A publication of the North American Lake Management Society

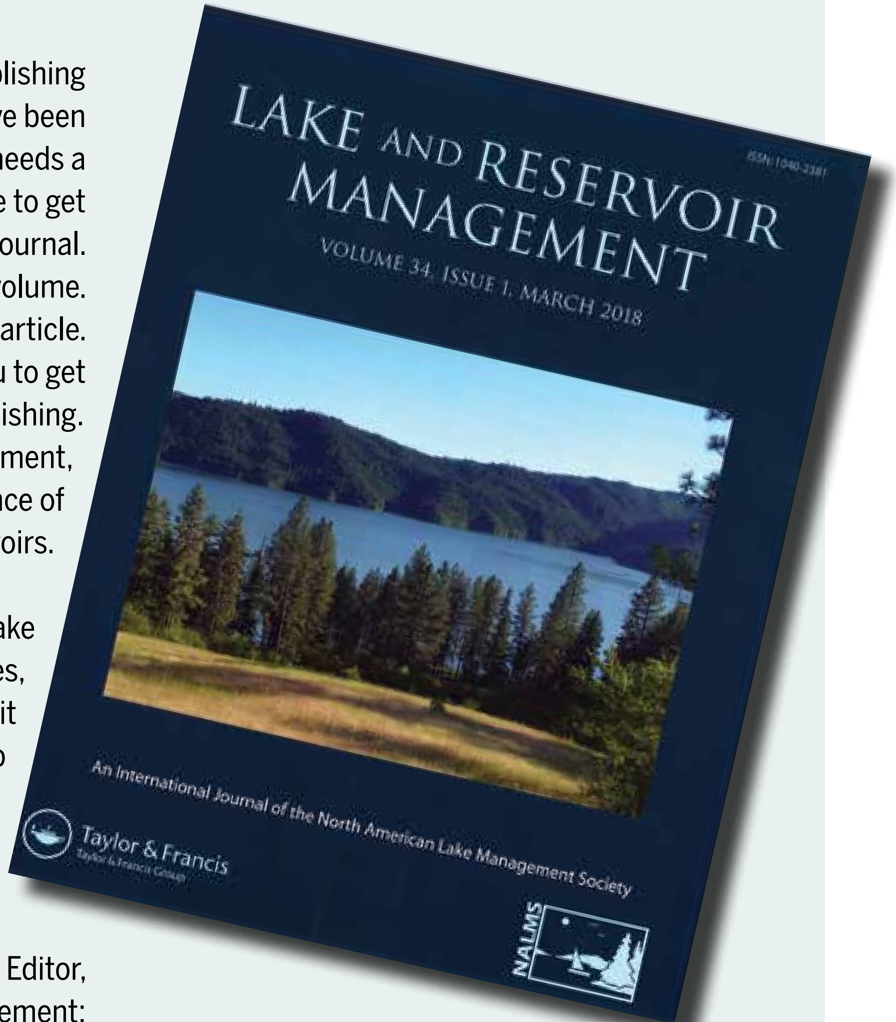
LakeLine

Volume 38, No. 4 • Winter 2018

Persistence in Lake Management

LAKE and RESERVOIR MANAGEMENT

A scientific publication of NALMS published up to four times per year solicits articles of a scientific nature, including case studies.



If you have been thinking about publishing the results of a recent study, or you have been hanging on to an old manuscript that just needs a little more polishing, now is the time to get those articles into your journal. There is room for your article in the next volume. Don't delay sending your draft article. Let the editorial staff work with you to get your article ready for publishing. You will have a great feeling of achievement, and you will be contributing to the science of managing our precious lakes and reservoirs.

Anyone who has made or plans to make presentations at any of the NALMS conferences, consider writing your talk and submitting it to the journal. It is much easier to do when it is fresh in your mind.

Send those articles or, if you have any questions at all, contact: Ken Wager, Editor, Lake and Reservoir Management; kjwagner@charter.net.

If there is anyone who would like to read articles for scientific content, please contact Ken Wagner. The journal can use your help in helping the editorial staff in editing articles.

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39th International Symposium of the
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November 11-15, 2019

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Vermont is home to more than 800 stunning lakes and ponds, including Lake Champlain, an aquatic gem we are fortunate to share with New York and Quebec. There is no better place to celebrate the partnership between local knowledge and scientific innovation than this lake that unites three borders. Burlington is a thriving and progressive small city, home to the University of Vermont, endless locally-sourced dining options, and a pedestrian-friendly waterfront. Visitors will enjoy scenic beauty and a wide variety of outdoor recreational opportunities.

For other details, visit www.nalms.org or contact one of the conference coordinators: Meg Modley (mmodley@lcbp.org), Jeff Schloss (jeff.schloss@unh.edu), and Perry Thomas (perry.thomas@vermont.gov).

- atmospheric deposition
- impacts of climate change
- citizen science
- water level management
- lake remote sensing
- sentinel lakes
- regional monitoring
- lake bioindicators
- cyanobacteria and algal blooms
- nutrient pollution
- flooding and extreme events
- aquatic invasive species


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LakeLine

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"Ice Harvest on Tobyhanna Mill Pond." Photographer Jason Smith. Photo entry in the 2018 NALMS photo contest.

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ISSN 0734-7978

P.O. Box 5443 • Madison, WI 53705
(All changes of address should go here.)

Address all editorial inquiries to:
Amy P. Smagula
29 Hazen Drive
Concord, NH 03301
Tel: 603/419-9325
LakeLine@nalms.org

Address all advertising inquiries to:
Alyssa Schulte
North American Lake Management Society
PO Box 5443 • Madison, WI 53705
aschulte@nalms.org

Payments:
PO Box 7276 • Boulder, CO 80306-7276
Tel: 608/233-2836

From the Editor

Amy Smagula

LakeLine encourages letters to the editor. Do you have a lake-related question? Or, have you read something in *LakeLine* that stimulates your interest? We'd love to hear from you via e-mail, telephone, or postal letter.

This winter issue of *LakeLine* brings to light some of the challenges we face in managing lakes and their watersheds. We all know that some projects are inherently fraught with frustrations or setbacks: things don't move as fast as we'd like, permitting is more onerous than expected, funding did not come through, equipment did not work as planned or realized improvements in water quality were not as predicted. This list could go on and on. We highlight some of these situations in this issue of *LakeLine*, and entitled it "Persistence in Lake Management."

Before we dig into the details shared by contributing authors, you will find a message from our new NALMS president, **Sara Peel**. Sara is a long-time member of NALMS, as well as a long-time board member (10+ years). Sara just took over as NALMS President during our 2018 symposium in Ohio. Please take a moment to read *From the President* to get to know Sara better, if you do not already know her and her commitment to NALMS.

Our first theme article for the winter issue is by **Ken Wagner**. He provides an overview of the evolution of managing Morses Pond, and the repeated and stepped-up measures to improve water quality and gain public support for the project.

Ben Lundsted, **Robert Robinson**, and **Jeff Marcoux** next showcase a project involving an urban pond with a long succession of difficulties they had to face in implementing best management practices (BMPs) to improve water quality of the pond and its inlets. These included coordination among multiple landowners, lack of space for installation of desired BMPs, pieced-together funding, regulatory hoops to jump through, waivers to be sought, as well as easements to negotiate.

Jamie Houle and **Dolores Jalbert-Leonard** then highlight the value of persistence in fostering buy-in from local municipalities in trying and modifying BMPs to work for them, and for improving water quality. Original designs of BMPs may not work for all communities, and the authors highlight the value of working closely with local entities to find a path forward towards implementation that works for water quality, and those involved in the installation and maintenance.

Mark Mitchell, **Laura Dlugolecki**, **Perry Thomas**, and **Angela Shambaugh** share an ongoing saga of a lake in peril in Vermont, and the efforts they are taking to combat both external and internal sources of phosphorus that are driving persistent cyanobacteria blooms. They do a great job at sharing the various management efforts along the way, and what they plan next for implementation.

Mark Mobley brings in some great perspective from an engineer who designs and implements methods and technologies that are used by water suppliers and others. He shares some of his experiences on the front line of in-lake management, and the sometimes very visible successes and occasional fails of projects like this. This real-time learning curve is something that we can all relate to!

Randi Notte, our student contributor, dons her detective cap for her article, sharing her frustrations but her persistence in tracking down the source of some significant error in phosphorus lab results that confounded her datasets for a while.

In the end, persistence paid off for each of the projects highlighted here. Lake and watershed managers need to be pretty savvy in their work, and not take fails or less than desirable results as a reason to walk away from a project. Often reevaluating a situation and shifting gears, or pushing a little farther down the intended path can make a marked difference in the outcome of a project. So when in doubt, or when you are frustrated with a project, keep these examples in mind, and just persist in finding a solution that works.

One of the best things about NALMS is the network it provides for those who are connected with the Society. If you find yourself in a tough spot with a project, reach out to someone in NALMS for some suggestions. You can start with our Subject Matter Experts list, which is an up-to-date list of NALMS members willing to serve as a sounding board for lake-related topics. You can find the list of Subject Matter Experts on the NALMS website at https://www.nalms.org/subject-matter-experts/.

I hope this issue of *LakeLine* helps to reinforce the value and importance of the work we do for our lakes, their watersheds, and the communities involved.

***

Please note that this is the final *print* issue of *LakeLine* magazine. NALMS has decided to move to a greener (paper free) version of the magazine, and will only be

(From the Editor . . . continued on p. 5)

From the President

Sara Peel

As past president Julie Chambers wrote in her first president's address – writing this article seems a bit surreal as I am usually on the other end and reading the most recent copy of *LakeLine*. And while I've served on the NALMS board of directors since 2010, I find myself in the same boat as Julie! Before I begin with thoughts on this issue's current theme, let me introduce myself.

I've worked in lake and watershed management since 1999, sampling lakes and stream across the state of Indiana with the Indiana Clean Lakes Program. There is nothing like dipping your toes into the waterbodies throughout your home state. I've enjoyed every year since, even as the setting has changed from my first professional position at a consulting firm before venturing into the nonprofit world, then striking out on my own and launching my own firm in 2012. As we begin 2019, I enter my 20^{th} year working on Indiana's natural treasures – some sparkling and crystal clear and others as green as the grass – but all uniquely Midwestern.

My first experiences with NALMS occurred at the Chicago lakes meetings in the mid-2000s. These and other NALMS conferences provide the opportunity to learn from and engage with friends and colleagues across the nation. Each year, the annual symposium brings great energy, excitement, and the opportunity to learn what is going on in the lake management arena through its diverse program topics on issues that face our lake resources. The opportunity to connect with friends made throughout the years while developing new connections is always something that I've enjoyed about attending NALMS conferences.

I started my journey with NALMS by attending conferences. When I suggested I wanted to be more involved, NALMS provided me with the option of contributing in small ways in the early years by serving on the membership and publications committees. I joined the board of directors in 2010 as the Region 5 director, and fast forward to now, I am serving as the NALMS president for 2018-2019. I am honored to have the opportunity to serve the organization in this capacity, and look forward to the year ahead with a bit of nervousness and a great deal of excitement and enthusiasm for the direction that the NALMS board is setting.

Persistence: If at first you don't succeed, try, try again. We've all heard those words – I'm sure my mother used them the no less than 30 times as I fell off my bicycle while learning to ride as a small child. And my "shake and bake" basketball playing father insisted that no less than 100 free throw shots daily were needed to learn his delicate free throw shooting stroke. In his mind, persistence pays off; and the same can be said for lake management.

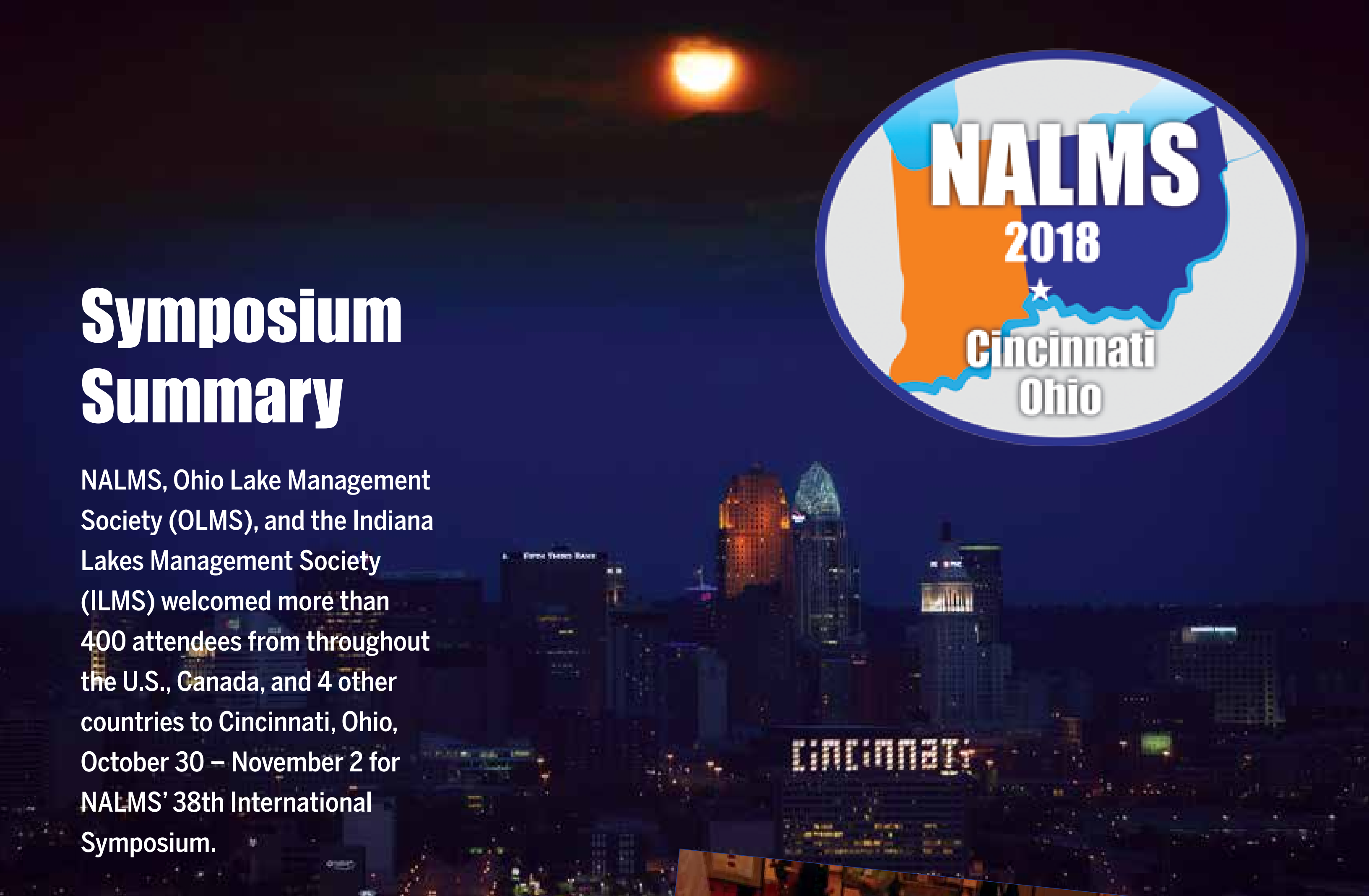
While all of our management efforts are built with science in mind, we are working on living, breathing, ever-changing bodies of water. Further, we are often working with boards of directors comprised of individuals. Each member loves their lake, feels passionately about their efforts to improve its quality, but may not agree on the techniques. Further, the first technique selected may not be the best or most effective option. The technique may be controversial, it may not work the way the board or planners thought and further, the results may not meet the original project goals. That's why we have a full toolbox – one used again and again by the lakes and their management efforts highlighted in this issue of *LakeLine*. We all have difficult projects. Be it technical issues, problems with planning, financial setbacks or controversial issues, finding the way to work through multiple fails or setbacks is instrumental in lake management. With this in mind, NALMS highlights the persistence needed to ensure that each and every one is successful in the end.

Sara Peel, CLM, is the NALMS president, previously serving as the director at large, two terms as secretary, and one term as the Region 5 director. Sara received her B.S. in biology and Chemistry from Alma College and her M.S. in environmental science from Indiana University School of Public and Environmental Affairs. Sara is the lead scientist and co-owner of Arion Consultants – a regional environmental consulting firm with a focus on lake and watershed management. She is an experienced leader in water quality and watershed management.

(From the Editor . . . continued from p. 4)

producing *LakeLine* in electronic format going forward, barring any special issues that we may elect to distribute in print format. We hope the convenience of an electronic *LakeLine* allows for you to access the magazine whenever and wherever you'd like.

Amy Smagula is a limnologist with the New Hampshire Department of Environmental Services, where she coordinates the Exotic Species Program and special studies of the state's lakes and ponds.



Symposium Summary

NALMS, Ohio Lake Management Society (OLMS), and the Indiana Lakes Management Society (ILMS) welcomed more than 400 attendees from throughout the U.S., Canada, and 4 other countries to Cincinnati, Ohio, October 30 – November 2 for NALMS' 38th International Symposium.

The week started on Tuesday with a busy day of ten workshops and three field trips. New workshops this year included Advanced Phytoplankton Ecology, Introduction to R for Aquatic Research, Lanthanum Modified Bentonite, and Lake Management Best Practices. The field trips took attendees to a local water treatment plant, the Thomas More Biology Field Station, and to a couple of U.S. Environmental Protection Agency research facilities.

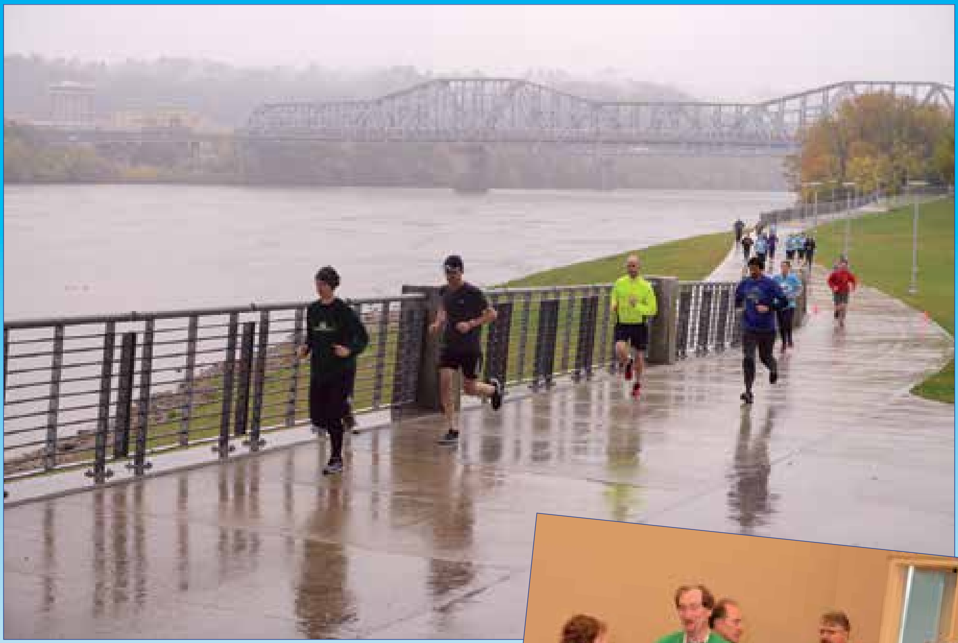
Attendees were welcomed on Wednesday by plenary sessions from Craig Williamson, the Ohio Eminent Scholar of Ecosystem Ecology at Miami University, and Amina Pollard, lead of the U.S. National Lakes Assessment for the U.S. Environmental Protection Agency. Following her presentation, Dr. Pollard and the National Lakes Assessment program were presented the Friends of NALMS Award.

