NATIONAL REPORT ON IMPLEMENTING TOTAL MAXIMUM DAILY LOADS (TMDLS), *supra* note 37, at 10 (finding that only eight percent of mapped nonpoint source TMDLs are associated with an implementation project funded through section 319 of the Clean Water Act). The actual implementation percentage may be somewhat higher; implementation can occur without a section 319 grant. But federal grants are likely to be one of the first sources would-be implementers look to—federal money is usually a welcome thing—so those numbers probably provide at least a rough proxy for actual implementation rates.

40. INDUS. ECON., INC., *supra* note 37, at ES-4 ("EPA TMDL respondents *consistently* ranked state and local planning agencies, state agricultural agencies, and USDA programs as stakeholders/organizations with the least understanding of the TMDL program, lowest commitment to achieve water quality standards based on TMDLs, and fewest action(s) taken to improve water quality based on TMDLs.") (emphasis and parentheses in original).

41. For one exception, see HORNBEEK ET AL., *supra* note 36, at 4–5 (describing state agency staff's perceptions about whether loading has decreased and water quality has improved).

42. *See* FY2010 NATIONAL REPORT ON IMPLEMENTING TOTAL MAXIMUM DAILY LOADS (TMDLS), *supra* note 37, at 2 ("[M]any obstacles to comprehensive TMDL implementation tracking exist . . . .").

43. GAO, *supra* note 35.

successful TMDLs and then chose a sample of TMDLs to compare to their metrics of success. Their results were not encouraging, as the following partial, but reasonably representative, sampling demonstrates:

- "EPA tracks basic information on TMDL development, such as the number, location, and type of long-established TMDLs but, generally, does not have information on the extent to which the TMDLs have been implemented or have improved the quality of impaired water bodies."[44]
- "[S]tate TMDL coordinators do not know the extent to which many long-established TMDLs have been implemented. For those TMDLs where information exists, state coordinators reported that pollutants had been reduced in many waters, but few TMDLs had helped water bodies attain water quality standards."[45]
- "Long-established TMDLs often do not contain key features that would help water bodies attain water quality standards, in part because EPA's regulations and guidance do not direct TMDLs to contain them."[46]
- "As reported by state TMDL coordinators, the absence of two key factors—specifically, legal authority and sufficient funding—has generally stymied the implementation of TMDLs meant to curtail nonpoint source pollution."[47]

Several authors have taken a different approach to reviewing TMDLs and have focused on identifying successful TMDLs and trying to discern what makes them work.[48] By design, these studies are not representative; they try to figure out what can be learned from the outliers. But the fact that the authors did find successful TMDLs to review is at least modestly encouraging, even if there is little reason to infer that those successes extend to the thousands of TMDLs not selected for the studies.

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44. *Id.* at 27.
45. *Id.* at 35.
46. *Id.* at 36.
47. *Id.* at 62.
48. *See, e.g.*, Brian Benham et al., *Lessons Learned from TMDL Implementation Case Studies*, 2 WATER PRAC. 1 (2008); U.S. ENVTL. PROT. AGENCY, OFFICE OF WETLANDS & WATER, WATERSHED BRANCH, TOTAL MAXIMUM DAILY LOADS WITH STORMWATER SOURCES: A SUMMARY OF 17 TMDLS (2007); CTR. FOR TMDL & WATERSHED STUDIES AT VA. TECH, TMDL IMPLEMENTATION – CHARACTERISTICS OF SUCCESSFUL PROJECTS (2006).

Finally, two other types of information are relevant to any inquiry about TMDLs. The type of information is water quality data. Under Clean Water Act section 305(b), states must monitor water quality in their rivers, lakes, streams, and bays, and EPA aggregates the state reports to produce nationwide summaries of water quality status and trends.[49] These reports also are not encouraging. They show that water quality problems remain pervasive across much of the American landscape.[50] They also show that pollution sources that fall outside the reach of the NPDES program—and therefore might be the central targets of TMDLs—are the primary culprits for much of that water quality impairment.[51] To blame TMDLs for the persistence of these water problems would be to oversimplify a complex situation; these problems might have been even worse had TMDLs not been prepared. But it is at least accurate to say that the problems that people hoped TMDLs would solve have not, in fact, been solved.[52]

The second type of information addresses the costs of developing TMDLs. Current aggregate data on those costs are not easy to find; EPA's last comprehensive estimate of the cost of TMDL development comes from a 2001 draft report, which predicts that aggregate state costs would level off at between 68 and 75 million dollars per year.[53] But that estimate is almost certainly much too low. EPA predicated the assumption on an estimate that an average TMDL would cost $52,000,[54] while recent data suggest that for California, at least, average TMDL development costs are now closer to 1.3 million dollars.[55] Everything is more expensive in California, of course, but even if those estimates represent an upper bound, they suggest that EPA's

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49. 33 U.S.C. § 1315(b).

50. U.S. ENVTL. PROTECTION AGENCY, *supra* note 9; *see* GAO, *supra* note 35, at 14 (chart showing water quality trends).

51. *See* U.S. ENVTL. PROTECTION AGENCY, *supra* note 9 (listing agricultural sources as the leading cause of water quality impairment).

52. *See* GAO, *supra* note 35, at 62 (noting the lack of progress in nonpoint source pollution).

53. U.S. ENVTL. PROT. AGENCY, THE NATIONAL COSTS OF THE TOTAL MAXIMUM DAILY LOAD PROGRAM (DRAFT REPORT) ii–iii (2001). EPA's cost estimates for implementing TMDLs are much higher. *Id.* But given the uneven implementation of TMDLs, those estimates may not correspond to anything actually occurring in the real world. They also may be far lower than the direct costs of developing some alternative program that effectively regulates the pollution sources that TMDLs might target. The financial benefits of such a program also might be quite large, but that is a question for another analysis.

54. *Id.* at iii.

