New York State of Opportunity | Department of Environmental Conservation | Department of Health | Agriculture and Markets

HARMFUL ALGAL BLOOM ACTION PLAN LAKE CHAMPLAIN

South Lake, Lake Champlain, Matt McCarthy via Lake Champlain Basin Program, 2018

www.dec.ny.gov

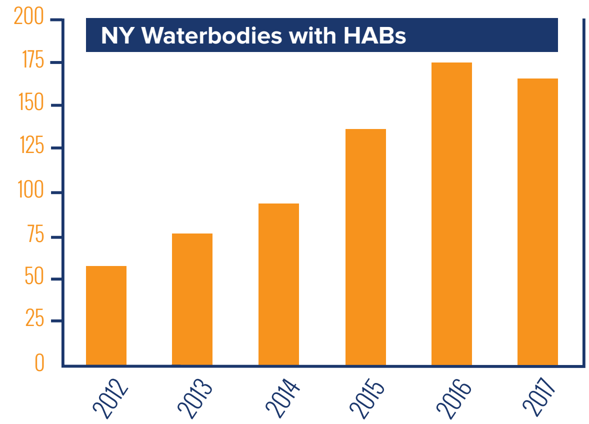
EXECUTIVE SUMMARY

SAFEGUARDING NEW YORK'S WATER

Protecting water quality is essential to healthy, vibrant communities, clean drinking water, and an array of recreational uses that benefit our local and regional economies.

Governor Cuomo recognizes that investments in water quality protection are critical to the future of our communities and the state. Under his direction, New York has launched an aggressive effort to protect state waters, including the landmark $2.5 billion Clean Water Infrastructure Act of 2017, and a first-of-its-kind, comprehensive initiative to reduce the frequency of harmful algal blooms (HABs).

New York recognizes the threat HABs pose to our drinking water, outdoor recreation, fish and animals, and human health. In 2017, more than 100 beaches were closed for at least part of the summer due to HABs, and some lakes that serve as the primary drinking water source for their communities were threatened by HABs for the first time.



GOVERNOR CUOMO'S FOUR-POINT HARMFUL ALGAL BLOOM INITIATIVE

In his 2018 State of the State address, Governor Cuomo announced a $65 million, four-point initiative to aggressively combat HABs in Upstate New York, with the goal to identify contributing factors fueling HABs, and implement innovative strategies to address their causes and protect water quality.

Under this initiative, the Governor's Water Quality Rapid Response Team focused strategic planning efforts on 12 priority lakes across New York that have experienced or are vulnerable to HABs. The team brought together national, state, and local experts to discuss the science of HABs, and held four regional summits that focused on conditions that were potentially affecting the waters and contributing to HABs formation, and immediate and long-range actions to reduce the frequency and /or treat HABs.

Although the 12 selected lakes are unique and represent a wide range of conditions, the goal was to identify factors that lead to HABs in specific water bodies, and apply the information learned to other lakes facing similar threats. The Rapid Response Team, national stakeholders, and local steering committees worked together collaboratively to develop science-driven Action Plans for each of the 12 lakes to reduce the sources of pollution that spark algal blooms. The state will provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

FOUR-POINT INITIATIVE

1 **PRIORITY LAKE IDENTIFICATION**
Identify 12 priority waterbodies that represent a wide range of conditions and vulnerabilities—the lessons learned will be applied to other impacted waterbodies in the future.

2 **REGIONAL SUMMITS**
Convene four Regional Summits to bring together nation-leading experts with Steering Committees of local stakeholders.

3 **ACTION PLAN DEVELOPMENT**
Continue to engage the nation-leading experts and local Steering Committees to complete Action Plans for each priority waterbody, identifying the unique factors fueling HABs—and recommending tailored strategies to reduce blooms.

4 **ACTION PLAN IMPLEMENTATION**
Provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

LAKE CHAMPLAIN

Clinton and Essex Counties

Lake Champlain, consisting of about 283,400 acres, is one of the 12 priority lakes impacted by HABs. The lake is a popular destination for swimming, boating and fishing, as well as camping along its shores. There is also a water intake servicing the village of Rousses Point in the Isle La Motte region of the lake.