The three-day technical program included approximately 180 oral presentations and 25 poster presentations. Wednesday's program included concurrent sessions offered by the Water Management Association of Ohio, the parent organization of OLMS. Special sessions included large data sets and long-term monitoring, Army Corps water quality activities, paleo-limnology, Phoslock, and molecular techniques for HABs.

Cyanobacteria take human form on Halloween during the NALMS Exhibitor Reception.

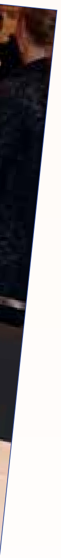
Not even pouring rain could deter some dedicated runners in the annual Clean Lakes Classic. Of the approximately 30 runners registered for the race, two-thirds braved the elements for a run along the Ohio River.

President Frank Brown making opening remarks.



A wet Clean Lakes Classic 5K this year.

Algal workshop.



Dr. Craig Williamson giving a plenary presentation on Lake Browning.

Our annual awards festivities were held in the art deco splendor of the Hilton Cincinnati Netherland Plaza where the accomplishments and contributions of NALMS members and other worthy recipients to lake management were recognized. The Secchi Disk Award, the Society's most prestigious award, given to a member who has made extraordinary contributions to the goals and objectives of the Society was bestowed upon Gertrud Nürnberg.

We also took a moment to look ahead to the 2019 NALMS Symposium where we'll reconvene on the shores of Lake Champlain in Burlington, Vermont. The 2019 symposium will be hosted by the New England Chapter of NALMS. Thank you to all who attended this year's symposium! We look forward to seeing you next November in Burlington for NALMS 2019!

Past president Julie Chambers and incoming president Sara Peel with her new gavel.

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Thank you to the Ohio Lake Management Society and the Indiana Lakes Management Society and the 2018 symposium host committee!

David Culver, Chair
Eugene Braig, Co-chair
Sara Peel, Co-chair
Suzanne Gray, Program Committee Co-chair
Doug Kane, Program Committee Co-chair
Jeff Schloss, NALMS Conference Coordinator
Philip Forsberg, NALMS Director of Programs and Operations
Alyssa Anderson, NALMS Director of Marketing and Membership
Marty Hilovsky, Sponsorship Committee Co-chair
Dana Oleskiewicz, Sponsorship Committee Co-chair
Chris Lorentz, Local Arrangements Committee Chair
Sarah Powers, Volunteer Committee Chair
Joe Bischoff
Heather Buck
Bret Henninger
Matt Rayl

NALMS 2017 by the Numbers

415 Final number of full-conference attendees.
81 Number of attendees from Ohio.
29 (Indiana) Largest attendance from a state other than Ohio.
43 Number of U.S. states and districts represented.
6 Number of countries represented.
39 Number of students in attendance.
11 Number of students who received travel grants through the Eberhardt Memorial Student Fund.
51 Number of technical sessions.
177 Number of oral presentations.
25 Number of poster presentations.
46 Number of exhibitors.
31 (registered) / 19 (rain-soaked participants) number of competitors in the Clean Lakes Classic.
798 Distance in miles, as the crow flies, between Cincinnati, Ohio, and Burlington, Vermont, site of the 2019 NALMS Symposium.

2018 North American Lake Management Society Awards

Dana Stephens, Awards Committee Chair

With a beautiful, art deco backdrop in Cincinnati, Ohio, the North American Lake Management Society (NALMS) recognized individuals, teams, and organizations for devoted efforts in lake and reservoir management at the 38th annual symposium.

NALMS success is a product of individuals volunteering their time as officers and directors to advance the NALMS' mission. Thank you, 2018 outgoing officers and directors.

Award recipients were nominated and selected by the NALMS board of directors per each award category. Nominations are available on NALMS website https://www.nalms.org/2018-achievement-award-nominations-recipients/ and highlight accomplishments for each award recipient. Congratulations to the 2018 award recipients!

OUTGOING OFFICERS AND DIRECTORS

Officers
Frank Browne, Past President

Directors
Kiyoko Yokota, Region 2
Bradley Hufhines, Region 6
Shannon Brattebo, Region 10
John-Mark Davies, Region 12

LEADERSHIP AND SERVICE AWARDS: EDUCATION AND OUTREACH

Awards individuals or teams for design, facilitation, or performance of exceptional education and outreach activities supporting community understanding and appreciation of lake and reservoir management.

- Clear Lake Township Land Conservancy
- Holly Hudson
- Michigan Shoreline Stewards Program Volunteer

Bridget Harrison with her award for Significant Community Education and Outreach with Clear Lake Township Land Conservancy, pictured with President Frank Browne.

LEADERSHIP AND SERVICE AWARDS: VOLUNTEER

Awards individuals or teams for design, facilitation, or performance of exceptional volunteer activities supporting community understanding and appreciation of lake and reservoir management.

- Friends of Deep Creek Lake
- Stephen McCord

LAKE MANAGEMENT SUCCESS STORIES

Awarded to individuals or organizations accomplishing successful lake management effort. Nominees must show demonstrated improvements in lake conditions through lake or watershed management.

- Columbia Association
- Deal Lake Commission
- Deep Creek Lake POA and Partners
- Rice Creek Watershed District and Wenck Associates, Inc.

ADVANCEMENTS IN LAKE MANAGEMENT TECHNOLOGIES

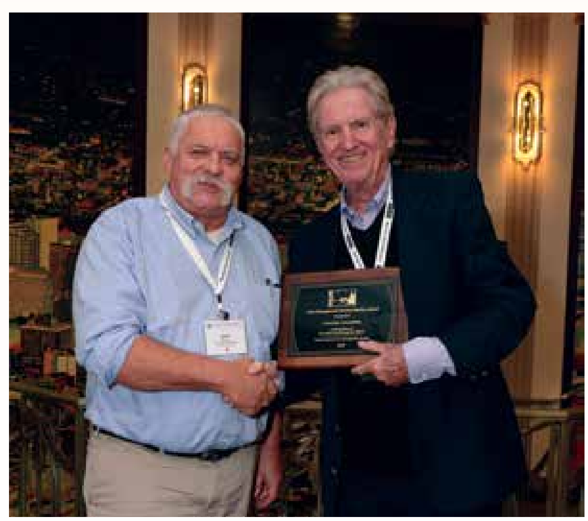
Awarded to individuals or organizations refining, developing, or discovering innovative or improved methods, technologies, or processes for achieving lake or watershed management outcomes. Outcomes are safer, more affordable, and contribute to the science of lake and reservoir management.

- William James

FRIENDS OF NALMS AWARD

Awards individuals or corporations making major contributions to NALMS.

- Amina Pollard and the EPA NLA Team
- Robert Carlson



President Frank Browne with John McCoy, who received recognition for the Columbia Association for Successful Lake Management Efforts.

Steve Sousa (left) accepting the Lake Management Success Stories Award for Deal Lake Commission.

Lake Management Success Award to Rice Creek Watershed District – Bill James, Joe Bischof, Matt Kocian, and NALMS President Frank Browne

Bill James with his Award for Advancements in Lake Management Technologies

Dr. Amina Pollard (right) accepting the Friends of NALMS Award from Dr. Dana Stephens after Dr. Pollard's plenary presentation

JIM FLYNN AWARD

Awarded to an organizational member to have contributed the most to NALMS's goal. Recipient must be a NALMS Corporate member.

No recipient this year

JIM LABOUNTY AWARD

Lake and Reservoir Management selects the best paper published in 2017 in the *Journal of Lake and Reservoir Management*.

Mark Edlund, Shawn Shottler, Euan Reavie, Dan Engstrom, Nolan Baratono, Peter Leavitt, Adam Heathcote, Bruce Wilson and Andrew Paterson. 2017. Historical phosphorus dynamics in Lake of the Woods (USA-Canada) – does legacy phosphorus still affect the southern basin? *Lake and Reservoir Management* 33 (4):386-402.

JODY CONNOR STUDENT AWARDS

Each year NALMS presents student awards to the best student presentation and best student poster at the annual NALMS symposium. The awards are sponsored by SOLitude Lake Management. The NALMS Board renamed the student award as the Jody Connor Student Award in memory of Jody Connor, a long-time friend of NALMS who was active on the Education Committee and participated in the reviews of student presentations and posters.

The first place winner receives a check for $200 and a plaque. Honorable mention or second place winners receive a plaque. The Student Awards Committee is co-chaired by Alex Horne and Frank Browne. Members of the committee include Amy Smagula, Harry Gibbons, Holly Waterfield, Jennifer Graham, Ann St Amand, Matt Albright, and Dick Osgood. The awards are based on scientific merit, research design, visual aids, clarity and presentation.

The 2018 first-place winner of the student presentation award was Vinicius Taguchi from the University of Minnesota, Minneapolis, Minnesota for his paper "Some Stormwater Ponds Release Phosphorus." The second-place award went to Rachel Pilla from Miami University, Oxford, Ohio for her paper "Structural Changes to Lake Ecosystems Resulting from Long-Term Browning."

The 2018 first-place winner of the student poster session was Hayden Henderson from Michigan Technological University, Houghton, Michigan for his poster "Neither Wolf nor Dog: P-Management in a Quasi Polymictic Lake." Honorable mention for the poster session went to Keiko Wilkins from Miami University, Oxford, Ohio for the poster "The Effects of Hydrogen Sulfide Within the Hypolimnion of a Dystrophic and Eutrophic Lake on Zooplankton Survival and Vertical Distribution."

Students are encouraged to present scientific papers at the NALMS symposium; it provides an excellent way to present research data and maybe win an award. We thank SOLitude Lake Management for sponsoring the student awards.

SECCHI DISK AWARD

Award recognizes an individual member considered to have contributed the most to the achievement of NALMS' goal.

- Gertrud Nürnberg

Gertrud Nürnberg with her 2018 Secchi Disk Award, with President Frank Browne

2018 North American Lake Management Society Photo Contest Winners

Coordinated by Amy Smagula

This year we were pleased to see eighteen great photos submitted for the NALMS Photo Contest. Photos ranged from gorgeous pictures of lakes, to capturing the life that lives in them. Photos spanned the calendar year, with all seasons represented. Each photo received some votes this year, so every photo was competetive, but the two winners that emerged at the end of the voting were:

- Editor's Choice (voted on by the *LakeLine* Production Editor and *LakeLine* Editor): "The Wolf of Peyto Lake" by Clint Calhoun (RIGHT >)

- Popular Vote (voted on by the NALMS conference attendees at the Annual Symposium): "Hanging Lake, Glenwood Canyon, Colorado," by Jillian Taylor (LEFT <)

The two winning photos are guaranteed to appear on *LakeLine* covers in the coming year. Other entries will be included on the NALMS website and across other NALMS publications and promotions.

Start snapping photos now for next year's contest. Maybe your photo will grace the cover of *LakeLine*!

2018 North American Lake Management Society Election Results

The annual election for officers and directors is an important way for NALMS members to provide input in the management of the Society. Our officers and directors are all volunteers who serve without pay. Thank you to all the candidates for their dedication to NALMS and thank you to all NALMS members who participated in this year's election!

President-elect – Perry Thomas

Elizabeth "Perry" Thomas has been Region 1 Director on the NALMS Board since 2016 and recently became co-chair of the newly formed Ethics Committee. She brings to the Board 15 years of management experience, ranging from working as dean of Sterling College to volunteering as president of the Federation of Vermont Lakes and Ponds. Perry currently practices strengths-based supervision as manager of the Vermont Lakes and Ponds Program – charged with protecting 823 inland lakes plus Lake Champlain. Perry earned a B.A. in biology from Dartmouth College and a Ph.D. in biology, with emphasis on aquatic ecology, from Northern Arizona University.

Secretary – Amy Smagula

Amy Smagula is a limnologist with the New Hampshire Department of Environmental Services where she coordinates the Exotic Species Program. Amy has an undergraduate degree in natural resources as well as a Master of Science in water resources management, both from the University of New Hampshire. Amy has over 20 years of experience in field and laboratory limnology, aquatic plant and algae identification and management, lake and watershed assessment and management, lake related policy-making, wetland inspection and permitting, and shoreland protection.

Region 1 Director – Ellen Kujawa

Ellen Kujawa has been appointed to fill the Region 1 Director position previously held by Perry Thomas. This appointment became effective on the Board's monthly conference call on December 6.

Region 2 Director – Chris Doyle

Chris graduated from Rutgers University with a BS in natural resource management. He has 25 years of experience as an aquatic biologist including 13 years of experience as a lake manager. Currently the director of biology at SOLitude Lake Management, he oversees field biologists conducting water quality and biological assessments in the Northeast. He has attended and presented at numerous lake management conferences since 2005, including NALMS, NYSFOLA, NJCOLA, NEAPMS, and NJISST. He became a Certified Lake Manager in 2008. He is a past president of the Northeast Aquatic Plant Management Society and currently is the their newsletter editor.

Region 6 Director – Victoria Chraibi

Victoria Chraibi, Ph.D., is an assistant professor of biological sciences at Tarleton State University in Stephenville, Texas. She teaches courses in limnology, aquatic ecology, phycology, and marine biology. She received an M.S. in water resources science from the University of Minnesota Duluth and a Ph.D. in earth and atmospheric sciences from the University of Nebraska-Lincoln. Her research focuses on paleolimnology, using diatom microfossils and other biological and geochemical proxies to reconstruct environmental conditions in a watershed over time. Past research has focused on Lake Memphrémagog, Lake Superior, and lakes in Yellowstone National Park; current research focuses on Texas streams and reservoirs. Victoria also specializes in science education and outreach; she has collaborated with aquariums, zoos, museums, state parks, and school organizations to develop and disseminate materials and lead activities about water resources and other scientific topics. She has been a member of NALMS since 2011.

Region 10 Director – Mark Rosenkranz

Mark Rosenkranz has been working on lakes in Oregon for over 20 years, first as a graduate student at Portland State University where he received a master's in environmental management followed by 16 years as staff scientist for the Lake Oswego Corporation (LOC). His work at LOC is focused on invasive species management, watershed monitoring, and phosphorus control in an urban lake. As climate change intensifies storm events and leads to warmer summer weather it is going to be crucial to plan for how surface water quality will be impacted. Mark has

Perry Thomas

Amy Amagula

Ellen Kujawa

Chris Doyle

VIctoria Chraibi

Mark Rosenkranz

Colleen Prather

Sarah Burnet

been a member of NALMS since 2002 and served as president of Oregon Lakes Association in 2004 and 2005.

Region 12 Director – Colleen Prather

Colleen Prather, Ph.D., P.Biol., is a water quality specialist with over 18 years of experience, and is currently with Golder Associates Ltd. in Edmonton, Alberta. Colleen's work focuses on lake and stream water quality monitoring and environmental impact assessment to support environmental permitting and licencing for mining operations in the three northern territories of Canada (Yukon, Northwest Territories, and Nunavut), and monitoring and assessment to support permitting and compliance reporting for various industries in British Columbia and Alberta. Colleen's most recent involvement with NALMS was as the technical program co-chair for the 2016 conference held in Banff, Alberta.

Student At-large Director – Sarah Burnet

Sarah Burnet is pursuing her Ph.D. at the University of Idaho, where she completed a MS in the spring of 2016. She received a BS from Western Washington University. Her Ph.D. research is focused on internal loading of phosphorus to reservoirs. Specifically, she is interested in understanding the relationships between sediment type, particle size, the availability of iron, and dissolved oxygen in the release of P. This builds on her MS research which focused on measuring the seasonal internal phosphorus load as part of a mass balance for Willow Creek Reservoir in Oregon. Sarah's previous work experience includes sampling and analysis on all five Great Lakes with Cornell University as well as collecting data and samples after the BP Deepwater Horizon Oil spill. Sarah has been a member of NALMS since 2014 and a Board member since 2016.

Outgoing NALMS directors (L-R): Perry Thomas (Region1), Kiyoko Yokota (Region 2), Shannon Brattebo (Region 10), and Brad Hufhines (Region 6).

Outgoing NALMS Board members (L-R): Brad Hufhines (Region 6),Kiyoko Yokota (Region 2), Shannon Brattebo (Region 10), Frank Wilhelm (past president), and Perry Thomas (Region 1).

If at First You Don't Succeed: Managing Morses Pond Over 25 Years

Kenneth J. Wagner, CLM

The old saying "If at first you don't succeed, try, try again" is not very useful in skydiving, but is very appropriate to lake management. Nowhere has this been more apparent in my career than at Morses Pond in Wellesley, Massachusetts.

Located on the border with Natick in the suburbs of Boston, 105-acre Morses Pond serves as a recreational amenity, an indirect source of drinking water, and habitat for a variety of aquatic organisms. It was artificially created in the 1600s and has additionally provided ice and waterpower historically, but for more than 100 years it has been mainly a place to swim, fish or enjoy nature as an oasis in a major urban area.

The town maintains a substantial open space area with a beach complex near the outlet on the southeast side and private residences dot much of the shoreline (Figure 1). There are adjacent town wells that pull water from the pond through the ground, especially during droughts, and this restricts some of the options for managing the pond. The pond reaches a depth of 24 feet, but about half of it is less than 10 feet deep, so it is prone to nuisance aquatic plant growths.

The watershed is over 50 times the area of the pond and largely developed, so the quality of incoming water can be an issue, and algae blooms were an intermittent problem for many decades. Wellesley is a proactive municipality, however, and management has been going on at the pond since the early 1970s. The town was involved in lake management from near the beginning of our profession.