55. *See* STATE WATER RES. CONTROL BD. & REG'L WATER QUALITY CONTROL BDS., CALIFORNIA TOTAL MAXIMUM DAILY LOAD (TMDL) PROGRAM SUMMARY REPORT, FISCAL YEAR 2013 – 2014 18 (2014) (showing cost data); Email from Greg Gearheart, Dir., Office of Info. Mgmt. & Analysis, Cal. Envtl. Prot. Agency, State Water Res. Control Bd., to Dave Owen (Oct. 21, 2015, 9:23 AM) ("Average (staff and contracts) cost per TMDL to be completed in CA is about $1.5M.") (parentheses in original) (on file with Vermont Journal of Environmental Law).

older estimates were off by a wide margin. EPA also predicated its estimate on the assumption that approximately 36,000 TMDLs would be prepared, and the current TMDL count is probably more than double that number, with thousands more still in the works.[56] While pinpointing the exact cost of TMDL development probably is not possible—and while the number, whatever it is, would pale in comparison to some other government programs—the expense of developing TMDLs clearly is far from negligible.

Those expenses also bring opportunity costs. To the extent that money for TMDLs comes out of lump sum allocations to state or federal environmental agencies, it could have been spent on environmental protection in some other form. And there is no shortage of needs. To provide just one example, state environmental enforcement efforts are notoriously underfunded, and several million additional dollars per year might go a very long way.[57] Whether that money would have been effectively spent is another question; agencies do not always turn money into good results. But at the very least, it is possible that alternative expenditures would have been environmentally valuable.

While all of this may seem dismal, it is important to realize how much we just do not know. The optimal TMDL studies would not just sample a limited set of reports and examine their content. Instead, they might compare water quality data from many watersheds with and without TMDLs, controlling for other variables, all in hopes of discerning whether the presence of TMDLs correlates with positive changes in water quality status. No one has done that kind of study.[58] Additionally, the TMDL experiment, while not entirely new, is still no further along than adolescence. Sometimes regulatory programs take a long time to mature, and the TMDL program of 2040 may be quite different from that which exists today. And, finally, individual TMDLs do provide some basis for optimism. Efforts like the Chesapeake Bay TMDL and the Lake Champlain TMDL suggest that, at least sometimes, a TMDL may help regulators and water quality advocates gain traction on water quality problems that had been very difficult to resolve. But with all that said, there currently is little evidence that the TMDL program is producing anything more than isolated successes.

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56. U.S. ENVTL. PROT. AGENCY, *supra* note 53, at ii.

57. David L. Markell & Robert L. Glicksman, *A Holistic Look at Agency Enforcement*, 93 N.C. L. REV. 1, 53–55 (2014) (describing limited and declining enforcement budgets).

58. I doubt that is for lack of interest, and the authors of TMDL studies have generally been candid about the limitations of their methodologies. And I do not know whether such a study would even be possible. One key question would be whether water quality databases with sufficient longitude and data quality even exist.

III. STRUCTURAL FLAWS

So why these uneven (and obscure) results? One possible answer is that it can be very difficult to discern the causal relationships between particular provisions of environmental law and environmental changes in the real world.[59] But suppose, for a moment, that an even simpler explanation is correct, and that the evidence of success is sparse because successes have been few and far between. That would not be entirely surprising, for section 303 of the Clean Water Act was not constructed particularly well in the first place.

To understand that assertion, it is helpful to think about three primary categories of pollution to which TMDLs often apply, and which also are common sources of water quality problems. The first category—and, it turns out, the category where TMDLs offer the best fit—includes the same industrial and wastewater treatment plant discharges that the NPDES program already regulates. The second category is nonpoint source runoff, which includes pollution from forestry operations, agricultural stormwater, and irrigation return flows from agricultural fields. The third category, which occupies something of an intermediate position between nonpoint source runoff and traditional point sources, is urban stormwater runoff.

A. Traditional NPDES Sources

By nearly all accounts, the Clean Water Act's greatest successes have come through the NPDES program, which applies specifically to point sources of water pollutants.[60] The NPDES program prohibits unpermitted point source discharges, and it establishes technology-based numeric effluent standards for those discharges. Because those standards are numeric, violations are clear-cut; rarely is there much ambiguity about whether permit condition have been met.[61] NDPES permits also require dischargers to monitor their effluent levels and to report the results of their monitoring.[62] The Clean Water Act backstops these requirements with provisions allowing both governmental and citizen enforcement.[63] The

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59. Dave Owen, *Mapping, Modeling, and the Fragmentation of Environmental Law*, 2013 UTAH L. REV. 219, 278 (2013). Studies of TMDL implementation often note the challenges associated with determining the actual water quality consequences of TMDLs. *See, e.g.*, HORNBEEK ET AL., *supra* note 36, at 4–5.

60. *See, e.g.*, Cannon, *supra* note 21, at 621 ("Technology-based limitations have produced substantial reductions . . . .").

61. William L. Andreen, *Water Quality—Has the Clean Water Act Been a Success?*, 55 ALA. L. REV. 537, 549 (2004).

62. *Id.*

63. 33 U.S.C. § 1365.

entire system sets environmental law's gold standard for transparency and enforceability.[64] And TMDLs do play a part in that system.

When EPA and the states write NPDES permits, they begin with technology-based standards for effluent.[65] Generally speaking, those standards limit pollution based on the technological capabilities of dischargers, not based on the vulnerabilities of receiving waters.[66] But the statute also calls for more stringent permits when technology-based standards alone will not be sufficient to attain compliance with water quality standards.[67] That requirement exists with or without a TMDL; there is no legal reason why regulators must wait for TMDLs to write water quality-based effluent limitations ("WQBELs") into permits.[68] But a TMDL should, in theory, make WQBELs easier to set. TMDLs create overall pollution budgets for waterways, and those budgets should help regulators as they figure out how much pollutant loading each NPDES permit holder can contribute.[69] They also can provide an informational basis for water quality trading systems, which generally allow NPDES permit holders to trade effluent allocations with each other, or to acquire offsets from nonpoint source dischargers.[70]

EPA regulations bolster these connections between TMDLs and NPDES permits. These regulations require subdivision of the overall pollution budget into a load allocation, which covers nonpoint sources, and a wasteload allocation, which covers point sources.[71] The latter sub-budget should in turn facilitate a more refined allocation of pollution limits to specific NPDES permit-holders. The regulations also prohibit additional discharges into impaired waterways unless the discharger can demonstrate that "there are sufficient remaining pollutant load allocations to allow for

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64. *See* Wendy E. Wagner, *The Triumph of Technology-Based Standards*, 2000 U. ILL. L. REV. 83, 103 ("Environmental enforcement by private citizens is highest for violations of the Clean Water Act . . . .").