The primary factors that contribute to HABs in Lake Champlain include:

Lake Champlain at Isle La Motte

- Nutrient and sediment inputs from agricultural lands within the contributing watershed; and
- Nonpoint source sediment and nutrient inputs from the contributing watershed, e.g., ditches.

Lake Champlain at Port Henry

- Stormwater runoff from developed areas; and
- Phosphorus inputs associated with Wastewater Treatment Plant (WWTP) discharges.

HABs have been documented in both portions of the lake prioritized by this initiative. There were beach closures due to HABs every year from 2014 through 2017 at port Henry and in 2016 and 2017 at Isle La Motte.

Although the causes of HABs vary from lake to lake, phosphorus pollution—from sources such as wastewater treatment plants, septic systems, and fertilizer runoff—is a major contributor. Other factors likely contributing to the uptick in HABs include higher temperatures, increased precipitation, and invasive species.

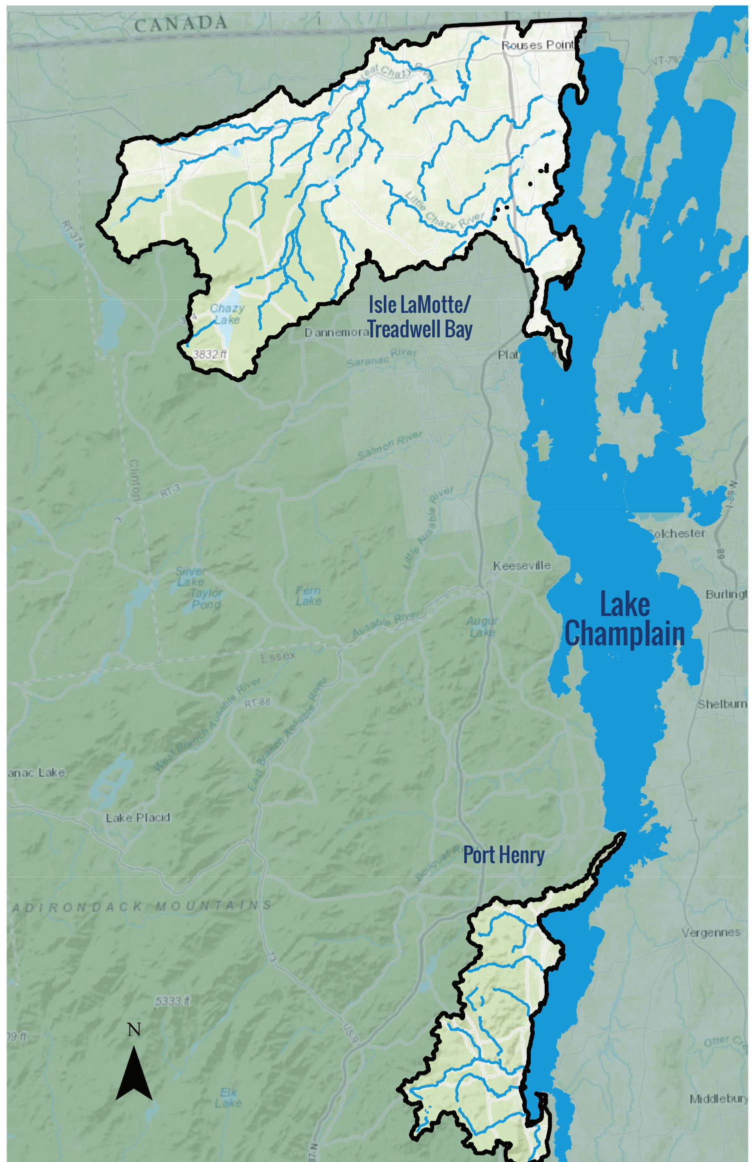
With input from national and local experts, the Water Quality Rapid Response Team identified a suite of priority actions (see Section 13 of the Action Plan for the complete list) to address HABs in Lake Champlain, including the following:

Isle La Motte

- Implement a livestock exclusion program to minimize soil erosion and nutrient loading, and implement alternative manure management practices into animal feeding operations to reduce nutrient loadings;
- Implement a cost-share program to provide financial and technical support; and
- Implement roadside ditch improvement projects.