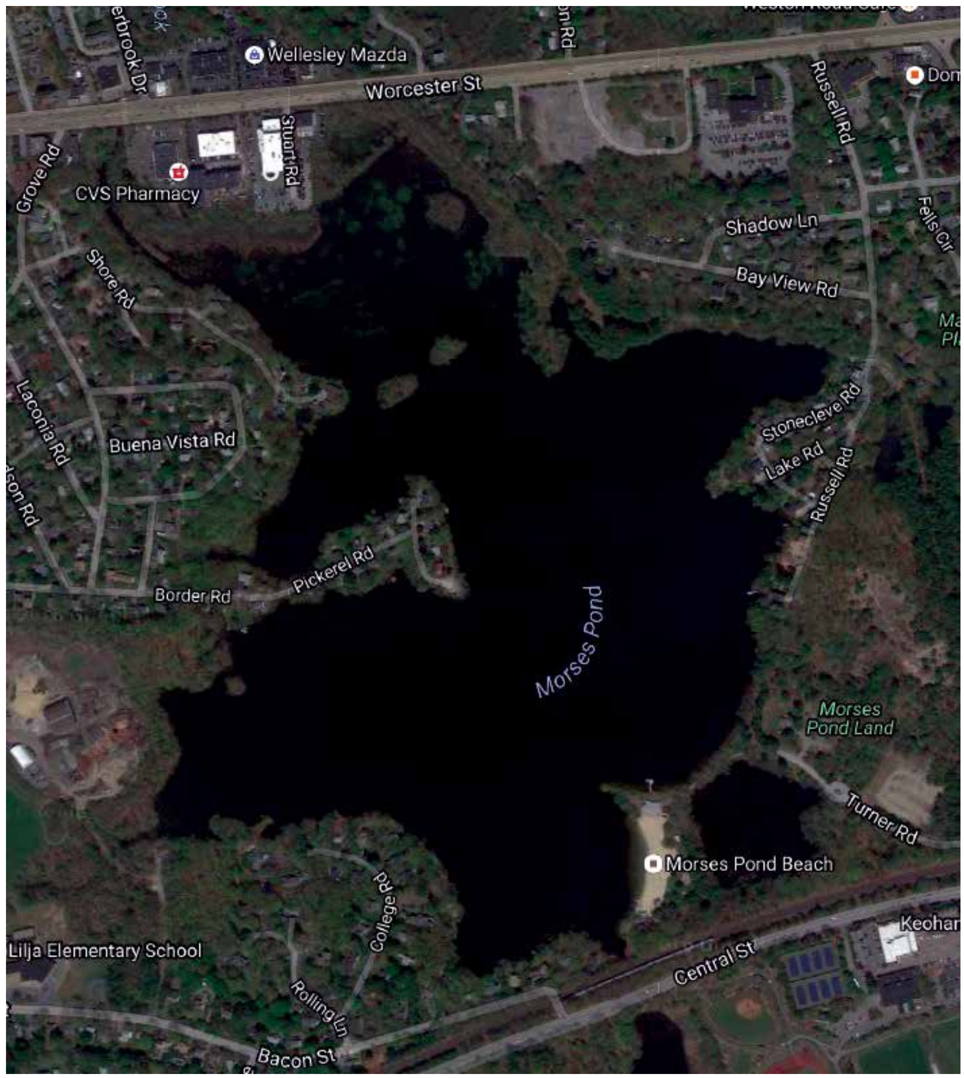


Figure 1. Morses Pond in Wellesley, Massachusetts.

The early years

In the early years, the town tried a number of ways to control rooted plants and algae but has tried to avoid the use of herbicides on public property, so most controls were physical. However, both potassium permanganate and aluminum were applied in the 1970s (Fugro 1993) to reduce algae and phosphorus levels. Permanganate never caught on, but aluminum is now recognized as a highly advantageous water quality management tool.

About 90 percent of the water entering the pond does so through two tributaries at the north end of the pond, and the 15-acre northern basin of the lake was dredged in the late 1970s to remove accumulated sediment and provide a detention area where contaminants might settle, thus protecting the downstream 90 acres of pond. This helped in drier years, but the capacity of the north basin to improve water quality was inadequate in wetter seasons. A wet spring followed by a dry summer was a recipe for algae blooms, including but not limited to cyanobacteria, and copper was applied to the swim area several times per summer to maintain swimming use.

Rooted plants proliferated, and in 1983 the town purchased a weed harvester. The design would not pass muster today, with an inclined storage area that caused the harvester to be top heavy when full, and it did indeed roll one time, fortunately with no harm to the operator. The harvester was also not capable of handling the total target area in the time necessary to prevent nuisance growths; it was a lot like trying to keep a dozen football fields mowed with a manual push mower. Much of the shallow area of the pond was subject to nuisance plant growths during summer, and multiple invasive species became abundant, including fanwort and two forms of milfoil that remain the dominant species in the pond.

In 1993, Wellesley hired Fugro, an environmental consulting firm for which I and several other long-time NALMS members worked, to prepare a management plan for Morses Pond. We looked at the watershed and the pond, the issues and possible solutions, and recommended a plan. That plan called for watershed resident education, bylaws to limit pollution generation and transport from the watershed to the pond, dredging of upstream impoundments and the north basin to enhance detention, a more intensive harvesting plan with bigger equipment, and phosphorus inactivation in the inlets or north basin to minimize algae blooms.

It was a good plan, but it was created in a vacuum with minimal input from any stakeholder groups. Various groups disagreed with certain parts of the plan, such as the recommended location for offloading harvested weeds. Some wanted something else done, like chemical treatment, despite the town policy against such treatments. Funding for most of the plan was denied at multiple town meetings. An upstream impoundment did get dredged, and an experiment was conducted to evaluate phosphorus inactivation. A more efficient weed cutting plan was also instituted with existing equipment. Basically, pond management limped along with stopgap measures and limited success.

The enlightenment

Enlightened town staff recognized the problem about a decade later and called for a new comprehensive plan to be developed in a more public fashion. I, and some of the same staff that were involved in 1993, were again chosen to provide that plan. This time we spread the process out over 18 months with frequent joint meetings and discussion among town departments, multiple public presentations, and extensive input from a wide range of groups. In the end, the 2005 (ENSR 2005) plan looked very much like the 1993 plan (Fugro 1993), minus upstream impoundment dredging which had already been accomplished, but had broad public support. All elements were funded through the town meeting process and work commenced in 2007.

A portion of the north basin was dredged again, town bylaws limited actions that caused runoff, more educational efforts were conducted, an effort was made to apply low-impact development techniques, a new and larger harvester was purchased and staff were dedicated to running it under a clear plan of action and priorities, and a phosphorus inactivation system was installed to address storm water inputs to the north basin. Capital expenses were approved and operational budgets were established. By 2009, there was a marked change in both the condition of the pond and the attitude of most citizens toward it. The beach complex became a very popular gathering place and a social and financial asset to the town. In a town survey, the pond was one of the most valued resources. There was a lot of cost involved, but also a lot of benefit.

Harvesting plants has involved focus on the invasive species, with native species largely left as desirable habitat. Yet as the invasive plants dominate the community, a lot of biomass is removed each year. That program has been carefully tracked, and the positive impact of harvesting during the first nine years was documented (WRS 2018). As the harvester aged, however, maintenance issues surfaced and success was elusive in 2016 and 2017. A lot was learned about proper harvester operation and proactive maintenance, and while a new harvester will be needed before long, maintenance enhancement in 2018 restored the success of this program to its typical level (Figure 2).

The combination of dredging the north basin and inactivating phosphorus before it reached the main body of the lake was a big success, although some credit should be given to the reduction of phosphorus in lawn fertilizers that has occurred over the last decade. Yet the concentrations of phosphorus in incoming

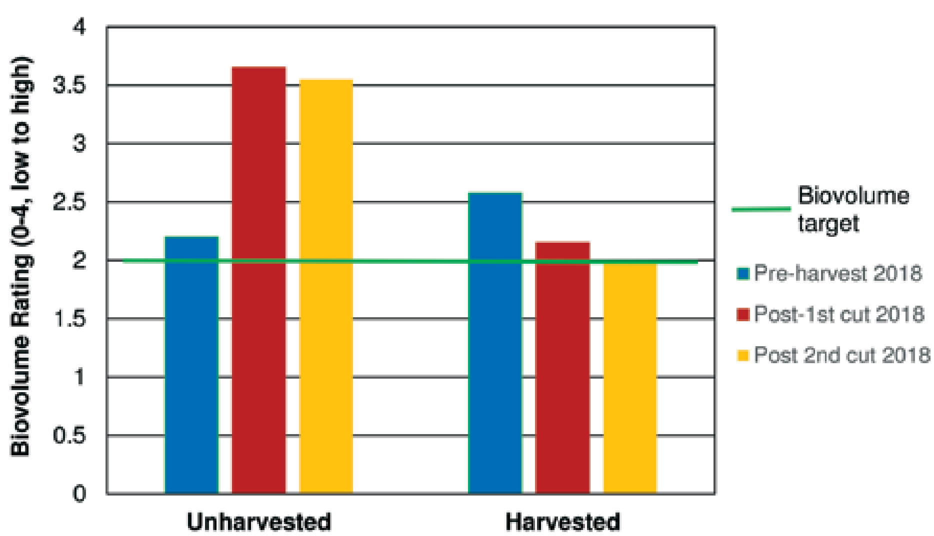


Figure 2. Biovolume comparison in areas with and without harvesting, 2012 and 2016. (Rating scale is in quartiles of the water column filled with plants, with 0=no plants, 1=1-25% filled, and so on, with a management target of <2. Note that not all targeted zones were harvested at the time of surveys)

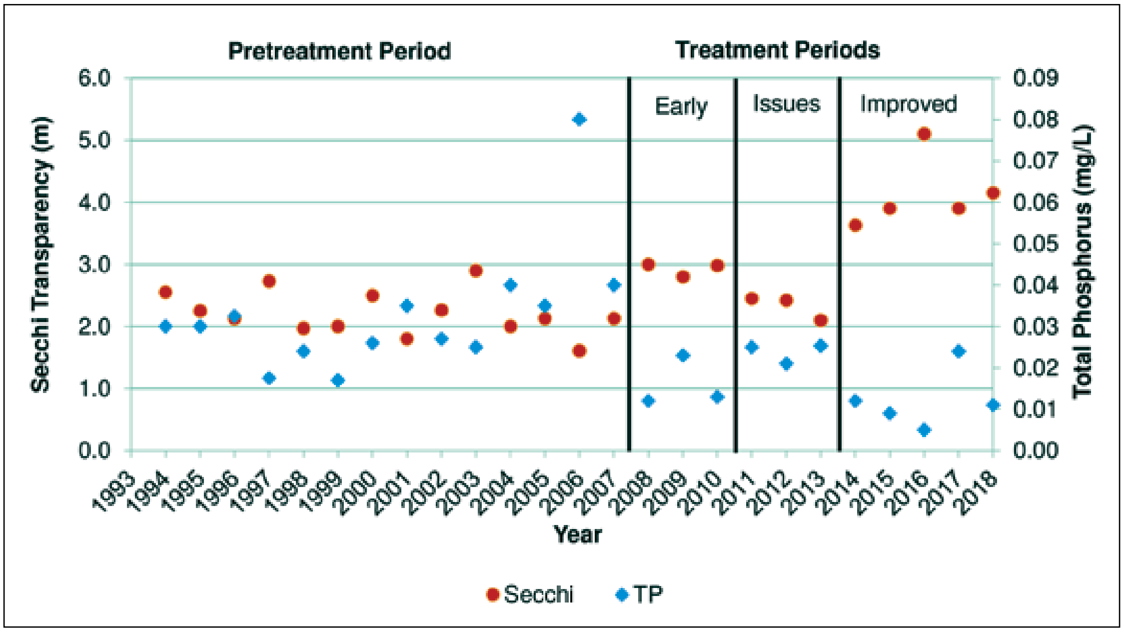


Figure 3. Average summer water clarity and total phosphorus in Morses Pond, 1994-2017.

storm water from an urban drainage area have averaged 130 µg/L in recent years, necessitating inactivation at least in late spring and early summer to prevent algae blooms during the high use season. The inactivation system and detention in the north basin reduced phosphorus in the main body of the lake to <20 µg/L, and with system adjustment over about seven years, further depressed starting summer phosphorus concentrations to <10 µg/L (Figure 3, Wagner 2017). Only one copper treatment was conducted after 2007, that in an especially wet year (2013) when system malfunctions limited our ability to keep up with inputs. Summer Secchi transparency in Morses Pond is high for an urban lake, and cyanobacteria blooms have been avoided in summer.

Yet the phosphorus inactivation system was not an unqualified success from the start. After three years of acceptable but not astounding results with only inactivation in place (prior to north basin dredging), equipment and manpower issues for this manually operated system limited effectiveness in the next three summers. Conditions were not worse than before treatment, but were not significantly better (Wagner 2017, Figure 3). A change in the aluminum chemical applied and focus on the inlets rather than the north basin as the treatment points helped address equipment issues, while automation of the system greatly reduced manpower needs. Dredging was completed in 2013, enhancing detention of treated water in the north basin. From 2014 through 2018, the system has performed admirably and water clarity in Morses Pond has been the best recorded since before 1994 (Figure 3).

Lessons learned

Three lessons stand out over 25 years of involvement in the management of Morses Pond. First, the value of a very public planning project should not be underestimated. Two similar plans were developed about a decade apart, but the first plan had minimal public input and failed to garner the support it needed for complete implementation. The second effort, conducted under a spotlight with a large, participatory audience, was much more successful. This aspect of lake management is often overlooked but is frequently the weakest link in the process.

Second, the value of a well-designed and consistently supported monitoring program should be recognized. Data for water clarity, nutrient concentrations, plant community features, and harvesting effort have all been instrumental in developing management plan elements and tracking progress. Progress needs to be quantified and not left to general opinion, and goals should be established from the start in a form that can be quantitatively evaluated. And when quantifiable goals are not met, the data are often essential to examining the causes and recommending corrective action.

Finally, the importance of realistic expectations and recognition of the potential and realized value of the aquatic resource cannot be overemphasized. The citizens and staff of the Town of Wellesley could have given up on Morses Pond, citing the large urban watershed, much of it outside the town boundary and jurisdiction, and the long history of algae and rooted plant problems as insurmountable obstacles to making the pond meet its designated uses. Vision by town leaders, in and out of positions of authority, successfully countered that attitude and made Morses Pond a wonderful resource that is now a focal point of summer activity.

References

ENSR 2005. Comprehensive Plan for the Management of Morses Pond in Wellesley, Massachusetts. ENSR, Willington, CT

Fugro 1993. Morses Pond Planning Project. Fugro, Northboro, MA.

Wagner K.J. 2017. Phosphorus inactivation of incoming storm water to reduce algal blooms and improve water clarity in an urban lake. *Lake and Reservoir Management*, DOI: 10.1080/10402381.2017.1288669

WRS 2018. Morses Pond Annual Report. Water Resource Services, Wilbraham, MA

Ken Wagner is a Certified Lake Manager with a Ph.D. in natural resource management from Cornell University and over 40 years of experience in lake and watershed management. He has operated Water Resource Services, Inc., since 2010 from his base in Massachusetts.

Nutt Pond: Restoration Challenges in an Impaired Urban Watershed

Ben Lundsted, Robert Robinson, and Jeff Marcoux

Introduction

Nutt Pond (a.k.a. Nutts Pond) is located in a heavily developed urban area of the city of Manchester, New Hampshire. Development includes high-density residential, commercial, and some industrial uses. Surrounded by these urban land uses and their attendant buildings, roads, and other impervious surfaces, Nutt Pond receives excessive amounts of polluted runoff during precipitation events and spring snowmelt. Water quality in the pond has been greatly impacted, and the pond is listed by the State of New Hampshire as impaired for primary contact recreation by chlorophyll-a and other recreational and aquatic life uses. The city of Manchester and project partners, including the State of NH Department of Environmental Services (NHDES) and the U.S. Environmental Protection Agency (EPA), developed a comprehensive watershed restoration plan in 2009, and have been implementing corrective actions in a multi-phased effort to restore Nutt Pond. There have been many challenges to overcome so far. The nature of those challenges has been both technical and logistical. Two significant factors included complications with developing in-lake response models due to the pond's unusually high sediment loading, and limited land availability for treatment practices.

Background

Nutt Pond is a small (16-acre) pond in a 560-acre urban watershed (Figure 1). Currently, the pond is classified as mesotrophic, but it has also been classified as eutrophic in past assessments. It is a natural pond with its elevation raised by a small outlet weir. There are four inlets to the pond with only one being fed by a natural stream known as Tannery Brook at the east inlet. The north, south, and west inlets include closed drainage systems that directly feed the pond with stormwater runoff. The watershed is heavily developed with additional development and redevelopment projects ongoing. There is evidence that water quality began suffering as early as the 1930s, when the city reportedly began

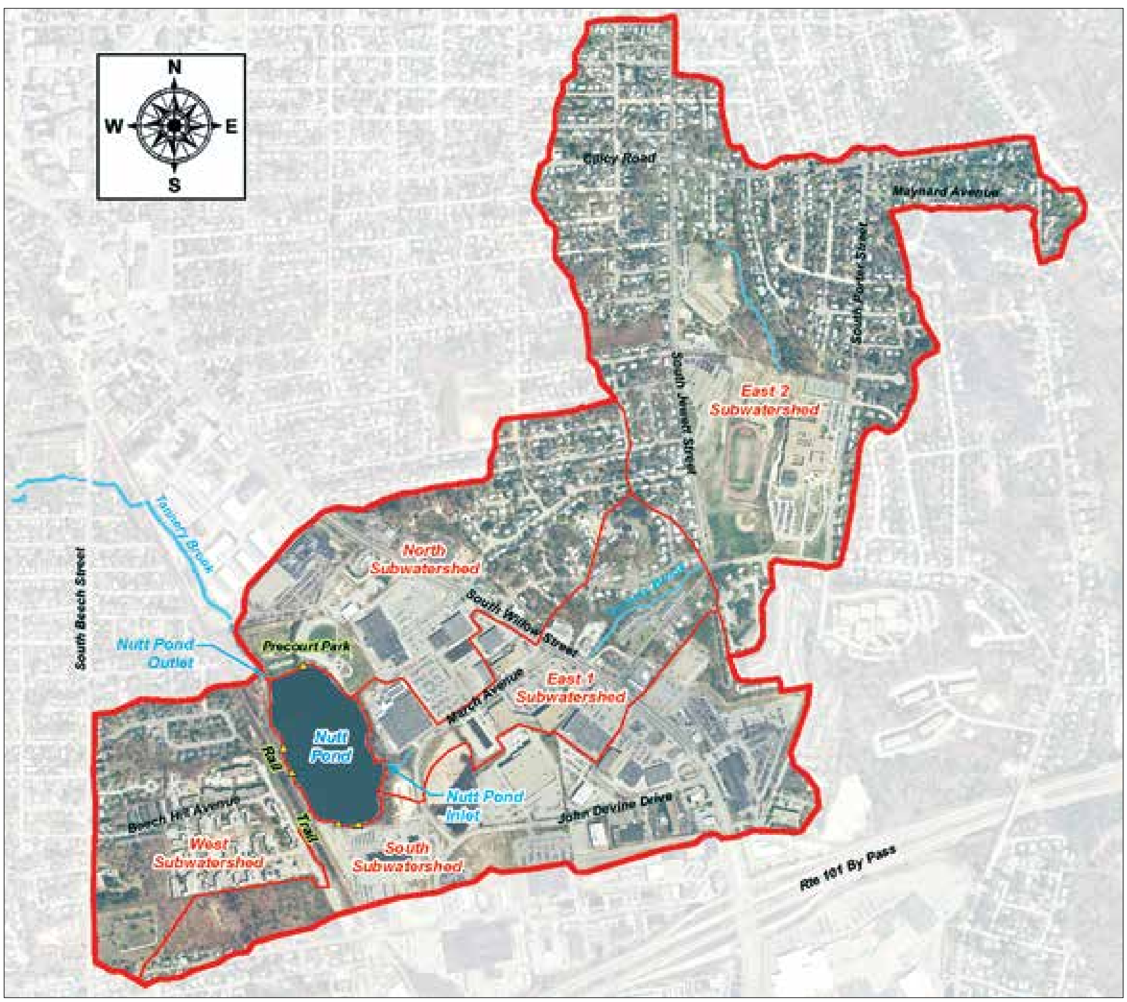


Figure 1, Nutt Pond Watershed map. By Comprehensive Environmental, Inc.

injecting the pond with chlorine to preserve its suitability for swimming (J.R. Slown 1987, as cited in Grindle 2001). The pond was closed to swimming in 1968, and it was later discovered that the pond's bacteria issues were caused by a combined sewer outfall into the pond (Grindle 2001). In 1978, the New Hampshire Sunday News reported that the city's Public Works Director declared the pond a hopeless case, which was "lost forever" (*NH Sunday News* 1978). In that article, city staff identified stormwater as the ultimate cause of the pond's demise, though evidently there wasn't thought to be an alternative to continuing that situation. Since that time, development in the watershed has continued, with this part of the city being its center of retail and other commercial activities.