65. Andreen, *supra* note 61, at 548.

66. *Id.*

67. 33 U.S.C. § 1312; 40 C.F.R. § 122.44(d) (2011).

68. *See* 33 U.S.C. § 1312 (containing no mention of TMDLs).

69. *See* U.S. ENVTL. PROT. AGENCY, NPDES PERMIT WRITER'S MANUAL 6-30 (2010) Memorandum from N.Y. State Dep't of Envtl. Conservation to Reg'l Water Eng'rs, Bureau Dirs. & Section Chiefs, Division of Water Technical and Operational Guidance Series (1.3.1): Total Maximum Daily Loads and Water Quality-Based Effluent Limits 2–3 (July 8, 1996) (explaining links between TMDLs and WQBELs).

70. BOBBY COCHRAN & TIM MARTIN, BUILDING A TOTAL MAXIMUM DAILY LOAD TO BETTER SUPPORT WATER QUALITY TRADING 3, 4 (2014). Water quality trading generally allows entities that can reduce pollutant loading relatively cheaply to cut pollution more than would otherwise be required and to then sell credits to other entities for whom pollution reductions are more costly. U.S. ENVTL. PROT. AGENCY, WATER QUALITY TRADING TOOLKIT FOR PERMIT WRITERS 4 (2007).

71. *See* 40 C.F.R. § 130.2(e), (g)–(i) (defining load and wasteload allocations, and defining the TMDL as the sum of the load and wasteload allocations and a margin of error).

the discharge; and existing dischargers into that segment are subject to compliance schedules designed to bring the segment into compliance with applicable water quality standards."[72] In practice, that prohibition links a state's ability to permit new development to its implementation of existing TMDLs.[73]

But how much are TMDLs actually changing the water quality impacts of NPDES permit holders? Despite these regulatory linkages, the question is difficult to answer. There are reasons to suspect widespread benefits; most importantly, the mandatory nature of WQBELs creates a potentially direct connection between the information in TMDLs and actual controls on discharging facilities.[74] But there are also reasons for skepticism. First, the legal link between water quality standards and WQBELs does not depend on the presence of a TMDL, so even if WQBELs are improving water quality, TMDLs cannot necessarily claim to be part of the causal chain. Second, and perhaps most importantly, WQBELs impact a set of dischargers that already is subject to technology-based standards, some of which are quite stringent.[75] The impacts of TMDLs on many permits therefore may be marginal.

The balance of these factors is nearly impossible to discern, at least based on existing information. There is surprisingly little empirical research on how WQBELs actually are affecting water quality; and while the literature on TMDL implementation generally finds higher implementation rates for point source discharges, that literature also has very little to say about actual water quality improvements.[76] Consequently, the front where TMDLs might actually be most effective has gone largely unstudied.

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72. 40 C.F.R. § 122.4(h)(2)(i).

73. *See* Friends of Pinto Creek v. U.S. Envtl. Prot. Agency, 504 F.3d 1007 (9th Cir. 2007) (holding that a new permit could not issue because of the lack of compliance schedules for existing permittees in the same watershed). If a state has not yet prepared a TMDL for an impaired waterway, that particular mandate does not apply, though new sources still cannot impair water quality. *See In re* Cities of Annandale and Maple Lake NPDES/SDS Permit Issuance for the Discharge of Treated Wastewater, 702 N.W.2d 768, 773 (Minn. Ct. App. 2005), *rev'd on other grounds*, 731 N.W.2d 502 (Minn. 2007).

74. GAO, *supra* note 35, at 35 (noting state regulators' perceptions that wasteload allocations are actually being implemented).

75. *See* Cannon, *supra* note 21, at 614 ("The CWA's policy apparatus now squeezes increasingly expensive increments of improvements from point sources . . . .").

76. *See supra* notes 37–48 and accompanying text.

B. Nonpoint Source Runoff

When the TMDL era began, nonpoint sources were often the centers of attention.[77] Agricultural pollution was then, as it is now, a huge source of water quality impairment,[78] and agricultural pollution is almost entirely exempt from the Clean Water Act's permitting requirements for point sources.[79] Another mechanism was needed, and TMDLs were the great hope.[80] In some places, those hopes have been validated, at least partially; TMDL-based regulation of nonpoint sources does exist.[81] But it is rare.[82]

The reasons why stem partly from the statutory structure. Clean Water Act section 303 mandates the identification of impaired water bodies, the creation of TMDLs for those water bodies, and the existence of continuing planning processes for improving water quality in those water bodies.[83] Other sections of the Clean Water Act also authorize federal grants for addressing nonpoint source pollution.[84] But nowhere in the Clean Water Act is there a mandate for putting those plans into effect.[85] An implementation plan does not become a binding set of requirements, as would occur under otherwise analogous provisions of the Clean Air Act.[86] A state that fails to attain water quality standards faces no threat of lost funding (other than EPA's grants for nonpoint source pollution, which are

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77. *See, e.g.*, Seema Mehta, *Ocean Cleanup May Reach More than 100 Miles Inland*, L.A. TIMES (Jan. 17, 2001), http://articles.latimes.com/2001/jan/17/local/me-13425 [https://perma.cc/C2RC-AVSL] (describing TMDLs as "limits for pollution sources such as farms, nurseries and cities that were largely ignored in earlier enforcement efforts").

78. *See* Andreen, *supra* note 61, at 563–64 (describing water quality problems in the early 2000s).

79. *See* 33 U.S.C. § 1362(14) (exempting "agricultural stormwater discharges and return flows from irrigated agriculture" from the Clean Water Act's definition of point sources, and thus from regulatory coverage under the NPDES program).

80. *See, e.g.*, Mehta, *supra* note 77 (quoting NRDC attorney David Beckman: "'This is cutting edge. . . . [The limits] are intended to actually accomplish the fundamental goal of the Clean Water Act—to make water safe for swimming, fishing and other uses people like. It's because they have teeth that there's opposition to virtually every TMDL I can think of.'") (brackets in original).

81. *See, e.g.*, N. COAST REG'L WATER QUALITY CONTROL BD., NORTH COAST IMPAIRED WATERS & TMDL PROGRAM FISCAL YEAR 2013 – 2014 ACCOMPLISHMENTS, http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/pdf/141205/140807_RMF_FY 13-14TMDLYearEndEssay_ForEORptB.pdf [https://perma.cc/5GSR-AN4Y] (describing TMDL implementation efforts, including several programs focused on nonpoint source discharges).