Port Henry

- Implement a stormwater management and reduction program within the Village of Port Henry and the Town of Moriah to reduce stormwater runoff and nutrient and sediment loading into Lake Champlain; and
- Upgrade the Village of Port Henry/Town of Moriah WWTP to include filtration of phosphorus.



The black outlines show the watershed areas for targeted portions of the lake. Rain, snowmelt, streams and runoff in these areas flow into the targeted portions of the lake. Land uses and activities on the land in these areas have the potential to impact the lake.

LAKE CHAMPLAIN CONTINUED

NEW YORK'S COMMITMENT TO PROTECTING OUR WATERS FROM HABS

New York is committed to addressing threats related to HABs, and will continue to monitor conditions in Lake Champlain while working with researchers, scientists, and others who recognize the urgency of action to protect water quality.

Governor Cuomo is committed to providing nearly $60 million in grants to implement the priority actions included in these Action Plans, including new monitoring and treatment technologies. The New York State Water Quality Rapid Response Team has established a one-stop shop funding portal and stands ready to assist all partners in securing funding and expeditiously implementing priority projects. A description of the various funding streams available and links for applications can be found here: https://on.ny.gov/HABsAction.

This Action Plan is intended to be a 'living document' for Lake Champlain and interested members of the public are encouraged to submit comments and ideas to DOWInformation@dec.ny.gov to assist with HABs prevention and treatment moving forward.

NEW YORK STATE RESOURCES

Drinking Water Monitoring and Technical Assistance:

The state provides ongoing technical assistance for public water suppliers to optimize drinking water treatment when HABs and toxins might affect treated water. The U.S. EPA recommends a 10-day health advisory level of 0.3 micrograms per liter for HAB toxins, called microcystins, in drinking water for young children.

Public Outreach and Education:

The **Know It, Avoid It, Report It** campaign helps educate New Yorkers about recognizing HABs, taking steps to reduce exposure, and reporting HABs to state and local agencies. The state also requires regulated beaches to close swimming areas when HABs are observed and to test water before reopening.

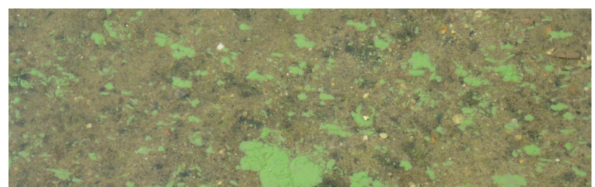
Research, Surveillance, and Monitoring:

Various state agencies, local authorities and organizations, and academic partners are working together to develop strategies to prevent and mitigate HABs. The state tracks HAB occurrences and illnesses related to exposure.

Water Quality and Pollution Control:

State laws and programs help control pollution and reduce nutrients from entering surface waters. State funding is available for municipalities, soil and water conservation districts, and non-profit organizations to implement projects that reduce nutrient runoff.

Pea soup appearance



Floating dots or clumps

Spilled paint appearance

Streaks on the water's surface

CONTACT WITH HABs CAN CAUSE HEALTH EFFECTS

Exposure to HABs can cause diarrhea, nausea, or vomiting; skin, eye or throat irritation; and allergic reactions or breathing difficulties.

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1. Introduction

1.1 Purpose

New York State's aquatic resources are among the best in the country. State residents benefit from the fact that these resources are not isolated, but can be found from the eastern tip of Long Island to the Niagara River in the west, and from the St. Lawrence River in the north to the Delaware River in the south.

These resources, and the plants and animals they harbor, provide both the State and the local communities with many public health, economic, and ecological benefits including potable drinking water, tourism, water-based recreation, and ecosystem services. Harmful algal blooms (HABs) have become increasingly prevalent in recent years and have impacted the values and services that these resources provide.