Watershed plan development challenges

A 2009 Watershed Restoration Plan targeted both sediment and phosphorus reductions as the primary focus for future restoration efforts. The plan included pollutant load modeling and identification of cost effective Best Management Practices (BMPs), both structural and nonstructural, to reduce stormwater runoff loadings throughout the watershed. It was determined that a major source of sediment loading was winter sanding operations, both on municipal roads and commercial parking lots. Thirty percent of the watershed is made up of large commercial properties and 52 percent is high density residential areas so the watershed is very impervious at just over 53 percent.

In 2011, a Total Maximum Daily Load (TMDL) for phosphorus was approved which requires a 70 percent phosphorus reduction totaling approximately seventy kg/year to meet water quality goals. Modeling was completed to compare predicted in-pond concentrations from estimated loadings to actual measured concentrations from historic sampling. Model results predicted that Nutt Pond had an average summer time epilimnion phosphorus concentration of 0.034 mg/L (NHDES and AECOM 2011), while observed mean levels were 0.025 mg/L (NHDES VLAP 2017). The pond has an approximate 40-60 day flushing rate and it is possible that groundwater has a large impact on the overall water balance of Nutt Pond (NHDES and CEI 2009).

The modeled phosphorus loading to the pond was approximately 98 kg/year from stormwater alone and it was predicted that a total phosphorus loading was 105 kg/year. Stormwater alone contributes approximately 510 million gallons of water per year and nearly 94 percent of the total phosphorus loading (NHDES and AECOM, 2011). The TMDL did not target Total Suspended Solids (TSS) or sediment, however, it is predicted that stormwater also contributes over 42,000 kg/year of TSS (NHDES and CEI 2009).

High-density residential areas contribute the highest phosphorus load at approximately 60 percent of the total. Commercial and institutional land uses contribute more than 20 percent and 15 percent, respectively. Models estimate that a phosphorus load reduction target would require treatment for 100 percent of the commercial and institutional areas and nearly 75 percent of the high density residential areas and result in treatment for approximately 250 acres of impervious area.

In order to meet this reduction goal, it is estimated that over 900,000 cubic feet of stormwater treatment volume be provided to meet Water Quality Volume requirements. This estimate is based on providing enough volume to store 1-inch of stormwater over the treated impervious area (NHDES and CEI 2008). BMPs sized for the 1-inch Water Quality Volume are typically between 60 percent and 65 percent effective at removing phosphorus (NHDES and CEI 2008), so in order to effectively remove 100 percent of the 70 kgs, the provided treatment volume would need to increase by a factor of 1.7 and result in 1.5 million cubic feet of storage required for this watershed. This would be like providing a two-foot deep BMP approximately 17 acres in size and would correlate to requiring enough space to total 10 percent of the available land owned by the city in the watershed. A BMP of this size would equal the surface area of Nutt Pond.

Implementation of the watershed plan

Beginning concurrently with the watershed planning effort, and continuing since that time, several phases of stormwater BMP implementations have been completed. While the types of treatment practices are varied, their intended functions are similar: to reduce, capture, or treat the sediment, nutrients such as phosphorus, trash, and other debris contained in stormwater runoff before it reaches the pond (Figure 2).

Figure 2. Sediment and debris accumulation in the East Inlet, Tannery Brook, forebay. Photo courtesy of Comprehensive Environmental, Inc. 2010.

The early implementation phases involved capitalizing on existing stormwater outfalls that were channeling stormwater into the pond, by adding treatment at those locations. This included adding settling basins and trash skimmers, sediment forebays, level spreaders (Figure 3), and enhancing existing degraded treatment wetlands to the east (Figure 4), north and south inlets. Outreach to commercial properties promoted winter parking lot sanding reductions to reduce loadings. In 2010, the city continued its watershed restoration efforts by addressing an unstable segment of Tannery Brook. This segment experienced loss of natural vegetated buffers and intrusion into the floodplain. High impervious cover in the watershed increased runoff velocity which caused channel erosion and contributed large sediment volumes to Nutt Pond. Removal of accumulated sediment and debris, installation of a sediment control chamber, and structural stabilization of this stream segment has greatly reduced sediment output.

The most recent BMPs were completed in 2016 and included installation of a bioretention cell, tree box filters, porous pavement, and replacement of the eroded boat ramp (Figure 5). A second public education kiosk was installed near a busy recreational walking trail to highlight NPS pollution issues and restoration efforts (Figure 6). Additionally, the city addressed stormwater runoff from residential areas at the west inlet by installing a settling basin and gravel wetland treatment train (Figure 7).

Figure 3. East Inlet, Tannery Brook, sediment forebay and level spreader shown immediately following construction, prior to revegetation. Photo courtesy of Comprehensive Environmental, Inc. 2006.

Figure 4. South Inlet, March Avenue, forebay and enhanced wetland. Photo courtesy of Comprehensive Environmental, Inc. 2010.

Land constraints: Making space for treatment practices

Prior to 2016, the treatment practices were mostly contained to undevelopable land including stream channels and wetlands. Most of these required easements with private property partners. The only other BMPs constructed were revisions to existing developed areas such as the city-owned parking lot and boat ramp. Land constraints in the watershed have been an ongoing challenge for planners and are highlighted by the issues that arose during planning and construction of the gravel wetlands at the west inlet. Runoff flowed in a poorly defined channel through a small forested area before crossing under the former Manchester & Lawrence Railroad corridor's paved rail trail. Stormwater flowed under the trail through undersized culverts that were chronically full of debris and sediment. In storm conditions, the trail's ditch line sometimes exceeded capacity, overtopping the trail, causing shoreline erosion, and undercutting the pavement.

At the project's outset, it was thought that the subject property was owned by the city, and that they would have the authority to construct the BMPs. The initial design preserved the 16-foot-wide rail trail, but otherwise occupied the subject area with a series of gravel wetlands. However, it was later discovered that the property had been transferred to the NH Department of

Figure 5. The improved boat ramp, one of four settling basins, and a tree box filter at Precourt Park. Photo courtesy of Comprehensive Environmental, Inc. 2016.

Figure 6. Outreach signage explaining the West Inlet gravel wetland's purpose and function. The sign is located near an access route to the pond and the rail trail. Photo courtesy of Comprehensive Environmental, Inc. 2016.

Transportation (NHDOT) Bureau of Rail and Transit at some earlier date. The 99-foot wide rail right-of-way (ROW) occupied the majority of the land that was thought to be available for BMP construction. As a result, the city needed to partner with NHDOT. The partnership included review and approval of BMP plans and to obtain permission for the city to lease the land. Since leases of State property typically incur lease payments, NHDES and NHDOT had to prepare a waiver justification, and petition the State's Long Range Capital Planning and Utilization Committee to waive those fees.

NHDOT also required flexibility for future ROW reversion back to rail if the need arises. This need conflicted with construction of the large-scale gravel wetland treatment practice as planned. At NHDOT's request, the treatment practice was scaled back and redesigned so that only the final wetland cell was in the NHDOT ROW and it could potentially be abandoned and filled to accommodate future rail use while allowing the rest of the BMP to continue to function at a reduced capacity (Figure 8).

These reconfigurations pushed the area of construction away from the rail corridor, but caused encroachment upon a power pole located in a utility ROW. The city then had to coordinate relocation of a power pole with its owner, and obtain permission from the ROW owner for construction of the redesigned BMP. Additionally, the rail trail could not be used to access the BMP for maintenance, so a separate access road had to be constructed across a private residential apartment complex property. This necessitated another easement, and installation of a recreational access path to meet that property owner's needs.

Conclusion

The comprehensive watershed restoration plan has provided a long-term roadmap that the city is using to guide their way to watershed improvements.

Stormwater modeling highlighted the difficulties of providing effective stormwater treatment in heavily developed urbanized areas. It was concluded that targeted reductions essentially required complete elimination of any non-naturally occurring pollutant input to the waterbody, which is likely unachievable. Less than 5 percent of the watershed remains natural, making these areas important to protect. The restoration plan also highlighted the lack of open and available space to provide effective stormwater treatment for improved water quality.

BMP siting and selection became one of the biggest hurdles for planners based on 83 percent of the watershed being privately owned with minimal unused space. The city owns several schools in the upper watershed and two large recreational parks totaling 95 acres. These areas became the focus for siting potential treatment locations and BMP designers had to effectively balance the intended use of the property with BMP efficiency. In locations where it was possible, publicly owned property was used to build BMPs which enhance treatment within existing drainage. When those options were exhausted, the project proponents found common interests and built partnerships across organizations to allow for BMP construction while providing mutual benefits for all involved parties.

While there were many puzzle pieces involved, and many partners needed to come to the table, the resulting BMPs provide pollutant load reductions to benefit the pond (Table 1) as well as improved drainage conditions and access that provide additional benefits for everyone involved.

While there is still no swimming in the pond, it is frequently used by anglers and paddlers and there is an improving trend in phosphorus and chlorophyll-a (NHDES 2017a). The dissolved oxygen concentration impairment was removed on the 2016 305(b) report (NHDES 2017b). Other monitored parameters have had variable results with no evident trend, though chlorides are significantly elevated and showing a worsening trend. While the watershed appears to be fully built-out at this point, the watershed continues to see redevelopment of existing sites into various other high density uses. Due to the highly impervious nature of the watershed, it's unlikely that Nutt Pond will ever be truly "fully restored," but ongoing efforts have stabilized water quality degradation and additional controls such as proper redevelopment and enforcement of stormwater controls will lead to future water quality improvements.

Figure 7. West Inlet gravel wetland cells shown shortly after construction. Photo courtesy of Comprehensive Environmental, Inc. 2016.

Figure 8. Final cell of the west inlet gravel wetland. This final cell is designed to be sacrificed if the land is needed to reestablish the rail corridor. Photo courtesy of Comprehensive Environmental, Inc. 2018.

References

Grindle, Art. 2001. *Manchester Urban Ponds Restoration Program: Year 1 Report,* 23-27.

McQuillen, Maurice. 1978. Nutt's Pond 'Lost Forever.' *New Hampshire Sunday News.*

New Hampshire Department of Environmental Services (NHDES). Volunteer Lake Assessment Program Individual Lake Reports. 2017a. Retrieved from https://www.des.nh.gov/organization/divisions/water/wmb/vlap/annual_reports

New Hampshire Department of Environmental Services (NHDES). 2016 Section 305(b) and 303(d) Surface Water Quality Assessments. 2017b. Retrieved from https://www.des.nh.gov/organization/divisions/water/wmb/swqa/index.htm

New Hampshire Department of Environmental Services (NHDES) and AECOM. 2011. Total Maximum Daily Load for Nutt Pond, Manchester, NH. Retrieved from https://www.des.nh.gov/organization/divisions/water/wmb/tmdl/documents/nutt-pond.pdf

New Hampshire Department of Environmental Services (NHDES) and Comprehensive Environmental, Inc. (CEI). 2009. Nutt Pond Watershed Restoration Plan. Retrieved from: https://www.des.nh.gov/organization/divisions/water/wmb/was/documents/nutt_pond_wbp.pdf

New Hampshire Department of Environmental Services (NHDES) and Comprehensive Environmental, Inc. (CEI). 2008. New Hampshire Stormwater Manual, Volume 1, Stormwater and Antidegradation. Retrieved from: https://www.des.nh.

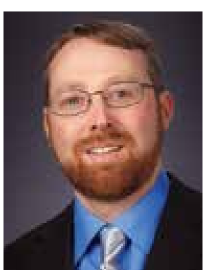
Table 1. Sediment Removal in Cubic Yards as Tracked by City Staff Who Periodically Clean the Sediment Capturing BMPs.*

Nutt Pond Sediment Removals (cu. yd.)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Totals
East (Tannery Bk.) Inlet Forebay	8.0	55.0	50.0	20.0	60.0	25.0	90.0	105.0	50.0	25.0	5.0	493.0
North Inlet (Precourt Park) Baffle Tank	20.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	1.0	24.0
South (March Ave.)Inlet Baffle Tank	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South (March Ave.) Inlet Forebay	000	0.0	0.0	0.0	144.0	120.0	200.0	75.0	0.0	0.0	1.5	540.5
Woodgate Court DS Catch Basin	Constructed 2010			0.0	0.5	0.5	0.5	0.5	0.5	0.0	0.5	3.0
Woodgate Court DS Drain Manhole	Constructed 2010			4.0	1.0	2.0	2.5	2.5	2.0	0.0	1.0	15.0
Tannery Brook Stream stabilization	Constructed 2010			4,500.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,500.0
Total to date	28.0	55.0	50.0	4,524.0	205.5	148.5	293.0	183.0	52.5	27.0	9.0	5,575.5

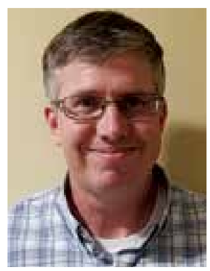
*Years shown as "0.0" indicate that the BMP was not cleaned that year. BMPs completed in 2017 will be cleaned and their removals tracked in future years. Modeling indicates that the West Inlet BMP should achieve reductions of 8.2 kg./yr. phosphorus, and 12,000 kg./yr. sediment.

gov/organization/divisions/water/stormwater/manual.htm

New Hampshire Department of Environmental Services (NHDES) and Comprehensive Environmental, Inc. (CEI). 2008. New Hampshire Stormwater Manual, Volume 2, Post-Construction Best Management Practices Selection and Design. Retrieved from: https://www.des.nh.gov/organization/divisions/water/stormwater/manual.htm



Ben Lundsted, P.E., is Principal, Environmental Engineer, at Comprehensive Environmental, Inc. Ben is a University of New Hampshire engineering graduate and professional engineer in the State of NH with 19 years of experience in transportation and environmental engineering. He has worked on several watershed restoration and water supply protection projects throughout New England with a focus on design, permitting and implementation of structural stormwater Best Management Practices. He is a resident of Deerfield, NH, and works in Merrimack, NH.



Robert J. Robinson, P.E., is a Wastewater Treatment Plant Superintendent with the city of Manchester, Environmental Protection Division. His duties include administration of the city's Wastewater Treatment Plant and project management. Mr. Robinson is a Registered Professional Engineer in New Hampshire with a B.S. in civil engineering from the University of Massachusetts, Lowell and a M.S. in project management from Granite State College.

Jeff Marcoux is Watershed Supervisor at the NH Department of Environmental Services, Watershed Assistance Section. A lifelong resident of New Hampshire, Jeff graduated from the University of New Hampshire with a degree in water resource management, and has worked for NHDES for more than 15 years. At NHDES, Jeff is responsible for helping local stakeholders achieve successful watershed plan development, and nonpoint source pollution remediation projects.

UPCOMING IN *LAKELINE* –

LakeLine Spring 2019:

NALMS student member issue! Graduate students are invited to submit articles outlining their ongoing studies on lakes and watersheds.

LakeLine Summer 2019:

The summer issue will focus on updates on cyanobacteria and harmful algal bloom concerns, so articles are being requested to support this theme.

LakeLine Fall 2019:

The fall issue will focus on source water protection.

Going the Distance **Along Dover's Berry Brook**

James Houle, Ph.D., CPSWQ, CPESC and Dolores Jalbert-Leonard

Practical Urban Stormwater Management

In 2006, Berry Brook became famous for the wrong reason: It was deemed "impaired" by the United States Environmental Protection Agency (USEPA). A good chunk of the watershed surrounding this short, hardworking urban stream was covered by impervious surfaces that channeled polluted stormwater runoff into the brook for decades.

Berry Brook flows through the urban heart of Dover, New Hampshire, extending from the city's Miracle Mile through one of its older neighborhoods before joining the Cochecho River, a major tributary of Great Bay. More than 30 percent of this short brook's 185-acre watershed includes paved roads, parking lots, and buildings. Stormwater runoff travels over this hardened landscape, picking up pollutants such as lawn fertilizer, pet waste, smog-related pollution, sediments, heavy metals, oil, and road salt, and washes them into the brook.

Today, Berry Brook is famous again. Now it is as a model for how scientists, engineers, and public works departments can collaborate to improve water quality in challenging urban settings. Low Impact Development (LID) retrofits designed to mimic natural hydrology, stream restoration, community outreach, persistence, and some good old fashioned ingenuity were all involved in this complicated restoration process.

Partnering for water quality improvement

In 2007, the University of New Hampshire Stormwater Center (UNHSC) partnered with the city of Dover's Department of Public Works and Utilities (DPW) with funding assistance from the New Hampshire Department of Environmental Services (NHDES) to implement approaches to filter and reduce stormwater runoff. The partnership resulted in in many deliverables, including:

- the installation of 25 LID retrofits including 12 bioretention systems;
- a tree filter;
- a subsurface gravel wetland;
- a standard wetland;
- day-lighted and restored 1,500 linear feet of stream at the headwaters and 500 linear feet of stream at the at the confluence;
- three grass-lined swales;
- two subsurface gravel filters; and
- an innovative filtering catch basin design that has been installed in three different locations (Figure 1).

The stormwater retrofits implemented in the Berry Brook watershed reduced the impervious cover percentage in the watershed from 30 percent to just under 10 percent. Sampling and modeling efforts show that these controls remove more than 19 tons of sediment, 710 lbs. of nitrogen, and 127 lbs. of phosphorus annually from the stream and drainage area. Additionally, LID approaches significantly reduced runoff volume and flooding (Figure 2).

Some of the Berry Brook LID retrofits were based on traditional designs tested at UNHSC's field site and proven for their ability to treat water quality and reduce runoff. Others were re-invented by city staff to decrease cost and reduce operation and maintenance burdens. The ability for city staff to reinvent and adapt stormwater Best Management Practices (BMPs) was critical to the success of the project and involved the direct participation of respected staff like Bill Boulanger, Superintendent of Public Works and Utilities for the city.

Through this give-and-take design process, Dover and UNHSC were able to tackle three fundamental challenges associated with municipal adoption of LID: compatibility, complexity, and "trialability," or, in other words, does the design fit the municipal management culture, can people understand it, and can local staff adapt the design for greater utility? It seems logical for trusted municipal officials to experiment with traditional LID designs to adapt seemingly complex configurations into forms more readily understood and embraced.