82. *See supra* notes 35–48 and accompanying text (describing multiple reports finding that TMDL implementation for nonpoint sources is particularly rare).

83. 33 U.S.C. § 1313(d).

84. 33 U.S.C. § 1329 (authorizing the section 319 grant program).

85. *See* Pronsolino v. Nastri, 291 F.3d 1123, 1140 (9th Cir. 2002) ("States must implement TMDLs only to the extent that they seek to avoid losing federal grant money; there is no pertinent statutory provision otherwise requiring implementation of § 303 plans or providing for their enforcement.").

86. *See* 42 U.S.C. § 7410(a)(2) (2012) (requiring enforceable controls).

not very large) or of a federal takeover of plan implementation.[87] Nor is there any requirement that water quality planners demonstrate that plans, if implemented, actually would reduce nonpoint source pollution enough to attain compliance with water quality standards.[88] The TMDLs and plans just have to exist.

The absence of a mandate is not a matter of coincidence or oversight, for Clean Water Act section 303 was designed to leave a substantial and discretionary role for the states.[89] And states can give TMDLs teeth if they want to; all it takes is state legislation linking completed TMDLs to mandatory controls on nonpoint sources. But such legislation is rare. In preparing this article, I searched Westlaw's databases of state statutes for every reference to TMDLs and reviewed those statutory sections for any provisions mandating that TMDLs be turned into nonpoint source controls. I found almost nothing. Only two states—Vermont and Virginia—have statutory language drawing such links explicitly.[90] One other—California—had state statutory language that regulators have interpreted as establishing such links.[91] But more common, in my search, was language like the following blunt proclamation of the Arizona Revised Statutes: "Any reductions in loading from nonpoint sources shall be achieved voluntarily."[92]

Of course, mandates can come from sources other than explicit statutory language. Sometimes regulators can do creative work with

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87. *But see* § 7410(c) (requiring federal implementation plans if state plans are not submitted or are inadequate).

88. *But see* § 7511a(c)(2)(A) (stating that air quality plans must "provide for attainment of the ozone national ambient air quality standard by the applicable attainment date," and requiring a modeled demonstration that attainment will actually occur).

89. *See* HOUCK, *supra* note 18, at 14–24 (describing the history of Clean Water Act section 303).

90. *See* VA. CODE ANN. § 10.1-104.8 (2011) (requiring plans to implement the Chesapeake Bay TMDL); VT. STAT. ANN. tit 10, § 1386(a) (2016) (requiring plans for implementing the Lake Champlain TMDL).

91. *See* CAL. ENVTL. PROT. AGENCY, STATE WATER RES. CONTROL BD., POLICY FOR IMPLEMENTATION AND ENFORCEMENT OF THE NONPOINT SOURCE POLLUTION CONTROL PROGRAM 6–7 (explaining the agency's interpretation of the Porter-Cologne Water Quality Control Act). At Vermont Law School's 2015 TMDL symposium, participants who were familiar with Florida's implementation practices commented that their state had integrated regulation of nonpoint sources into its TMDL program.

92. ARIZ. REV. STAT. § 49-234(G) (2002); *see* IDAHO CODE § 39-3611(10) (2015) ("Nothing in this section shall be interpreted as requiring best management practices for agricultural nonpoint source activities which are not adopted on a voluntary basis . . . ."); KAN. STAT. ANN. § 82a-2007 (2012) (authorizing the appointment of a staff person to "implement voluntary incentive based conservation programs"); MONT. CODE ANN. § 75-5-703(8) (1997) (calling for "a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL developed and implemented pursuant to this section").

ambiguous statutory provisions. But that will only happen if regulators have at least arguable statutory authority to impose such controls and if they operate in a political context where such controls are allowable. Just how often those circumstances arise is a question this article cannot definitively answer, but they do not appear to be common. In many states, legislation explicitly forbids state agencies from imposing any regulatory controls that exceed the minimum levels mandated by federal law.[93] In many states, also, the current political climate is not at all supportive of environmental regulation.[94] It would take a bold bureaucrat to defy those laws, or that culture, and impose discretionary controls on agricultural polluters. And retrospective studies of TMDL implementation for nonpoint sources suggest that such boldness is not occurring very often.[95]

And yet, boldness does occur sometimes. *Pronsolino v. Nastri*, the case that most succinctly summarizes the limitations of section 303, also hints at the potential: the TMDL at issue in that case actually did lead to significant controls on nonpoint source pollution from silvicultural activities.[96] Indeed, the North Coast Regional Water Quality Board—the California regional agency responsible for implementing that TMDL, and many others—has used the Garcia River TMDL as an important first step down a path toward broader regulation of nonpoint source pollution.[97] Much farther east, implementation of the Chesapeake Bay TMDL—probably the most ambitious and highest-stakes TMDL ever prepared—will include controls on nonpoint sources.[98] And, as the articles in this issue demonstrate, real controls on nonpoint sources are integral to implementation of the TMDL

93. *See* William L. Andreen, *Federal Climate Change Legislation and Preemption*, 3 ENVT. & ENERGY L. & POL'Y 261, 279–80 (2008) (describing such laws).

94. *See, e.g.*, Trip Gabriel, *Ash Spill Shows How Watchdog Was Defanged*, N.Y. TIMES (Feb. 28, 2014), http://www.nytimes.com/2014/03/01/us/coal-ash-spill-reveals-transformation-of-north-carolina-agency.html [https://perma.cc/83TJ-YQQ3] (describing political pressures against environmental regulation in North Carolina); Charles Duhigg, *Clean Water Laws Neglected, at a Cost in Suffering*, N.Y. TIMES (Sept. 13, 2009), http://www.nytimes.com/2009/09/13/us/13water.html?_r=0 [https://perma.cc/LHX7-TKEX] (describing political issues and public health consequences in West Virginia and other states).

95. *E.g.*, GAO, *supra* note 35, at 35 ("[state agency] coordinators reported that a higher proportion of long-established point source TMDLs helped water bodies attain water quality standards than did nonpoint source TMDLs.").

96. *See* 291 F.3d at 1129–30. ("In order to comply with the Garcia River TMDL, Forestry and/or the state's Regional Water Quality Control Board required, among other things, that the Pronsolinos' harvesting permit provide for mitigation of 90% of controllable road-related sediment run-off and contain prohibitions on removing certain trees and on harvesting from mid-October until May 1.").