This HABs Action Plan for Lake Champlain has been developed by the New York State Water Quality Rapid Response Team (WQRRT) to:

- Describe the physical and biological conditions
- Summarize the research conducted to date and the data it has produced
- Identify the potential causative factors contributing to HABs
- Provide specific recommendations to minimize the frequency and duration of HABs to protect the health and livelihood of its residents and wildlife.

This Action Plan represents a key element in New York State's efforts to combat HABs now and into the future.

1.2 Scope, Jurisdiction and Audience

The New York State HABs monitoring and surveillance program was developed to evaluate conditions for waterbodies with a variety of uses (public, private, public water supplies (PWSs), non-PWSs) throughout the State. The Governor’s HABs initiative focuses on waterbodies that possess one or more of the following elements:

- Serve as a public drinking water supply
- Are publicly accessible
- Have regulated bathing beaches.

Based on these criteria, the Governor’s HABs initiative has selected 12 New York State waterbodies that are representative of waterbody types, lake conditions, and vulnerability to HABs throughout the State. Lake Champlain, with its public beaches, recreational opportunities, multi-national setting, as well as documented water quality issues, was selected as one of the priority waterbodies, and is the subject of this HABs Action Plan.

Intended audiences for this Action Plan are as follows:

- Members of the public interested in background information about the development and implications of the HABs program
- New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), and New York State Department of Agriculture and Markets (NYSDAM) officials associated with the HABs initiative
- State agency staff who are directly involved in implementing or working with the NYS HABs monitoring and surveillance program
- Vermont DEC and other Vermont stakeholders that may be contributing to HABs in New York or impacted by HABs affected by New York activities
- Local and regional agencies involved in the oversight and management of Lake Champlain (e.g., Essex and Clinton County Soil & Water Conservation District [SWCD], the Adirondack Park Agency, Departments of Health [DOH], The Lake Champlain Basin Program [LCBP], and other Lake Champlain conservation and oversight organizations), including those in Vermont (Vermont Department of Environmental Conservation and Lake Champlain Committee) involved in HABs management
- Lake residents, managers, consultants, and others that are directly involved in the management of HABs in Lake Champlain

This Action Plan focuses on the Port Henry and Isle La Motte portions of Lake Champlain. Activities within these subwatersheds may impact the formation of HABs within other parts of the lake and likewise, activities elsewhere in the lake may influence HABs within these subwatersheds. Therefore, analyses conducted on these lake segments provide insight of the processes within Lake Champlain that influence HABs blooms.

1.3 Background

Harmful algal blooms in freshwater generally consist of visible patches of cyanobacteria, also called blue-green algae (BGA). Cyanobacteria are naturally present in low numbers in most marine and freshwater systems. Under certain conditions, such as high nutrient concentrations (e.g., phosphorus) and warm temperatures, cyanobacteria may multiply rapidly and form blooms. Several types of cyanobacteria may produce toxins and other harmful compounds that can pose a public health risk to people and animals through ingestion, skin contact, or inhalation. The NYSDEC has identified beach closures and other localized HABs impacts in the Port Henry and Isle La Motte segments of Lake Champlain in Essex and Clinton Counties, respectively, as a priority for mitigation activities. This Action Plan was prepared to identify the primary factors triggering HABs in the Port Henry and Isle La Motte portions of Lake Champlain and to facilitate decision-making to minimize the frequency, intensity, and duration of HABs.

2. Lake Background

2.1 Geographic Location

Lake Champlain flows from Whitehall, New York north to its outlet at the Richelieu River and spans areas of Vermont, New York, and the Province of Quebec, Canada. There are three bridges distributed along the lake and three ferries for crossing the lake at the wider sections (LCLT 2018). The lake is divided into five distinct segments based on the contributing sub-watersheds. These segments are South Lake, the Main Lake, Malletts Bay, the Inland Sea, and Missisquoi Bay.