This project underscored the benefits of adapting "text book," research-based LID designs with what is practical and realistic for public works departments working in highly urban settings. Sharing lessons learned about how to do this is an important step toward helping other communities adopt LID strategies to manage stormwater. Many communities in the region now look to Dover as the leader in LID innovation and implementation. Their story and experience is powerful for local DPW staff working on the ground to manage stormwater.

Sometimes, when its "pouring buckets," the Town of Dover's superintendent (Bill Boulanger) will drive over to the Berry Brook watershed to see how the stormwater systems handle the deluge. He is satisfied with their construction and performance and

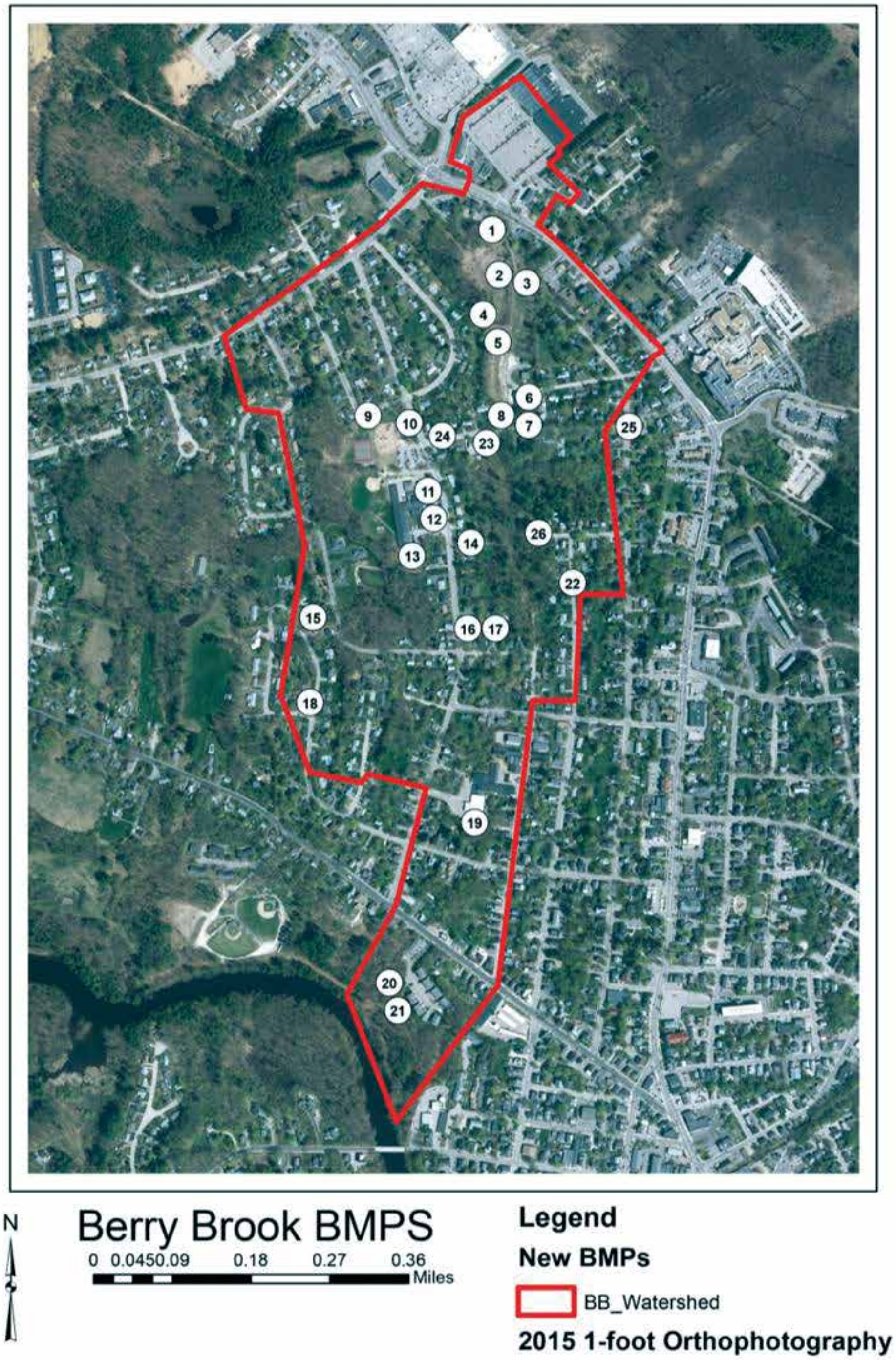


Figure 1. An innovative filtering catch basin design that has been installed in three different locations.

the systems have made a believer out of him. High praise from a self-defined "construction guy" whose pragmatic, resourceful attitude as superintendent has set the tone for the City's Department of Public Works and Utilities for over 25 years.

Dover makes LID work for them

In public organizations, decisions to adopt new technologies like LID often rely on the construction phase where traditional designs are re-invented to better suit the community. When he first began to work with stormwater in the Berry Brook watershed, Boulanger acknowledged it was challenging to make traditional LID approaches work for Dover. The designs, and concepts that make LID effective in treating water quality, were new for him, his staff, and the contractors they worked with – and they were skeptical. Additionally, the costs seemed high and Boulanger wondered if there were simpler ways to achieve the same benefits of traditional LID.

Maintenance was Boulanger's major concern. After installing several traditional LID installations, he noted that rain gardens and porous pavements could routinely collect a lot of silt and debris that would be difficult to manage for a busy DPW. To address these maintenance concerns, Boulanger worked with UNHSC's engineers to reinvent LID technologies to suit the city's operational capacity; for example, rain gardens were outfitted with deep sump catch basins to hold water and collect silt, making maintenance easier. Planted rain gardens were replaced with grasses that could be easily mowed and maintained. Porous asphalt was replaced with easily maintainable subsurface gravel filters. These adaptations were then installed and monitored to show effectiveness at treating stormwater and reducing runoff volume.

Reinvention leads to adoption

Some LID stormwater options, such as porous asphalt, were simply off the table due to critical barriers. Lacking equipment to maintain a porous asphalt system, the city developed the "Boulanginator," a system that mimics porous asphalt features through subsurface storage and filtration connected to easily maintainable catch basins (Figure 3). Underground, the system looks like a typical porous pavement design; however, the surface is paved with normal dense mix asphalt, but stormwater moves through the system via a hydraulic inlet and outlet controlled by perforated inlets and under-drains. The system was monitored over the period of five months and results can be seen in Figure 4. Not only was this system effective at improving water quality through filtration, sedimentation, and infiltration, the system exceeded performance expectations having never reached capacity despite treating four rain events larger than the design storage (1 inch of rainfall).

Boulanger and his crews were also able to use leftover materials from other projects to build it – special materials and equipment were not needed. They also timed installations to coordinate with other infrastructure upgrades to save

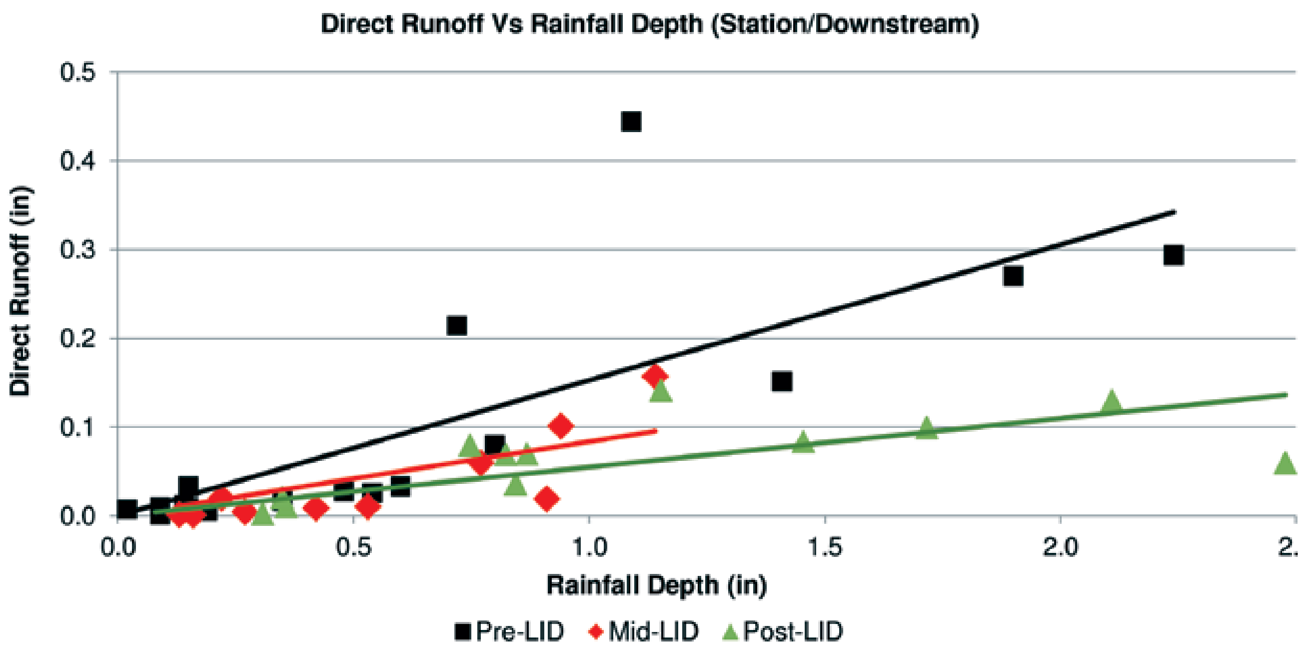


Figure 2. Low Impact Development (LID) approaches significantly reduced runoff volume and flooding

Figure 3. The "Boulanginator," a system that mimics porous asphalt features through subsurface storage and filtration connected to easily maintainable catch basins.

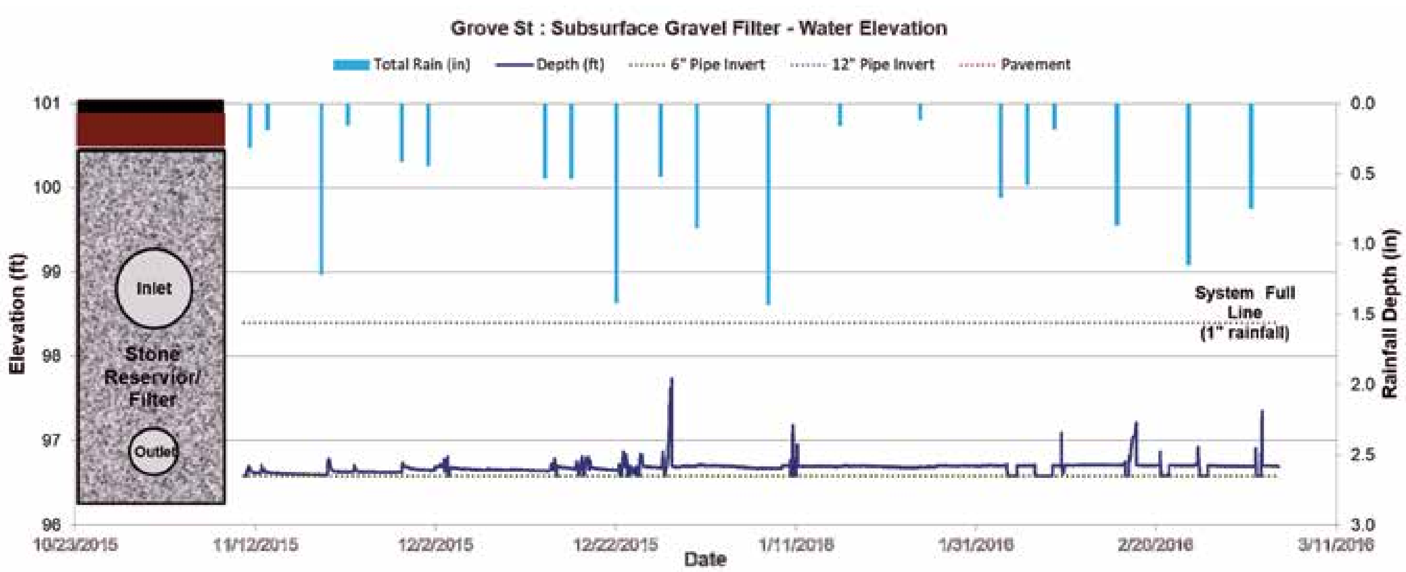
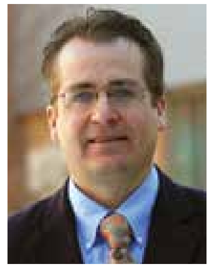


Figure 4. Results of monitoring the system over the period of five months.

money and time and minimize public disturbance.

This process of re-invention underscores another key to successful wide scale LID implementation: to get municipal buy-in, maintenance considerations should dictate design. Maintenance and maintainability of stormwater controls is the ultimate predictor of performance, not necessarily the system itself. That is, if a system is not maintained, regardless of what it is, it is not going to function long-term.

For Dover's Berry Brook, ten years and 25 LID systems later, it's well on its way to a clean bill of health. Perhaps even more importantly, Boulanger and his colleagues have changed how they approach stormwater across the city – Boulanger's low-cost LID adaptations are now go-to stormwater management tools adopted for use throughout the city. The next challenge is to take the Berry Brook message to other communities to show other DPWs how to make LID simple, cost-effective, and easy to maintain.



James Houle is program manager at The UNH Stormwater Center, Department of Civil and Environmental Engineering, University of New Hampshire. For more information, he can be reached at Phone: 603-862-1445, or email: James.Houle@unh.edu.

Dolores Jalbert-Leonard is a trincipal at Roca Communications.

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Intense Cyanobacteria Blooms Spur **New Approach to an Established Plan**

Mark Mitchell, Laura Dlugolecki, Perry Thomas, and Angela Shambaugh

Severe cyanobacteria (blue-green algae) blooms in a Vermont lake recently caused managers in the state's Department of Environmental Conservation (DEC) to revisit their planned approach toward restoration. Blooms in Lake Carmi in Franklin, Vermont, started mid-summer and continued late into the fall of 2017, bringing recreation to a halt (Figures 1 and 2). Though cyanobacteria blooms have been common on this lake, the 2017 event was particularly intense.

Figure 1. Boaters on Lake Carmi. Image by Larry Myott.

Figure 2. The start of the fall 2017 cyanobacteria bloom, as viewed from North Beach. Image by Misha Cetner.

About Lake Carmi

Located in northwestern Vermont near the Canadian border, Lake Carmi has a surface area of 1,402 acres, a maximum depth of 33 feet, mean depth of 13 feet, and total basin area of 7,710 acres (Figures 3 and 4).

Extensive restoration work had already been accomplished in Lake Carmi's watershed, prior to the headline-grabbing algae blooms of 2017. In 2009, the U.S. Environmental Protection Agency approved a Phosphorus Total Maximum Daily Load (TMDL) plan for Lake Carmi (VTDEC, 2008), and DEC began collaborating with the Franklin Watershed Committee and other regional partners to reduce phosphorus loading from the watershed.

In 2015, partners working in the watershed formed the Lake Carmi Implementation Team (LCIT) to accelerate progress, bringing clean water actions prescribed by the 2015 Vermont Clean Water Act to Franklin as soon as possible (VTDEC 2016).

Watershed and in-lake sources of phosphorus

Weather and monitoring data help tell the story of the intense, prolonged

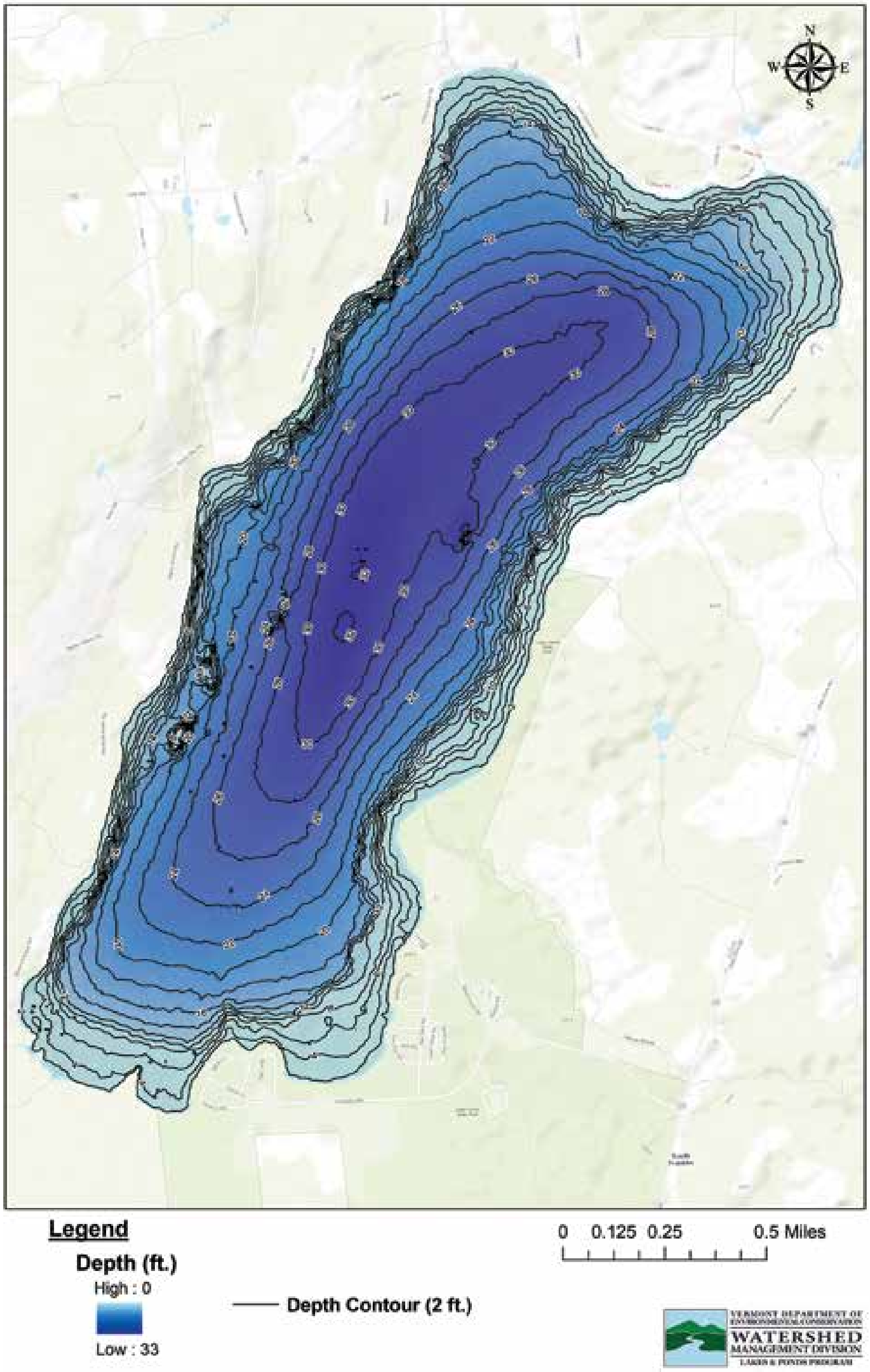


Figure 3. Bathymetric map of Lake Carmi, Franklin, Vermont.

cyanobacteria bloom of 2017. Unusually high levels of rainfall in late spring and early summer increased inputs of phosphorus from the watershed through runoff and erosion (i.e., external loading), feeding early summer algal blooms.