97. *See generally* JONATHAN WARMERDAM, N. COAST REG'L WATER QUALITY CONTROL BD., GARCIA RIVER WATERSHED AND SEDIMENT TMDL ACTION PLAN (May 5, 2010), http://www.waterboards.ca.gov/academy/courses/mtshasta/050510_jwarmerdam.pdf [https://perma.cc/LD52-9FJT] (PowerPoint describing implementation activities).

98. *See Am. Farm Bureau Fed'n*, 792 F.3d 281 (describing the TMDL).

for Lake Champlain. These efforts demonstrate beyond doubt that nonpoint source regulation can be done and that TMDLs can be part of the regulatory process. But these efforts also seem to be outliers.

C. Urban Stormwater

A third major category of pollution sources does not fit neatly into either of the analytical categories described above. One of the leading causes of water quality impairment—the leading source, in the areas where most people live and work—is urban stormwater pollution.[99] Legal commentators often lump urban stormwater runoff into the larger category of nonpoint source pollution, but that is mostly incorrect; most urban stormwater discharges through point sources.[100] But the laws and physical realities of urban stormwater are sufficiently different from those of other point sources that urban stormwater generates its own distinctive problems and merits its own separate discussion.[101]

The problems with urban stormwater TMDLs arise partly because of mismatches between the requirements of section 303 and the nature of urban stormwater pollution. Section 303 is highly specific in its prescriptions: states must set daily loading budgets for individual pollutants.[102] That is a sensible system for discrete pollutants that arrive in predictable increments.[103] But stormwater tends to move in erratic pulses, and those pulses typically contain cocktails of different pollutants, all of which interact to degrade waterways.[104] Some of the stressors associated with urban stormwater runoff also do not meet the Clean Water Act's definition of pollutant.[105] Excess flow, for example, is an excellent proxy for pollutant levels and also is a major stressor for many urban

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99. *See* Owen, *supra* note 6, at 441–44 (describing the pervasiveness of urban stormwater pollution).

100. Dave Owen, *Stormwater, Point Sources, and the Importance of Getting Terms Right*, ENVTL. L. PROF BLOG (Feb. 12, 2014), http://lawprofessors.typepad.com/environmental_law/2014/02/stormwater-point-sources-and-the-importance-of-getting-terms-right.html [https://perma.cc/N3AU-FMJ4].

101. *See generally* Owen, *supra* note 6, at 445–54.

102. 33 U.S.C. § 1313(d).

103. *See* Wendy E. Wagner, *Stormy Regulation: The Problems that Result when Stormwater (and Other) Regulatory Programs Neglect to Account for Limitations in Scientific and Technical Information*, 9 CHAP. L. REV. 191, 201 (2006) (describing some of the advantages of the NPDES program).

104. Owen, *supra* note 6, at 446–47.

105. *See* 33 U.S.C. § 1362(6) (defining "pollutant" to include "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water").

waterways.[106] But flow is not itself a pollutant.[107] Despite those challenges, TMDLs can be written for stormwater-impaired streams.[108] But during past research projects, regulators bluntly, and repeatedly, told me they found the TMDL requirements to be a misfit for urban waterways.[109]

Regulators' efforts to work around that mismatch also face legal impediments. One creative solution to the challenges of stormwater TMDLs is to create a proxy TMDL, which uses some other watershed feature—typically stormwater flow levels or impervious cover—as a proxy for pollutant loading.[110] As I have argued elsewhere, this approach makes scientific sense, for it focuses attention on root rather than intermediate causes of impairment, and policy sense, for it can produce budgets that municipal planners might actually use.[111] But proxy TMDLs have raised legal questions. Most prominently, a federal district court in Virginia recently held that EPA's use of a proxy TMDL for Accotink Creek was arbitrary and capricious.[112] The Clean Water Act, the court noted, required TMDLs for pollutants, and EPA's proxy—flow—was not a pollutant.[113] As a district court decision, the case holds no precedential value, and other courts might reach different results.[114] But, at the very least, the decision signals that proxy TMDLs occupy a legal gray zone, and it may persuade states and EPA to retreat from what initially seemed like promising policy innovations.[115]

106. *See* Owen, *supra* note 6, at 452–53 (noting the problem).

107. *Id.*

108. *See* U.S. ENVTL. PROT. AGENCY, *supra* note 48 (providing case studies of stormwater TMDLs).

109. Owen, *supra* note 6, at 453–54.

110. *See, e.g.*, CONN. DEP'T OF ENVTL. PROT., A TOTAL MAXIMUM DAILY LOAD ANALYSIS FOR EAGLEVILLE BROOK, MANSFIELD, CT (2007) (using impervious cover as a proxy); VT. DEP'T OF ENVTL. CONSERVATION, TOTAL MAXIMUM DAILY LOAD TO ADDRESS BIOLOGICAL IMPAIRMENT IN POTASH BROOK, CHITTENDEN COUNTY 4–5 (2006) (using flow as a proxy).

111. Owen, *supra* note 6, at 462–63.

112. Va. Dep't of Transp. v. U.S. Envtl. Prot. Agency, No. 1:12-CV-775, 2013 WL 53741, at *7 (E.D. Va. 2013).

113. *Id.* at *4–*9.

114. While I have discussed issues with the legality of proxy TMDLs, see Owen, *supra* note 6, at 463–64, I think the district court was too quick to dismiss arguments favoring the legality of the Accotink Creek TMDL. In that particular TMDL, EPA was using flow as a proxy measure for a specific pollutant (sediment). That strikes me as a different situation than if EPA was using flow as a proxy for a suite of stressors, some of which are not pollutants. But that distinction did not seem important to the district court. *See* Dave Owen, *An Important Stormwater Case (and It's not the One You're Thinking of)*, ENVTL. L. PROF BLOG (Jan. 9, 2013), http://lawprofessors.typepad.com/environmental_law/2013/01/an-important-stormwater-case-and-its-not-the-one-youre-thinking-of.html [https://perma.cc/K3DC-NRKT] (discussing the Accotink Creek decision).

115. *See* Owen, *supra* note 6, at 463–64.