Lake Champlain is a very large freshwater lake that provides a variety of aquatic habitats to support an ecologically diverse aquatic food web. It also offers a myriad of recreational opportunities including boating, swimming, and fishing, and is a drinking water source for many communities. It receives both industrial and municipal wastes, in addition to runoff from agricultural and urban areas. Collectively, these inputs contribute to recognized water quality problems within the lake and associated watersheds (State of Vermont 2018).

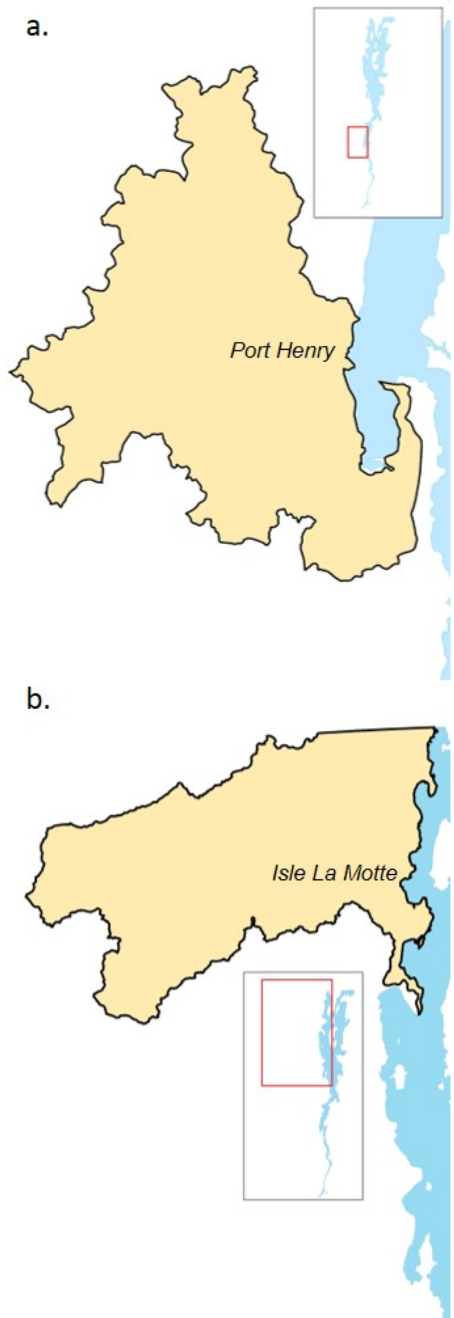


Figure 1. (a) Port Henry and (b) Isle La Motte watersheds in relation to Lake Champlain (see inserted maps for reference).

Both Port Henry and Isle La Motte are located within the Main Lake segment (**Figure 1**) of Lake Champlain. Port Henry is located on the western shore in the southern third of the lake, approximately 40 miles north of Whitehall, New York, and its watershed encompasses the towns of Moriah, Elizabethtown, Westport, and Crown Point (**Figure 2**). Isle La Motte is located in the northern portion of the lake in the Grand Isle Basin approximately 130 miles north of Whitehall (LCBP 2018a), and its watershed encompasses the towns of Champlain, Chazy, Beekmantown, Plattsburgh, Dannemora, Saranac, Altona, Ellenburg, Clinton, and Mooers (**Figure 3**). For the purpose of this report, only the subwatersheds located within the State of New York are included in the analyses and discussions.

2.2 Basin Location

Lake Champlain is located within the Lake Champlain basin, an 8,234-square mile watershed (LCLT 2018). Fifty-six percent (56%) of the basin is in Vermont, 37% is in New York, and 7% is in the Province of Quebec (UVM Watershed Alliance 2016). The Main Lake segment that includes both Port Henry and Isle La Motte consists of approximately 262 square miles. This segment is bordered by New York to the west, the Province of Quebec, Canada to the north and Vermont to the east.