Some community members blamed manure spread during the early spring; however, inputs from other sources across the watershed, including poorly maintained private roads, also likely contributed to the increase in phosphorus to the lake. Subsequently, typical summer stratification led to a lack of mixing in the hypolimnion and depletion of oxygen from biological activity there. Under these conditions, legacy phosphorus was released from sediments along the lake bottom and built up in the hypolimnion (i.e., internal loading).

Unusually cool temperatures for a short period in late August 2017, combined with stiff breezes, caused early mixing of the lake layers. This occurrence resulted in entrainment of phosphorus from the lake bottom to the surface, providing a nutrient bonanza for cyanobacteria already thriving in the lake. An extended period of unusually warm and calm weather from September into November prolonged the cyanobacteria bloom right through the typical fall lake turnover period. Temperature and oxygen profiles indicated that weak stratification re-formed during this period, following the late August mixing event (Figures 5 and 6). This resulted in another smaller phosphorus pulse when temperatures dropped in mid-October, causing mixing again (Figure 7).

Why the worry?

Obviously, Lake Carmi is still showing signs of impairment, despite watershed efforts to reduce nutrient loads. While high phosphorus levels are a concern for overall lake health, expansive and persistent cyanobacteria blooms are a concern for aquatic and human health.

Cyanobacteria blooms can affect humans, animals, and the overall lake environment. Some cyanobacteria can produce potent toxins – called cyanotoxins – that may cause stomach upset, tingling/numbness, or sometimes more severe responses. Children and pets are at higher risk, since they may drink water while swimming and playing; therefore, beaches are closed when cyanobacteria blooms are present and pet owners are warned to keep dogs away from the water. There may be other, long-term health effects associated with exposure to these toxins as well (USEPA 2017). Other compounds produced by cyanobacteria can cause skin irritation and allergic responses. Severe blooms lead to oxygen depletion in lake waters that can threaten fishes and other water-dwelling wildlife.

What's the fix?

The Vermont DEC typically prioritizes protection, restoration, and remediation activities in the watersheds of lakes with nutrient TMDLs. Some load reductions, as mentioned earlier, were already implemented in the watershed of Lake Carmi over time (Figure 8). In-lake

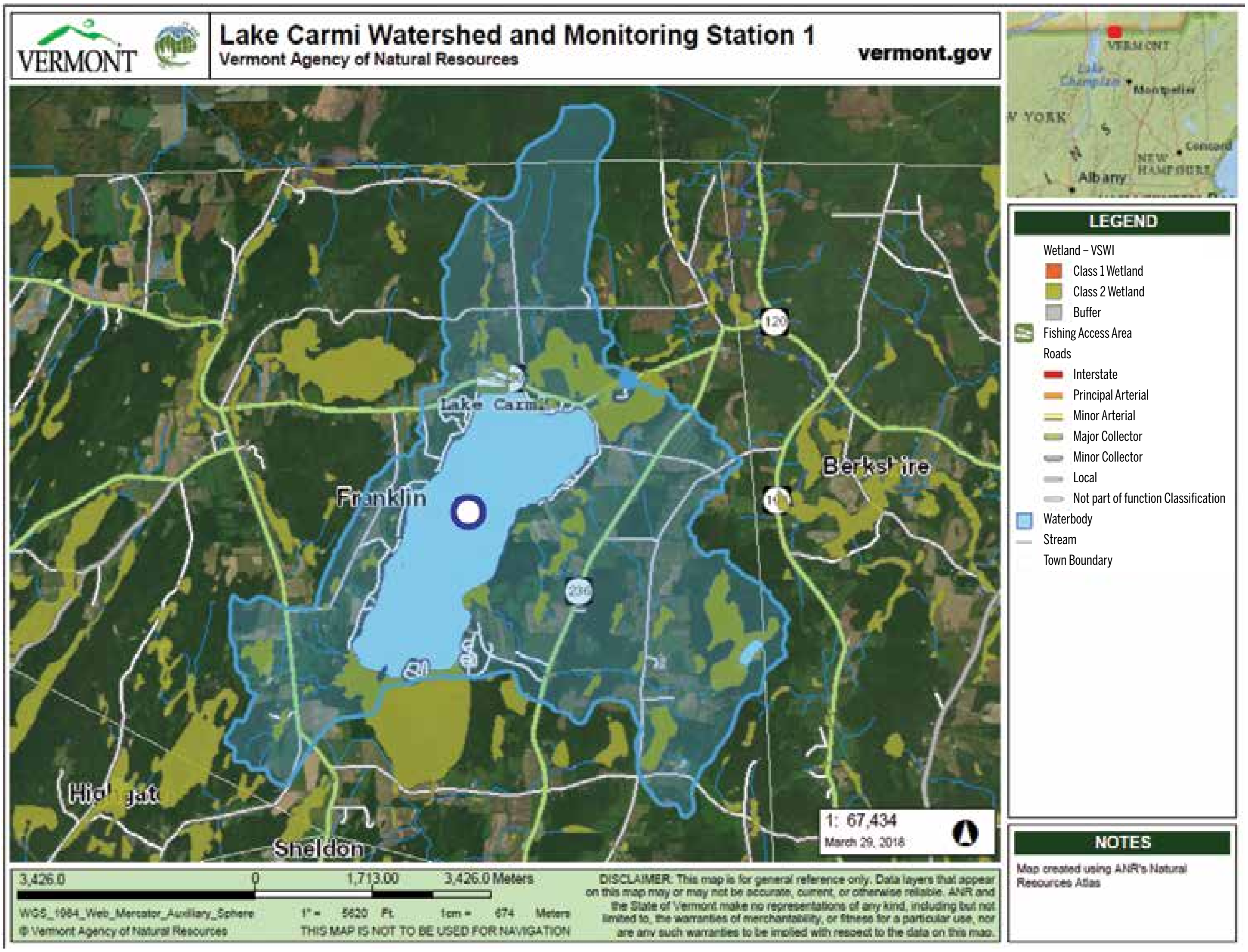


Figure 4. Location of monitoring "Station 1" on Lake Carmi and its watershed.

management options to reduce internal loading are costly and considered only when watershed-based efforts to reduce external loading have made sufficient progress; otherwise, in-lake controls may be overwhelmed by continued watershed loading. In the case of Lake Carmi, however, the intense prolonged cyanobacteria and the potential human health risks associated with them have made reducing their occurrence a priority.

In-lake management efforts will be deployed in 2019 with the intent of providing more immediate relief for the lake community, while DEC and the greater community continue to work within the watershed and along the shoreline to meet long-term water quality goals. Given the ongoing, concerted effort in the Lake Carmi watershed to address external loading of phosphorus and data showing that internal loading is a significant driver of the blooms, DEC has initiated plans to install an in-lake treatment system.

Water quality data have been collected on Lake Carmi for 40 years. Dissolved oxygen concentrations near the bottom sediments have routinely been observed at or near zero, indicating anoxic conditions in the hypolimnion that result in the release of phosphorus (Nygren et al. 2017), providing fuel for cyanobacteria blooms.

Bring in the oxygen

Over the past year, DEC carefully weighed the pros and cons of different approaches to in-lake management for mitigating intense cyanobacteria blooms in Lake Carmi, and decided to pursue whole-lake aeration. The primary benefit of the proposed aeration method (artificial circulation) is that it would prevent accumulation of phosphorus in the bottom layer by keeping the lake waters mixed and higher in oxygen concentration during the summer months. Modeling conducted by consultants shows that aeration should prevent development of an anoxic layer and prevent accumulation of phosphorus in the lowest layer, thereby reducing internal loading of phosphorus. Secondarily, artificial circulation creates physical conditions that discourage cyanobacteria growth by encouraging growth of diatoms and algae that do not produce cyanotoxins (Bormans et al. 2015).

Inherent risks

There may be drawbacks of aeration in Lake Carmi, including potentially:

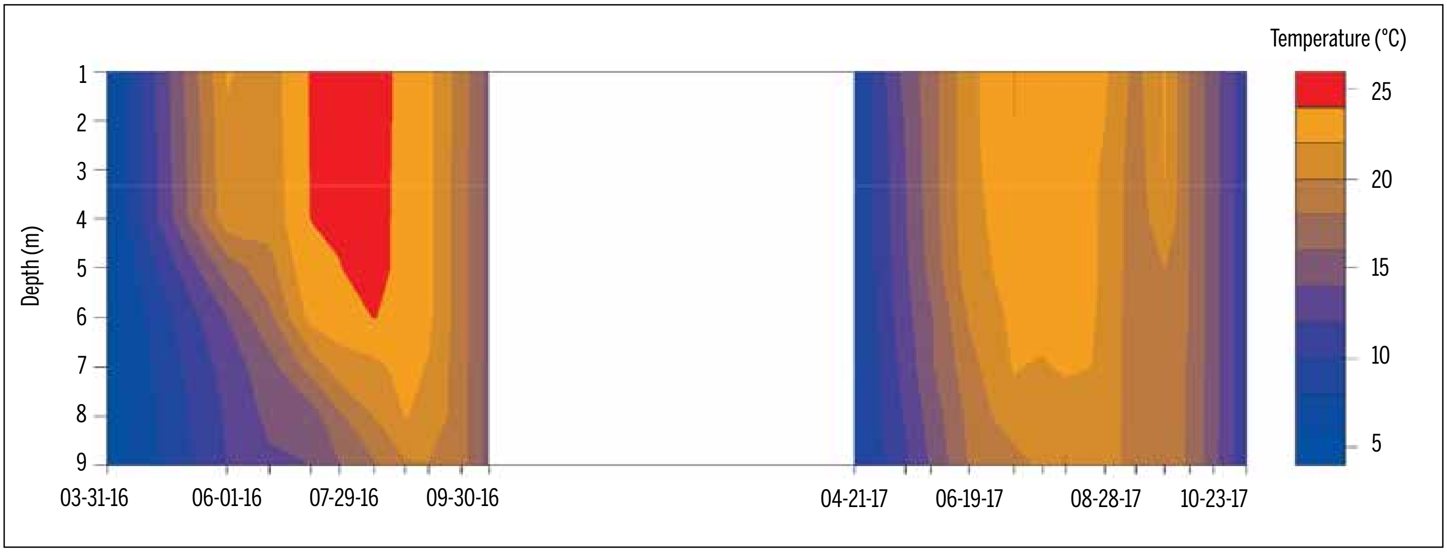


Figure 5. Comparison of temperature profiles for 2016 and 2017.

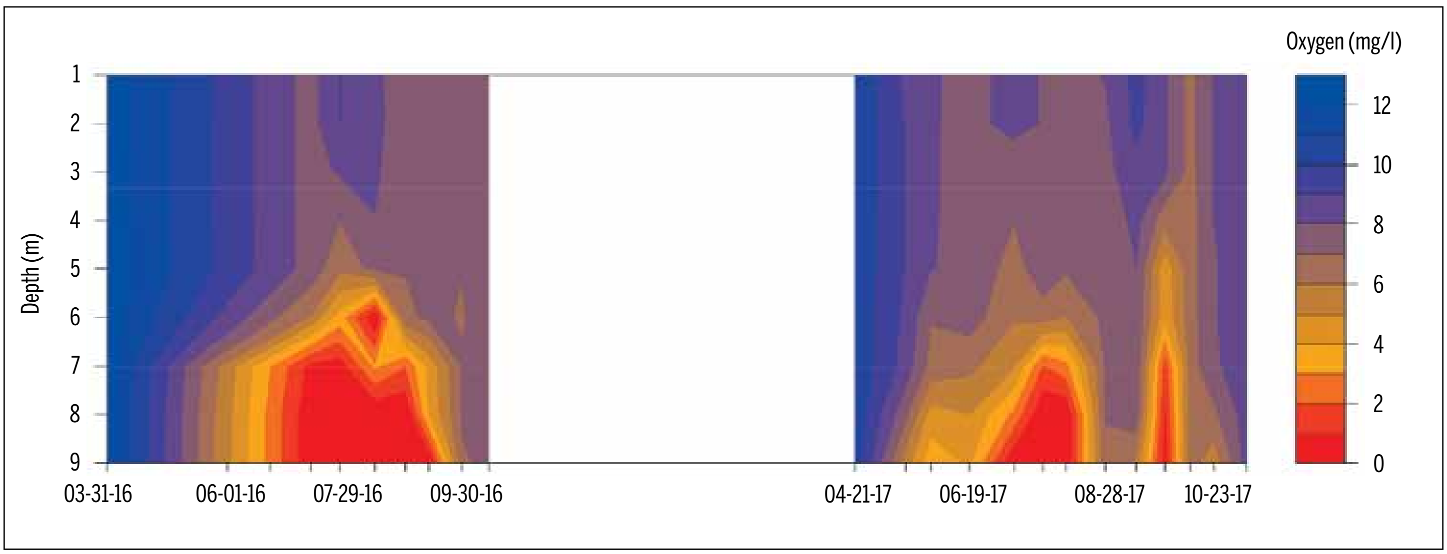


Figure 6. Comparison of dissolved oxygen profiles for 2016 and 2017.

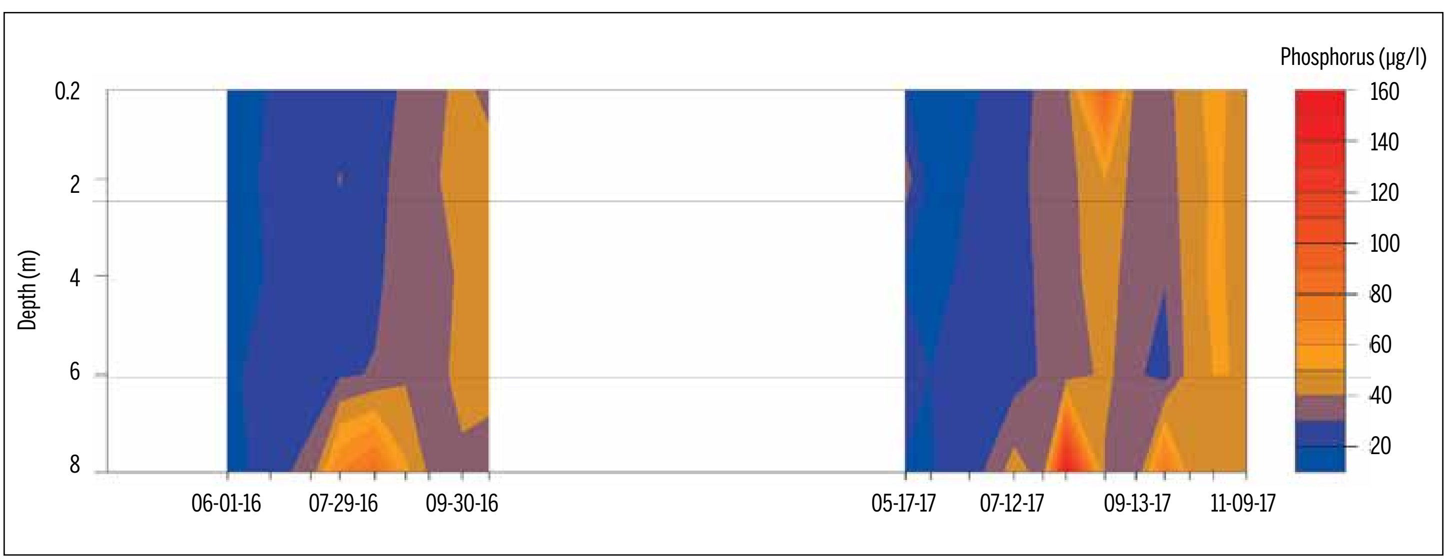


Figure 7. Comparison of total phosphorus concentrations for 2016 and 2017.

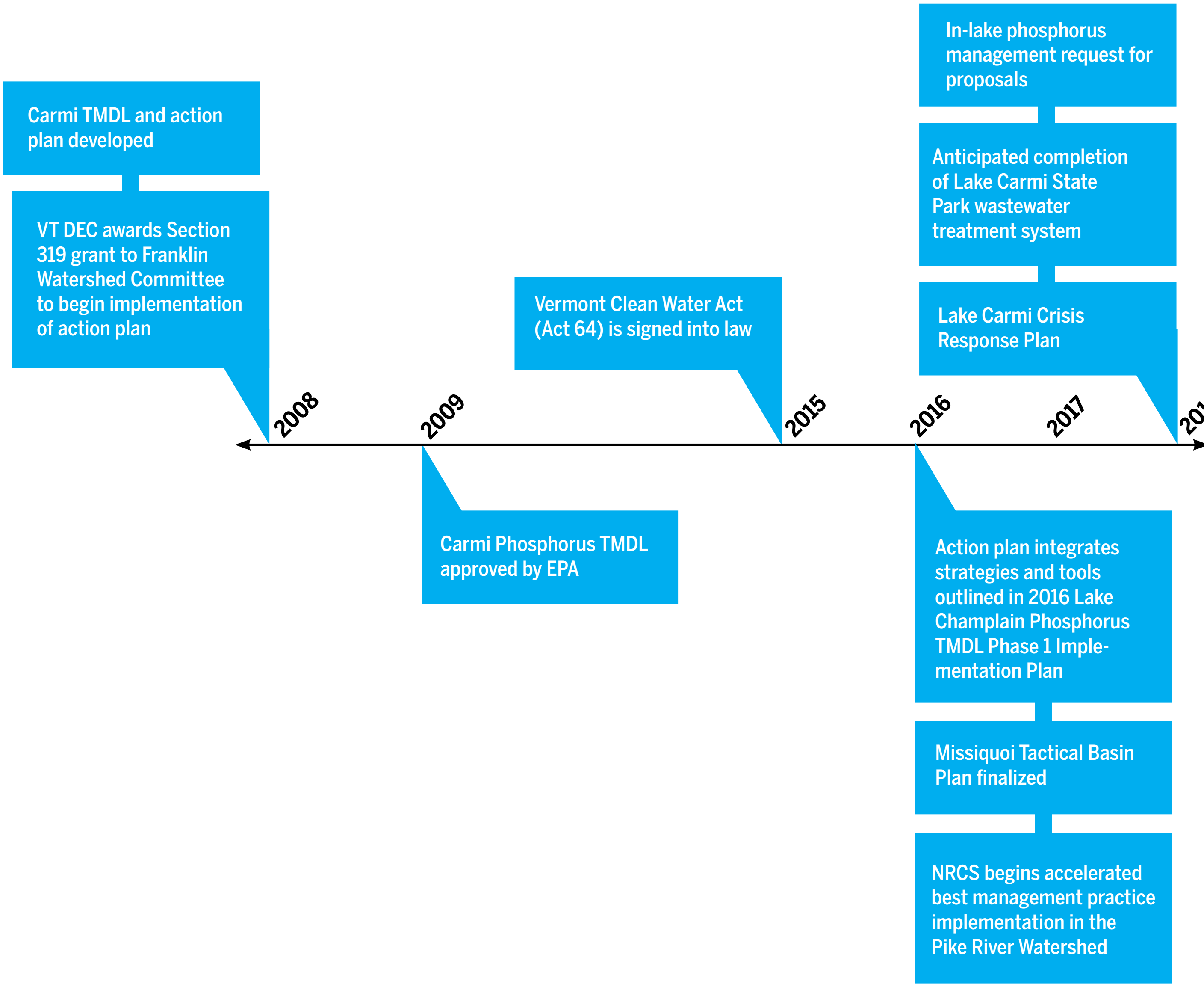


Figure 8. Timeline of Lake Carmi watershed restoration actions from development of the Total Maximum Daily Load (TMDL) in 2008 through 2018.