Urban stormwater TMDLs also face a significant additional challenge: the mechanisms for translating them into controls on individual sources are weak. That might initially seem like a surprising statement, for, as explained above, urban stormwater largely discharges through point sources, and point source permits generally must contain limitations designed to implement water quality standards and, therefore, TMDLs.[116] But for two reasons, that linkage is weaker with urban stormwater. The first reason is that many point source discharges are not part of the NPDES program. Clean Water Act section 402(p) creates a convoluted regulatory structure for stormwater runoff, and the upshot of that structure is that only a subset of stormwater point sources require NPDES permits.[117] Some major categories of sources—for example, developed sites in smaller municipalities or in census tracts with low population density—are exempt.[118] Second, courts have held that the NPDES program's requirements for WQBELs are not mandatory for municipal stormwater discharges, even if those stormwater discharges are subject to NPDES permitting.[119] Those holdings weaken what might otherwise be a powerful mechanism for turning TMDLs into enforceable controls.

Again, all of these obstacles have not prevented states from addressing urban stormwater in some TMDLs. Regulators in California, for example, have taken aggressive—and controversial—steps to use TMDLs as the basis for limitations on litter.[120] In Vermont, regulators have stood by their proxy TMDLs, notwithstanding legal controversies elsewhere about their use. The Chesapeake Bay TMDL should spur major steps to address urban stormwater pollution.[121] But each of these efforts involves state or local regulators with an independent commitment to water quality protection. For a recalcitrant state, the spurs to action remain limited.

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116. *See supra* notes 60–73 and accompanying text.

117. 33 U.S.C. § 1342(p).

118. Owen, *supra* note 6, at 449.

119. *See* Defs. of Wildlife v. Browner, 191 F.3d 1159, 1166 (9th Cir. 1999) ("In conclusion . . . Congress did not require municipal storm-sewer discharges to comply strictly with 33 U.S.C. § 1311(b)(1)(C)."); Md. Dep't of the Env't v. Anacostia Riverkeeper, 112 A.3d 979, 990–92 (Md. Ct. Spec. App. 2015), *rev'd on other grounds*, 2016 WL 929349 (Md. 2016).

120. City of Arcadia v. State Water Res. Control Bd., 38 Cal. Rptr. 3d 373 (Cal. Ct. App. 2006) (considering, and mostly upholding, a TMDL for trash in the Los Angeles River).

121. *See* U.S. ENVTL. PROT. AGENCY, CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD FOR NITROGEN, PHOSPHOROUS AND SEDIMENT 8-14 to 8-15 (2010) (describing limits on urban stormwater pollution); Donna Peterson, *Arlington County Taking Lead in Curbing Runoff to Potomac River and Chesapeake Bay*, WASH. POST (Aug. 13, 2012), https://www.washingtonpost.com/blogs/the-state-of-nova/post/arlington-county-taking-lead-in-curbing-runoff-to-potomac-river-and-chesapeake-bay/2012/08/13/cc8615ce-e564-11e1-936a-b801f1abab19_blog.html [https://perma.cc/24U3-7XPZ] (discussing municipal efforts to curb stormwater runoff).

IV. LESSONS

The history of environmental law is filled with success stories. The United States has achieved major improvements in air quality while the economy has continued to grow;[122] many rivers are much cleaner than they were in the late 1970s;[123] and current practices for managing hazardous waste make the sloppiness of generations past seem mind-boggling.[124] Many of those successes are readily traceable to specific statutory provisions. But Clean Water Act section 303 does not yet seem to belong in the environmental law hall of fame, and there are reasons to suspect, based on the structural flaws described above, that it never well. That raises a question, then: what can we learn from all the things TMDLs, and section 303 more generally, seem not to have achieved?

Of many possible answers to that question, the discussion below focuses on just two. One involves designing statutes, and the other involves the decisions litigants make about forcing those statutes' implementation.

A. Mandates and Work-Arounds

One of the most striking features of section 303(d) is its particularity. In just a few words, the statute binds regulators to a single process: they must specify a maximum daily load of specific pollutants. Nowhere in the statute is there express permission for a state regulator to say, "what's impairing water quality in this stream is flow fluctuations, or water withdrawals, or a loss of riparian habitat, or dams, and calculating a daily pollutant load doesn't make sense, so we're not going to do it." Nor—according to the United States Court of Appeals for the D.C. Circuit, at least—can regulators say, "daily pollutant loads don't really make sense; let's use some other time period."[125] Nor does a regulator have clear statutory authorization to say, "we know the root problem of impairment and how we should go about

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122. *Clean Air Act Overview: Progress Cleaning the Air and Improving People's Health*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health [https://perma.cc/9BZY-5HXX] (last visited Apr. 5, 2016).

123. *See* James Salzman, *Why Rivers No Longer Burn: The Clean Water Act Is One of the Greatest Success in Environmental Law*, SLATE (Dec. 10, 2012 5:20 AM), http://www.slate.com/articles/health_and_science/science/2012/12/clean_water_act_40th_anniversary_the_greatest_success_in_environmental_law.html [https://perma.cc/UY74-FT99] (describing the transformation of pollution control from 1969 to today).

124. I base this assertion on my own experience, prior to becoming a lawyer, performing hazardous waste management audits and working on waste site cleanups. The differences from past to current practices are dramatic.

125. *Friends of the Earth*, 446 F.3d at 142 ("Daily means daily, nothing else."). *But see* Natural Res. Def. Council v. Muszynski, 268 F.3d 91, 99 (2d Cir. 2001) (allowing non-daily measurements of loading).

regulating it, so let's just go ahead and do that."[126] The statute presumes that one regulatory method always works best, with other methods offering supplements but not substitutes.

In historical context, that specificity makes some sense. In the early 1970s, Congress recognized that government agencies would be essential to the project of implementing environmental law, and that the states would need to be involved too, but reliance did not mean trust.[127] So Congress turned to highly specific mandates, often backstopped by petition and citizen suit provisions, to ensure that state and federal agencies actually carried out their mandates.[128] For that reason, perhaps the most anomalous feature of section 303(d) is not the specificity of its mandates but their incompleteness. In other areas of environmental law, like the Clean Water Act's provisions for regulating point sources or the planning provisions of the Clean Air Act, the mandates extend not just to planning but also to implementation.[129] In section 303, Congress somewhat uncharacteristically stopped short.

Four decades later, however, that level of distrust looks anachronistic. EPA is not simply a timid expert, capable of regulating effectively if and only if Congress tells it exactly what to do and how to do it. Instead, it does things—often bold things—partly on its own initiative; it comes up with regulatory techniques that Congress might not have contemplated; and, sometimes, it exercises restraint for sensible reasons.[130] Other agencies can and do exercise similar judgment.[131] Spurs to action still clearly have a place in environmental law. But to bind an entire regulatory process within a narrow statutory straitjacket no longer makes much sense.

And there are alternatives. Section 303(d) could have been constructed to require EPA and the states to prepare TMDLs or, if they explained why

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126. States can prioritize among streams, and the resulting latitude does provide some flexibility for EPA or a state to prepare higher-value TMDLs first. But, in theory at least, a TMDL is eventually required for every impaired waterway.

127. *See* RICHARD J. LAZARUS, THE MAKING OF ENVIRONMENTAL LAW 87–91 (2004) (describing widespread distrust of EPA).

128. *See id.* at 79–84; SAX, *supra* note 32 (providing an intellectual blueprint for many of these accountability mechanisms).

129. *See, e.g.*, 42 U.S.C. § 7410 (setting forth requirements for state implementation plans).

130. EPA's Clean Power Plan (in my view, at least) exemplifies this: EPA used a creative regulatory mechanism, and it also tried to push to, but not beyond, the limits of political and legal feasibility. *See generally* Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64662 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60).

131. *See, e.g.*, Dave Owen, *Little Streams and the Transformations of Environmental Law*, 2016 UTAH L. REV. (forthcoming) (on file with Vermont Journal of Environmental Law) (describing a largely agency-driven process of expanding regulatory protections for small streams); John D. Leshy, *The Babbitt Legacy at the Department of the Interior: A Preliminary View*, 31 ENVTL. L. 199, 212–14 (2001) (describing changes to ESA implementation).

the TMDL approach did not make sense, to adopt enforceable recovery plans for impaired waterways. Similarly, it could have given regulators the option of skipping TMDLs, and skipping planning entirely, if they demonstrated that a regulatory program already in place would effectively address impairment in the affected waterway. To put the point more generally, the statute could have taken the same partial flexibility that reformers have long demanded for the regulated community and extended it to the regulators themselves: it could have established performance standards for regulators while allowing those regulators to determine how best to achieve those standards.[132] And, similarly, it could encourage more effective regulation by allowing actual regulatory controls—and results—to substitute for extra layers of regulatory process.

These alternative regulatory approaches would not be novel.[133] The Clean Air Act planning process, for example, allows some similar flexibility, giving regulators discretion to select many of the elements of state implementation plans, but backstopping that discretion by requiring a demonstration that the plans will work.[134] Other statutes create opportunities to substitute performance for process. Federal agencies often comply with the National Environmental Policy Act and the Endangered Species Act, for example, by reducing projects' environmental impacts so that they do not exceed regulatory thresholds, thus avoiding what otherwise would be complex regulatory procedures.[135] Sometimes those workarounds are controversial.[136] But TMDL implementation provides a stark reminder that the absence of a workaround can mean compelling agencies to allocate resources in rather sub-optimal ways. As environmental law grows up, that kind of narrow mandate is increasingly dated.

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132. *See* CARY COGLIANESE ET AL., PERFORMANCE-BASED REGULATION: PROSPECTS AND LIMITATIONS IN HEALTH, SAFETY AND ENVIRONMENTAL PROTECTION 1–2 (2002) (describing the push for performance standards; the report also identifies circumstances where performance standards would not make sense).

133. *See generally* Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Toward a Bounded Pragmatism*, 87 MINN. L. REV. 943 (2003) (supporting the use of penalty default regulatory structures, which use a somewhat blunt default legal arrangement as an incentive for parties to craft solutions better tailored to their needs).

134. 42 U.S.C. § 7410(a) (requiring assurances of attainment).

135. *See, e.g.*, Dave Owen, *Probabilities, Planning Failures, and Environmental Law*, 84 TULANE L. REV. 265, 295 (2009) (describing common mechanisms of NEPA compliance); U.S. FISH & WILDLIFE SERV., EARLY ACTION: CANDIDATE CONSERVATION AGREEMENTS (2012), http://www.fws.gov/southeast/candidateconservation/PDF/earlyactionCCAAbrochure.pdf [https://perma.cc/WN7S-P5VF] (describing candidate conservation agreements, which generally involve using commitments to heightened conservation to avoid the listing of species as threatened or endangered—and thus to also avoid all the procedural and substantive constraints a species listing entails).

136. *See* Bradley C. Karkkainen, *Whither NEPA?*, 12 N.Y.U. ENVTL. L.J. 333 (2004) (summarizing (and partially disagreeing with) critiques of mitigated FONSIs).

That insight may come too late for Clean Water Act section 303(d), for sympathetic amendments to our foundational environmental laws rarely gain much traction in the current Congress.[137] But if times change, adjustments that give regulators less discretion about whether they address water quality impairment and more discretion about how they do so would make a lot of sense. Similarly, as legislators design other environmental laws, the misconstruction of section 303 offers a useful reminder that giving regulators a range of tools to choose from can sometimes be a wise idea.

B. Considering Litigation's Pathways

The other key lessons apply to litigators. TMDL litigation was a grand experiment, and its core hypothesis—that requiring TMDLs would lead to significant and systemic improvements in water quality—has not been proven. If it remains unproven or, worse, is proven false, then environmentalist litigators ought to take note, not just for TMDL litigation but also across the fields of environmental and administrative law.

More than anything else, the uncertain outcomes of TMDLs underscore the importance of considering what will happen after one wins a case. Will the losing agency be compelled, not just to take some intermediate step toward environmental protection, but also to see the regulatory process through to actual environmental results?[138] Will a victory create a default prohibition on some kind of environmentally destructive action, thus requiring regulated entities to obtain permission—and, most likely, comply with protective conditions—before they act?[139] Sometimes the answer to one or both of those questions will be "yes," and then it may make sense to spur even a highly reluctant regulator to act. But if victory will only compel regulators to take some intermediate step that might or might not lead to environmental results, filing suit may be unwise, even if environmentalists are sure they can win. TMDLs exemplify this point. Only for one category of sources—traditional NPDES discharges—did generating a TMDL create a clear pathway to actual regulatory controls.[140] Other than that, the prevailing litigators were just compelling the production of documents that could sit, ignored, on dusty shelves.