(1) changing the communities of phytoplankton, zooplankton, and other primary food sources that larval and juvenile fish species rely on in their early life stages; (2) making nutrients more available to phytoplankton and aquatic plants, increasing their rate of growth; (3) decreasing availability of still water to those species that need it; and (4) increasing temperature throughout the water column due to the mixing of warm surface water downward.

To minimize the risks inherent with the aeration approach, DEC continues to work with consultants to model and design a suitable system. For details of how we are preparing for an in-lake treatment, including scoping and modeling reports from the consultants supporting our decision-making process, see the "Restoring Lake Carmi" web page (VTDEC 2018). Even as we proceed with plans for a whole-lake treatment, we recognize inherent risks in attempting to manage a complex lake ecosystem. No matter how we proceed, DEC and our partners are committed to following through with carefully planned actions in the watershed and along the shoreline to reduce phosphorus loading as prescribed by the Lake Carmi Phosphorus TMDL. Lake Carmi is a work in progress, and we plan to persist in ameliorating the causal effects and symptomatic signs of impairment in this lake. We look forward to reporting progress as work continues to restore Lake Carmi and mitigate intense cyanobacteria blooms. Our ultimate goal is to prevent the need for posting "Health Alert" signs on Lake Carmi's beaches and boat launches (Figure 9).

Literature Cited

Bormans, M., B. Maršálek, and D. Jančula. 2015. Controlling internal phosphorus loading in lakes by physical methods to reduce cyanobacterial blooms: a review. *Aquatic Ecology* 50: 423-441.

Nygren, N.A., P. Tapio, and J. Horppila. 2017. Will the oxygen-phosphorus paradigm persist? – Expert views of the future of management and restoration of eutrophic lakes. *Environmental Management* 60:947-960.

USEPA. 2009. EPA New England's TMDL Review. http://dec.vermont.gov/

Figure 9. Health Alert posted at the Lake Carmi State Park fishing access area. Image by Perry Thomas.

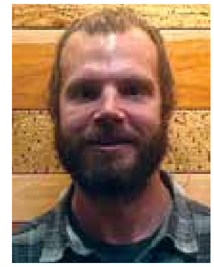
content/2009-lake-carmi-phosphorus-tmdl-epa-approval

USEPA. 2017. Cyanobacteria/ Cyanotoxins: Health and Ecological Effects. https://www.epa.gov/nutrient-policy-data/health-and-ecological-effects

VTDEC. 2008. Phosphorus Total Maximum Daily Load for Lake Carmi. http://dec.vermont.gov/content/2009-lake-carmi-phosphorus-tmdl

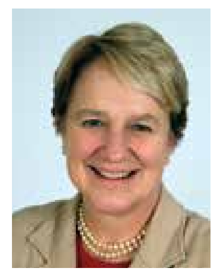
VTDEC. 2016. Taking a Team Approach to Restoring Lake Carmi. https://vtwatershedblog.com/2016/03/24/taking-a-team-approach-to-restoring-lake-carmi/

VTDEC. 2018. Restoring Lake Carmi. http://dec.vermont.gov/watershed/cwi/restoring/carmi.

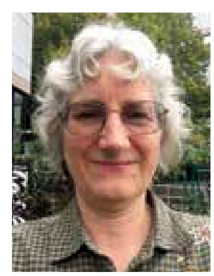


Mark Mitchell serves as the lake assessment coordinator for the Vermont Department of Environmental Conservation. In this role, he uses all available monitoring data to determine water quality status and trends for Vermont's lakes. Mark also coordinates the Vermont Lay Monitoring Program – monitoring conducted by a network of volunteers across the state, including Pete Benevento on Lake Carmi.

Laura Dlugolecki is a regional permit analyst with the VT DEC's Lakes and Ponds Program. Laura provides technical review of water quality and habitat impacts to projects affecting lakes and ponds in Vermont, including impacts and benefits from the use of aeration. Laura also provides outreach to shoreland property owners concerning shoreland best management practices.



Perry Thomas, Ph.D., is manager of the Lakes and Ponds Program (VT DEC) and president-elect of the North American Lake Management Society. Since 2015, Perry and her VT DEC colleagues have partnered with Franklin Watershed Committee members to coordinate the Lake Carmi Implementation Team.



Angela Shambaugh is an aquatic biologist with the Lakes and Ponds Program (VT DEC). She has over 30 years of experience in the fields of water quality and plankton ecology. Currently, she coordinates the Lake Champlain Long-Term Biological and Water Quality Monitoring Program for Vermont as well as cyanobacteria monitoring efforts on Champlain and around the state. It's been an opportunity that allows her to use her love of phytoplankton and microscopy to protect clean water.

The Role of Failure in Success – **Or . . . Try, Try Again**

Mark Mobley, P.E.

The Role of Failure in the Development of Successful Dissolved Oxygen Enhancement Techniques

In his book "*To Engineer is Human – The Role of Failure in Successful Design,*" Dr. Henry Petroski has an entire chapter entitled "Falling Down is Part of Growing Up." In that chapter and in the book, Dr. Petroski explores how failure is a necessary part of engineering design and how lessons learned from failure can lead to advances in technology, improvements in understanding and… growing up. When my brother-in-law gave me the book, I read it from cover to cover. Dr. Petroski's message was right on target for my situation. Many of my recent designs at the Tennessee Valley Authority (TVA) Engineering Laboratory had ended in failure and I needed some encouragement to help me concentrate on learning from them to improve my future designs.

Working at an engineering laboratory, we were often experimenting with new designs and new technology, pushing the envelope and exploring a range of "what if" scenarios. These experiments sometimes pushed designs to failure but most were conducted on physical scale models in controlled conditions in the laboratory. The designs my team and I were working on were much more visible and public since they were large, full-scale installations at a hydropower dam.

Crashing cranes and heavy equipment

At Douglas Dam in the mid-1980s and eventually 15 other hydropower projects over the next decade, TVA was implementing water quality enhancements through the Reservoir Release Improvement Program. I was assigned to review and test the application of Garton pumps at Douglas Dam. Garton pumps (or surface water pumps) were large floating propeller pumps that looked like 15-foot-diameter ceiling fans. The idea was for the pumps to push the warm surface water that is high in dissolved oxygen (DO) content down into the deep withdrawal zone of the hydroturbine to dilute the cold anoxic water that is released during summertime stratified conditions.

The pumps had been invented and developed by Dr. James Garton at Oklahoma State University. It turned out that a full-scale test of three pumps had been conducted at Bagnell Dam by Union Electric Company with some promising results in release DO improvement. But their floating platform design was insufficient to withstand the wave action of the Lake of the Ozarks, so the pump equipment had been removed, surplused, and was lying in a scrap yard at the dam. I convinced my boss that we could buy the surplus equipment, redesign the floating platform, and test them at Douglas Dam. The pump equipment included a 30 HP electric motor and gearbox to drive the 15 foot long driveshaft attached to the propeller. Since this shaft was fixed in the gearbox, we built scaffolding to support the new floating platforms 20 feet or so off the ground so that the pump equipment could be mounted. The assembled pumps were to be lifted by a crane and moved across the dam to be lowered into the reservoir. But ignoring our flagmen and instructions, our crane operator did not lower the load from scaffolding height before he moved the crane over the rough ground of the construction site. The crane overturned, falling onto a smaller crane and smashing our first surface water pump on the ground. Miraculously, no one was hurt but the incident was captured on film by a professional TVA photographer (Figure 1).

This was not a design failure but a failure to communicate our plans clearly to the operator (and make sure he followed them). Eventually, with replacement parts, a new crane (and a different operator), we got three pumps installed and tested. The resulting DO improvement led to two more pilot test designs and eventually permanent installation of nine surface water pumps at Douglas and Cherokee dams that are still in operation today.

Spread it out – Development of the line diffuser design

My next assignment was to investigate the use of pure oxygen gas to further increase the DO in the releases at Douglas Dam. The surface water pumps had achieved about 2 mg/L of increase but more was needed to reach the desired target of 4 mg/L in the releases. Oxygen diffusers had been tested by TVA in the late 1970s and were being used by the U.S. Army Corp of Engineers at the Richard B. Russell hydropower project. Both systems used fine pore ceramic diffusers to create very small bubbles for optimized oxygen transfer from the bubble to the water but the diffusers were prone to clogging, creating a significant maintenance problem. To address this problem, my design team and I chose a laser slit diffuser disk used in waste water treatment and designed a frame and deployment method (Figure 2). The diffuser and deployment all worked well. We installed three frames directly in front of Unit 4 for testing. We achieved an initial DO increase of about 2 mg/L with

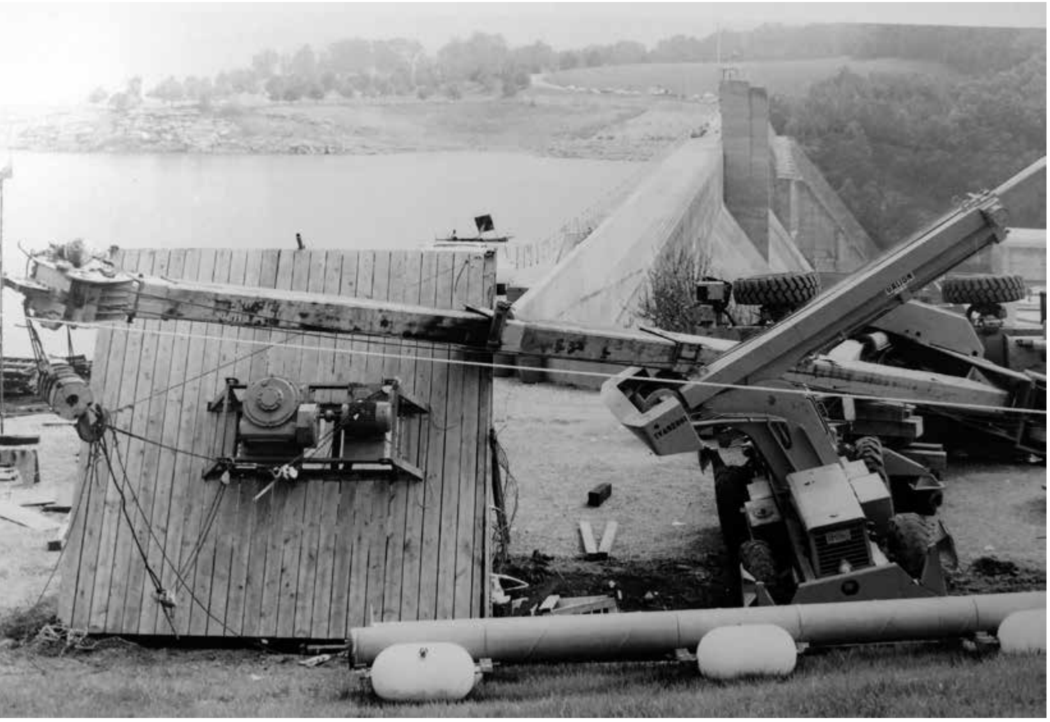


Figure 1. Overturned crane and smashed equipment at Douglas Dam.

Figure 2. Compact diffuser design.

72-percent oxygen transfer efficiency, but the strong bubble plumes stirred up and entrained bottom sediments that increased oxygen demands, eventually zeroing out our overall DO addition and clogging the raw water cooling system in the hydro plant (Figure 3). I was not popular with the plant operators.

This experience indicated a clear need for a means to spread the bubbles over large areas to reduce mixing and entrainment of oxygen demands from the sediments. Looking to replace the diffuser disk design, my team came up with garden variety "soaker hose" made of recycled automobile tires. The hose stretches slightly under pressurization to allow gas or water flow through the walls and made beautiful bubbles in the laboratory. We designed the hose to have the same flow rate per 50-foot hose as in the 1989 design for a 9-inch membrane diffuser head, thus drastically increasing the distribution of the oxygen. Of course that meant the frame to support the hoses had to be extra-large as well. In 1991, we constructed a 400-foot by 100-foot floating frame of PVC pipe to support 100 porous hoses (Figure 4). Buoyancy chambers built into the PVC frame supported the entire frame and anchor assembly on the surface until the chambers were flooded to deploy the frame to the reservoir bottom. The huge frame required a fleet of small boats and ropes from the shoreline to position it in the forebay. Unfortunately, some of the PVC pipes shattered due to stresses generated during the deployment allowing uncontrolled water into chambers needed for buoyancy. "And then it sank…" The entire frame immediately sank irretrievably to the bottom.

Eventually, in 1993 with program support for a new design, 16 smaller PVC diffuser frames, measuring 100 feet by 120 feet, were successfully deployed in Douglas Reservoir. Each frame supports 80 hoses for a total of over 12 miles of porous hose. Although these diffusers were effective and capable of providing up to 2 mg/L of DO improvement in the 16,000 cubic feet per second peak hydropower flows of the four turbines at Douglas Dam, the frames and buoyancy connections were too unwieldy and expensive for future designs.

The next diffuser application at TVA was for a non-power reservoir where aeration was desired to remove dissolved metals and hydrogen sulfide in the reservoir through aeration and precipitation. For this application, a linear deployment was required to fit the diffuser in the deepest, most anoxic portion of the reservoir – in the old riverbed. A two-pipe line diffuser system was designed using a buoyancy pipe and gas supply pipe constructed of polyethylene (HDPE), with porous hose running the entire length of the diffuser, distributing the gas in small bubbles over as large an area as possible. This installation was the first of the line diffuser design. It was successfully deployed in the narrow

Figure 3. Manual cleaning of raw water heat exchangers.

Figure 4. PVC frame diffuser.

curvilinear channel and is still in use today.

This design, developed through so many failures, led to the successful application of line diffuser aeration and oxygenation systems in more than 50 lakes and reservoirs for enhancement of hydropower releases, water supply and fish habitat. Persistence pays off!

Getting rid of hydrogen sulfide and only hydrogen sulfide

After leaving TVA to found Mobley Engineering, Inc. (MEI), I was involved in a DO enhancement project in 2004 at the Lake Wallenpaupack hydroelectric project for Pennsylvania Power and Light (PPL). At this project, the powerhouse and turbines are some 3.5 miles downstream of the dam releasing water directly into the Lackawaxen River. Turbine venting, drawing air directly into the water flow beneath the turbine, had been successfully implemented to increase the DO of the hydropower releases. But the localized air intake caused the hydrogen sulfide (H_2S) in the water flow to degas immediately at the hydropower plant and waft strong rotten egg odors along the river to the very nice riverfront houses with nice patios and decks. Needless to say, the neighbors were not happy with PPL even if they were now meeting their state water quality DO standard.

A team from Kleinschmidt Associates and Reservoir Environmental Management Inc., determined that up to 196 cfs of H_2S laden water was being withdrawn during hydropower operations and that an aeration equivalent to 2 mg/L would be sufficient to oxidize the H_2S in the reservoir before it was moved into the hydropower withdrawal. A Mobley Engineering Line Diffuser aeration system was designed and installed with operation instructions for an air flow of 176 standard cubic feet per minute (scfm) to aerate the incoming H_2S during turbine operation and 12 scfm to maintain DO levels during long periods of no generation.

Upon operation, the aeration system immediately eliminated H_2S odors in the releases – a very public and popular success. This went on very well until the next summer when our team got a call from PPL complaining of very turbid, rusty-looking water in the releases (Figure 5). The beautiful Lackawaxen River was murky and reddish downstream of the hydropower plant. This was a very obvious and public failure. With a couple of site visits and review of operations, it was discovered that the operators thinking that "if a little air was good then more would be better" had left the aeration system in full operation during non-generation periods leading to the aeration of not only H_2S but some of the very high dissolved iron content of the reservoir causing the rusty, turbid water in the releases. Careful operation of the aeration system has provided relief from H_2S odors without objectionable turbidity ever since.

Super-saturation without scouring

Building off our successful side stream super-saturation (SSS) system

Figure 5. Turbid hydropower release into the Lackawaxen River.

installation in Falling Creek Reservoir for the Western Virginia Water Authority in 2012, a team from MEI, Gantzer Water Resource Engineering and Burgess & Niple extrapolated the design for a much larger system for the Wolf Creek Reservoir for the City of Barberton Ohio in 2015.

With a SSS system, cold water is removed from the bottom of the reservoir, pumped through a pressurized oxygen contact chamber (Speece Cone) and redistributed into the hypolimnion of the reservoir. The trick is to distribute the highly oxygenated (DO content sometimes over 100 mg/L) supersaturated water back over the bottom of the reservoir without degassing the oxygenated water or mixing the reservoir. At Falling Creek, we used eductor nozzles to mix the super-saturated water with four times the volume of ambient water in a jet. This diluted the oxygenated water from super-saturated conditions and spread the oxygen placement in the hypolimnion. At Barberton, we upsized the nozzles for the higher flows and without knowing better, deployed the piping system on a much softer reservoir bottom. The system performed as expected at first, dramatically increasing DO levels. But the goal of the application was reduction of manganese (Mn), and the system was showing unexplained spikes of high soluble manganese. Wondering if our nozzles had somehow gotten twisted into pointing into the sediments, the city hired a dive team for an inspection. They found that our pipe anchoring system had sunken completely into the sediments instead of holding the pipe some distance above and that there was a two-foot-deep, six-foot-long hole scoured out of the sediments at every nozzle. Well, it was back to the blackboard (or whiteboard) for the engineers (Figure 6). We kicked around several new designs and then tested new nozzles in a local lake to determine the nozzle that provided the best mixing and least jet (Figure 7). Last

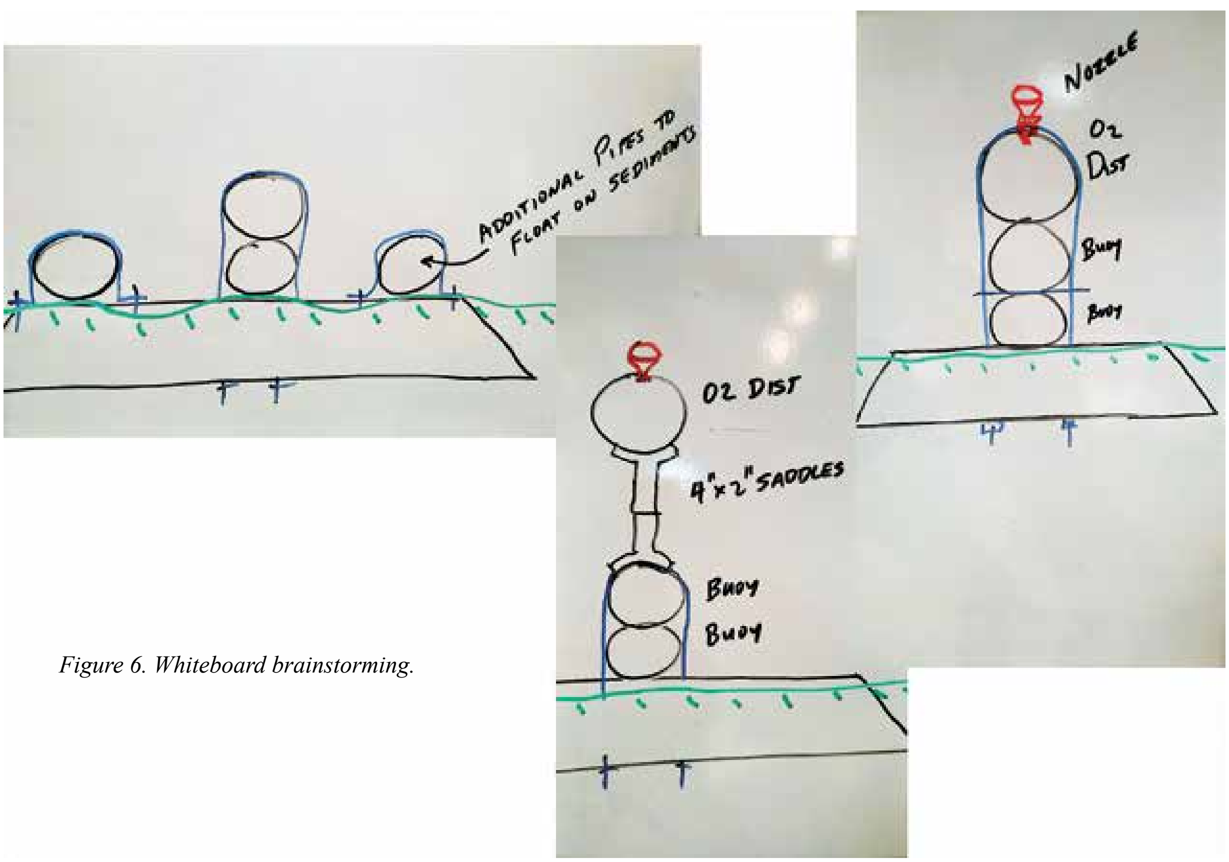


Figure 6. Whiteboard brainstorming.

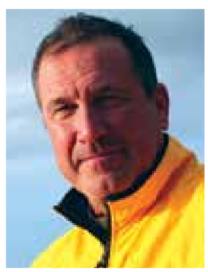
Figure 7. Nozzle test.

year, we modified the distribution piping with additional piping and new nozzles. Results were much improved with the lowest Mn levels yet measured, but the oxygen supply equipment suffered a long term shutdown and we will have to wait until the system is fully operational again to claim complete success with this design.

"No one *wants* to learn from mistakes, but we cannot learn enough from successes to go beyond the state of the art."

Dr. Petroski asserts that failure is a necessary part of innovation – that new technologies require at least some element of risk. These days we can minimize those risks with complex computer models, but at some point you have to go build it and see if it works. And we learn from our mistakes.

Petrowski, Henry. 1985. *To Engineer is Human – The role of Failure in Successful Design,* St. Martin's Press, New York.



Mark H Mobley, P.E., founded Mobley Engineering, Inc. in 1999 after 16 years with the Tennessee Valley Authority Engineering Laboratory. He has been responsible for the installation of over 50 reservoir diffuser systems using compressed air or oxygen to enhance drinking water, hydropower releases and fish habitat. He can be reached at: Mobley Engineering, Inc., PO Box 600, Norris, TN 37828; 865.494.0600 ofc; 865.806.8050 mobile; mark@mobleyengineering.com.

Randi Notte

Student Corner

Lessons Learned: A "who done it?" investigation in search of mistakes in laboratory methods, the solution, and resulting data

Crime scene

"It's physically and theoretically impossible," I cautiously explained to my thesis committee member, "but the weekly results are like this consistently. What am I doing wrong?"

I knew that something had gone sideways in my laboratory analysis, but I never guessed that only one month into my graduate studies I had identified a chemistry conundrum that would follow me through the first year of my program. So like a criminal investigator supported by the chief of police and a high-ranking forensic scientist (read: my Master's Thesis advisor and chemistry-lead committee member), I set out to find and correct the error before the end of the field season.

Opening the investigation

As with every serious investigation, just as in scientific pursuits, it is critical to establish the storyline and lay out the facts. Beginning in June 2017, the Coeur d'Alene Lake Management periphyton project was established to develop and implement a periphyton monitoring method to observe potential changes in trophic status within littoral zones in the lake (Figure 1). Along with periphyton biomass samples from artificial substrates, weekly sampling for various water quality parameters included pH, temperature, conductivity, chlorophyll-*a*, total nitrogen, and the ever-fateful total and ortho-phosphorus samples (TP and OP samples, respectively).

Collected at 4 meters near the substrate surface, TP and OP samples were dispensed from the same Kemmerer sampler into their respective, acid-washed and native-rinsed 125 ml bottles. In the case of OP samples, water was filtered through a pre-rinsed 0.45 um nitrocellulose filter within 15 minutes of collection prior to bottling according to common methods (SM 4500-P; Eton et al. 2005). TP samples were preserved with sulfuric acid until digestion and OP was unpreserved but processed within 48 hours.

Laboratory methods were equally locked into place and well-worn. Generations of previous graduate students in the University of Idaho Limnology Lab had followed these lab methods for the colorimetric determination of TP and OP, although none before me had encountered my fatal error.

Despite using routine methods, week after week the near-bottom water samples from Coeur d'Alene Lake were returning OP concentrations two to five times higher than TP samples from the same location. This, of course, is impossible. OP is a fraction of TP, and should never be higher than TP. Immediately, a list was made of possible explanations including contamination, faulty filters, and minimum detection limits on the machines, etc. With a list made, the scientific process of elimination began. Contamination tests were executed on every piece of equipment

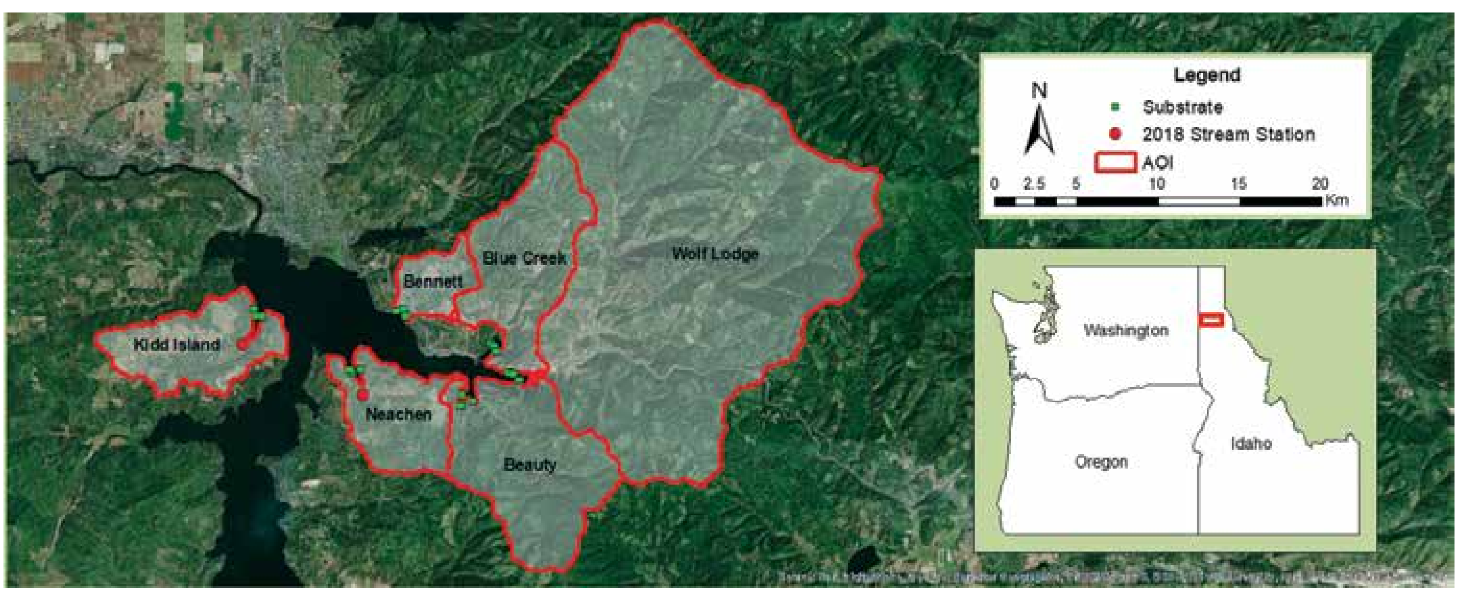


Figure 1. Site Map Water chemistry samples collected from substrate locations. Bay watersheds indicated as polygons.

and reagent present in the field or lab. Laboratory machinery was interrogated for reliability, minimum detection and reporting limits calculated and percent recovery determined. Filters, those used by the group as well as other comparable brands, were tested on samples collected specifically for the investigation. All together, these tests yielded no reliable leads.

Trail growing cold

With little headway gained in that line of questioning, minute variables of the colorimetry method were tested. Although others before me had used non-digested standards for spectrophotometer calibration, I determined that slight changes in TP were indeed occurring with digested standards compared to non-digested standards, a method that more closely matched the sample handling methods. However, this distinction only occurred at higher concentrations than those seen in my low-level lake samples, making it a suspect without probable cause, incapable of altering my results significantly.

So, new experiments were devised to compare to historical TP and OP data available from Coeur d'Alene Lake. I moved along to question an expert witness, the technician from the local lab that had analyzed phosphorus samples from previous lake management projects at our site. The interview was promising but yielded few results. Detail after detail checked out and all my steps seemed to be in order, despite the technician's perfect record and my dismal one.

By fall, the case was growing as cold as the lake, signaling the end of my field season and my window to bring justice to the dataset. A year had passed and everyone in my greater academic circle had been consulted, if not begged, for information. It seemed time to close the case file, to move on without the data and draw conclusions about water-column nutrients some other way.

New evidence

Spring came, with fresh pursuits and new cases on my academic docket. They brought with them new expert witnesses, one ultimately providing the detail that would resurrect my cold case and solve it for good. The issue of sample digestion and handling was raised while training on an automated TP method in a new lab. Groups of grad students with varying phosphorous colorimetry methods were forced to amass a lab-wide, officially accepted method and through the discussions, an idea was born. "The calibration standards! Have the standards been treated *exactly* like the lake samples?"

Like a witness casually interviewed at the scene by first responders, calibration standard handling procedures had always appeared harmless and had been taken for granted. Preservation of samples, a step unique to TP but unemployed in OP samples, had been evaluated early on. Preserved samples in split tests had shown reduced TP concentrations when preserved, but not to a level of significance necessary for a trial judge's (or thesis advisor's) sentencing. However by my own fault, both preserved and non-preserved samples had been analyzed according to un-preserved standards in that test, the fatal mistake. Simple lab tests of the theory produced the smoking gun.

Case closed

All along, TP concentrations had been suppressed while I ran preserved samples on an un-preserved standard curve – the acidity between the samples and calibrants was wildly different and falsified the relationship between concentration and measured absorbance. The suppression had caused TP values to fall below the OP values, those samples which had not been affected by the preservation mix-up because they had never been preserved to begin with.

Effectively, a year's worth of stress had come down to the slope of a calibration line (Figure 2). Unpreserved standards had a steeper slope in the regression between calibrant concentration and machine-read absorbance values, meaning that for the same sample, the unpreserved standard curve calculated a lower TP concentration than a preserved standard curve would.

At long last, I had my answer. With so much time invested in this fatal mistake, I had to ask myself,

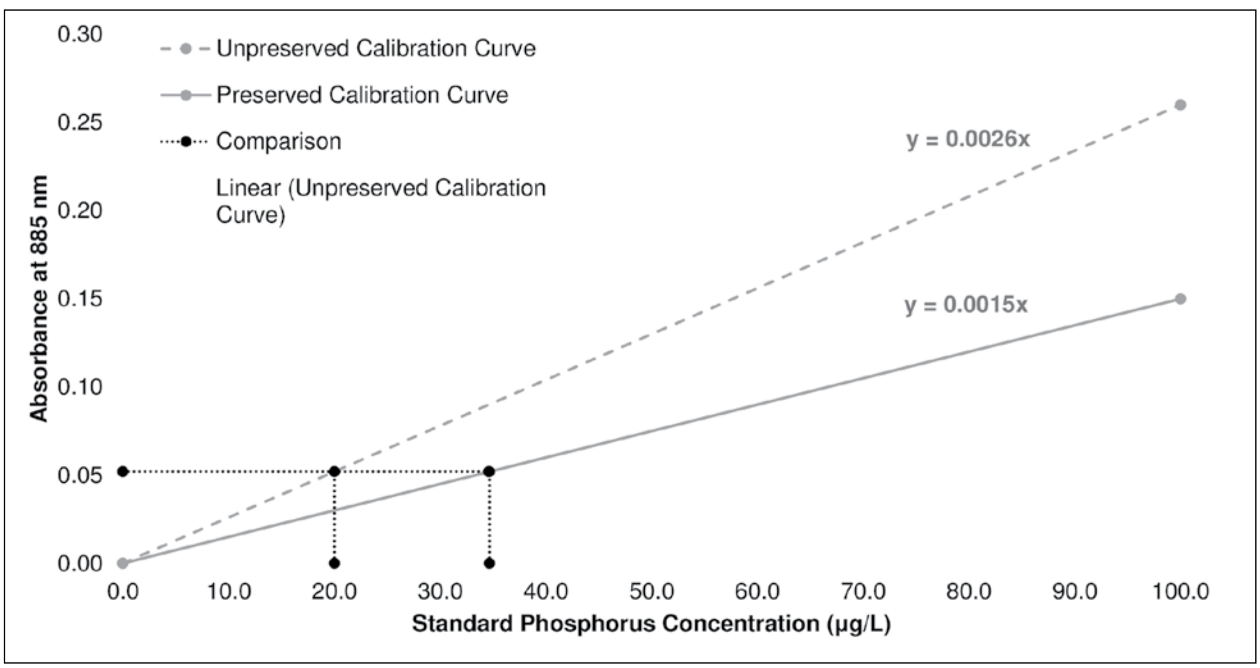


Figure 2. Effects of standard preservation on calculated phosphorus concentration When absorbance is held constant, total phosphorus concentration is lower (suppressed) when calculated on an unpreserved standard curve.

"How did this happen?" Simply, no other students following the Limnology Lab methods had ever preserved their TP samples, yet I had insisted on the practice based on recommendations from others. Despite the confusion there was ultimately clarity, my lessons learned: In a mystery novel, never overlook the seemingly harmless bystander. And in science, your data is only as accurate as your calibration.

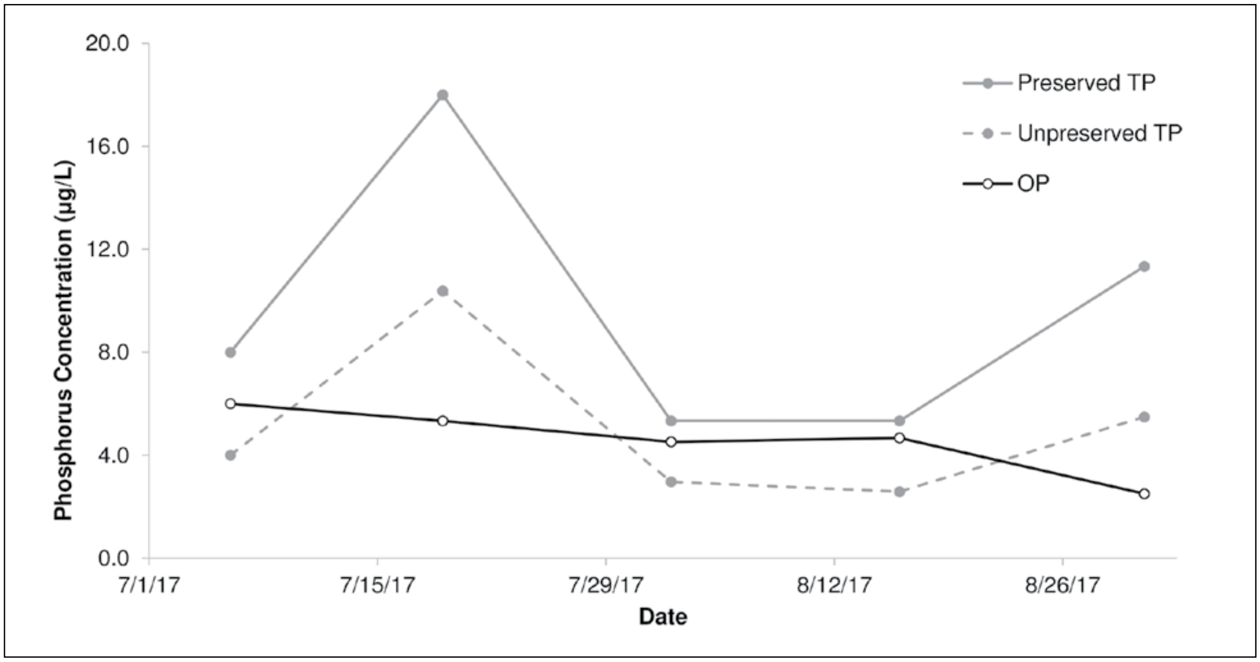


Figure 3. Corrected TP values Nutrient concentrations given for an example site over the course of the 2017 field season.

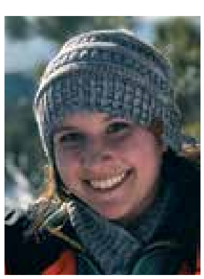
Moving forward

After the trial, it was time to reconcile my new-found knowledge to my victimized dataset. Fortunately, lab experiments showed a linear calibration relationship using preserved standards, allowing for the back-calculation of the first season's TP values. Better yet, corrected TP was greater than OP in all cases except when indistinguishable by the equipment reporting limit (4.90 mg/L). In conclusion, I'd like to draw the jury's attention to the final evidentiary exhibit, Figure 3, where data from a selected site displays the results of TP back-calculation. Although unpreserved TP values hang victimized below OP for most of the summer, corrected preserved concentrations rise above, resolved.

References

Eaton, A.D., L.S. Clesceri, E.W. Rice, A.E. Greenburge, and M.A.H. Franson. (SM 4500-P). 2005. *Standard Methods for the Examination of Water and Wastewater*. 21st ed. American Public Health Association, American Water Works Association, Water Environment Federation.

Randi Notte earned her B.S. in environmental science from Northern Arizona University in 2016. She now studies as a Master's student in environmental science at the University of Idaho, conducting research on Coeur d'Alene Lake where she focuses on littoral periphyton response to nutrient loading.



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