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137. Richard Lazarus, *Environmental Law Without Congress*, 30 J. LAND USE 15, 28–33 (2014).

138. The Endangered Species Act, which mandates protection for listed species, provides a good example of such compulsion: winning a listing case means that species must receive protection. *See* 16 U.S.C. §§ 1536, 1538 (2012) (providing mandatory protections for listed species).

139. *See, e.g.*, 33 U.S.C. § 1311 (categorically prohibiting pollutant discharges, unless the discharger obtains and complies with a permit).

140. *See supra* Section III.

The second, and related, lesson is to consider the culture of the agency being challenged. Sometimes litigation compels reluctant agencies to act, and sometimes it unleashes them.[141] In the latter circumstance, it may not matter quite so much that a victory will not compel a process that will necessarily culminate in regulatory controls. But in the absence of an agency culture sympathetic to the underlying goals of an environmental case, taking off the leash will not do much good.

Here, TMDLs present a more complicated story. EPA clearly has shown a commitment to the basic goals of TMDLs, and its TMDL regulations do flesh out the basic statutory mandate.[142] In past regulatory processes, EPA also came close to adding real teeth to TMDL requirements; late in the Clinton Administration, EPA proposed rules that would have further strengthened the TMDL program by demanding that states provide reasonable assurances of actual implementation.[143] Those rules did not last, but the fact that they almost became operable suggests that litigants were not irrational in their hopes.[144]

Nor were litigants crazy to expect that at least some of the fifty states would embrace TMDL requirements and try to turn them into something meaningful. Environmental politics vary tremendously from state to state, and some of those states—California is perhaps the best example—take pride in their reputations as environmental leaders.[145] In addition to EPA and the states, there are many other actors, both private and public, that could turn TMDLs into documents with real meaning.[146] Sub-state actors, other federal agencies, and watershed groups all could, and sometimes have, taken TMDLs and turned them into stepping stones toward environmental progress.[147]

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141. The *Massachusetts v. EPA* litigation against EPA arguably exemplifies the latter dynamic. 549 U.S. 583 (2007). Many people working at EPA in the mid-2000s had the competence and, most likely, the inclination to take steps toward addressing climate change, and the Supreme Court's ruling gave them—eventually—the ability to begin taking those steps.

142. For example, the regulations call for load and wasteload allocations—requirements that do not appear within the statute itself. *See Am. Farm Bureau Fed'n*, 792 F.3d at 300 (finding these regulatory requirements to be lawful).

143. *See* Linda A. Malone, *The Myths and Truths that Ended the 2000 TMDL Program*, 20 PACE ENVTL. L. REV. 63, 64–66 (2002) (describing EPA's efforts).

144. *See id.* at 68–69 (chronicling the demise of the rulemaking effort).

145. *See, e.g.*, Richard M. Frank, *California & the Future of Environmental Law & Policy*, 35 ECOLOGY L. CURRENTS 62 (2008) (describing California's leadership roles and also a few arenas in which it is a laggard).

146. *See* Mark Lubell et al., *Watershed Partnerships and the Emergency of Collective Action Institutions*, 46 AM. J. POLI. SCI. 148, 149 (2002) (noting the existence—as of 2002—of 958 watershed partnerships in the United States).

147. *See, e.g.*, KAJSA STROMBERG ET AL., NORTH FORK COEUR D'ALENE RIVER SUBBASIN WATERSHED RESTORATION EFFECTIVENESS REVIEW – SEDIMENT REDUCTIONS AND BIOLOGICAL RESPONSE (2013), https://www.deq.idaho.gov/media/1060945-

TMDL litigation, in short, was not obviously quixotic. Nevertheless, the inescapable reality is that most TMDL lawsuits were compelling states to take one additional, and partial, step in a process that they had never wanted to begin in the first place, and that would not lead to water quality protection without additional initiatives. Because of that history, any assumption that many states would say, "well, we never wanted to do TMDLs at all, but now that we're doing them, let's turn them into meaningful regulatory documents," seems to have been far-fetched.[148]

The point of this discussion is not condemn the litigators who sought to compel TMDLs. Clearly, I am skeptical of the utility of the cases they filed, but hindsight makes judgment all too easy. At the time, these litigators were facing huge unresolved water quality problems and better options for addressing nonpoint source pollution did not exactly seem abundant. Litigation and lawmaking also are highly uncertain practices, and often one cannot achieve a positive outcome without first engaging in the fight. But if hindsight is no basis for condemnation, it is a useful basis for assessing the future. And hindsight about TMDLs suggests the need for caution about when environmental litigators sue, even if a case seems like it can be won.

CONCLUSION

This article's conclusions may seem a little belated. After all, Congress and litigators did what they did, and with the TMDL program now in full swing, the lessons of the past may matter less than finding ways to make a flawed program work in the future. For that reason, the more important story in this volume is about the Vermonters who are turning the TMDL program, warts and all, into a viable tool of water quality improvement. Strong institutions and smart individuals can sometimes conjure good policy from weak law, and in the Lake Champlain basin, and elsewhere in the country, many people are trying to do just that with TMDLs. Some have already succeeded; others may yet do so.

But underlying legal structures still matter, and we can learn a thing or two from the past. Here, the primary lesson is that a major environmental program has not yet proven its worth. And while future studies may fill what presently are large information gaps, and also may paint a more

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north_fork_cda_river_sba_watershed_restoration_effectiveness_review_0913.pdf [https://perma.cc/RV3H-N6MJ] (describing successful implementation of several TMDLs in Idaho); VA. DEP'T OF ENVTL. QUALITY, TMDL PROGRAM SIX YEAR PROGRESS REPORT 2000 - 2006 (2007), http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/06prgrpt.pdf [https://perma.cc/82HC-EM3B] (providing detailed case studies showing water quality improvements).

148. *See* HOUCK, *supra* note 18, at 133–34 (quoting multiple Congressmen's observations about the states' reluctance to protect water quality).

positive picture, the presently-thin evidence of success offers cautionary lessons for statutory and regulatory design and for litigants choosing future battles. Sometimes a regulatory program just is not constructed to succeed, at least not on a widespread basis, and occasionally, regulators may be right to leave a mandate on the shelf.