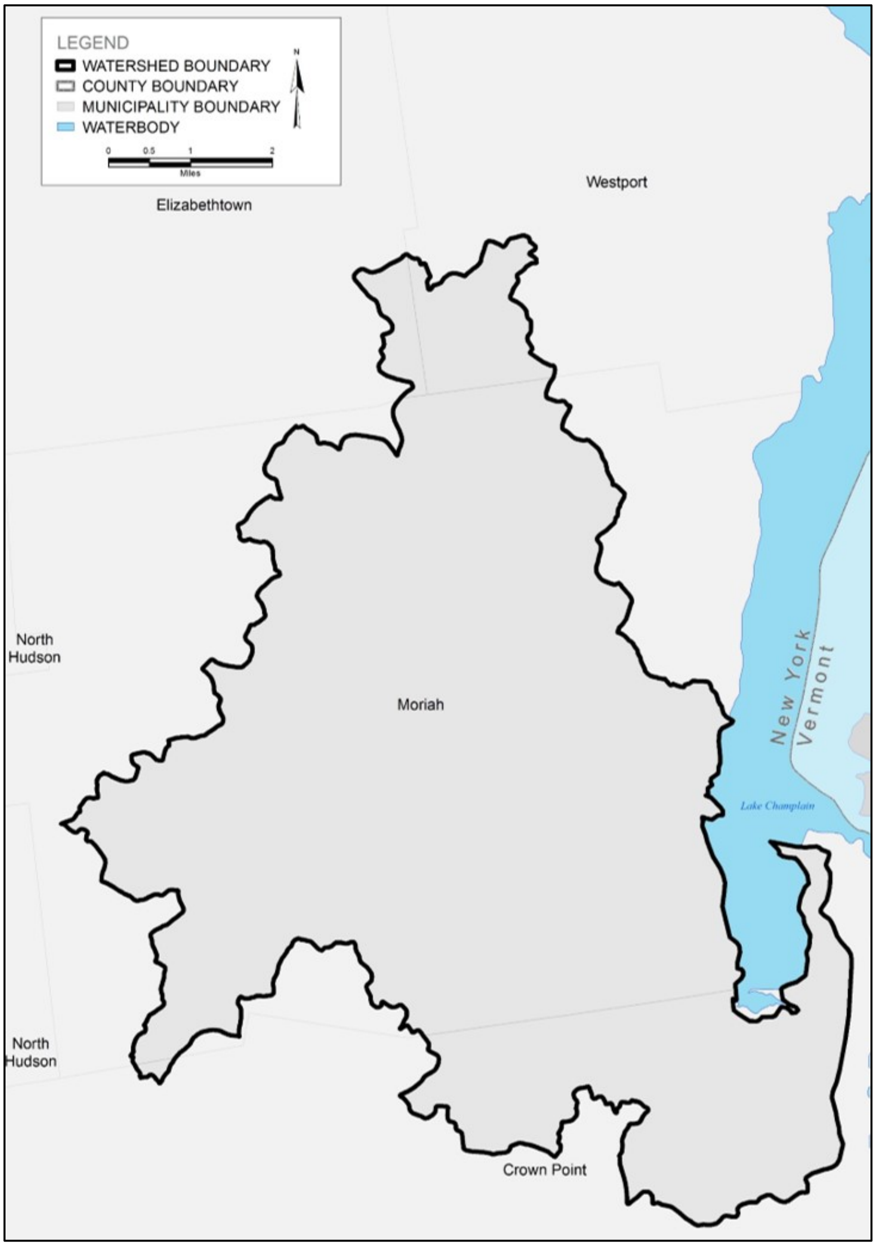


Figure 2. Political boundaries within the Port Henry subwatershed.

2.3 Morphology

Lake Champlain is 120 miles long (generally north to south) and 12 miles wide at its widest point, with a surface area of 283,400 acres. It has 587 miles of shoreline and 71 islands. The Lake's maximum depth is 400 feet, with an average depth of 64 feet (**Figure 4**). The deepest waters are located between Essex, New York and Charlotte, Vermont (LCLT 2018). The average volume of water in the lake is 6.8 trillion gallons (LCBP 2018a).

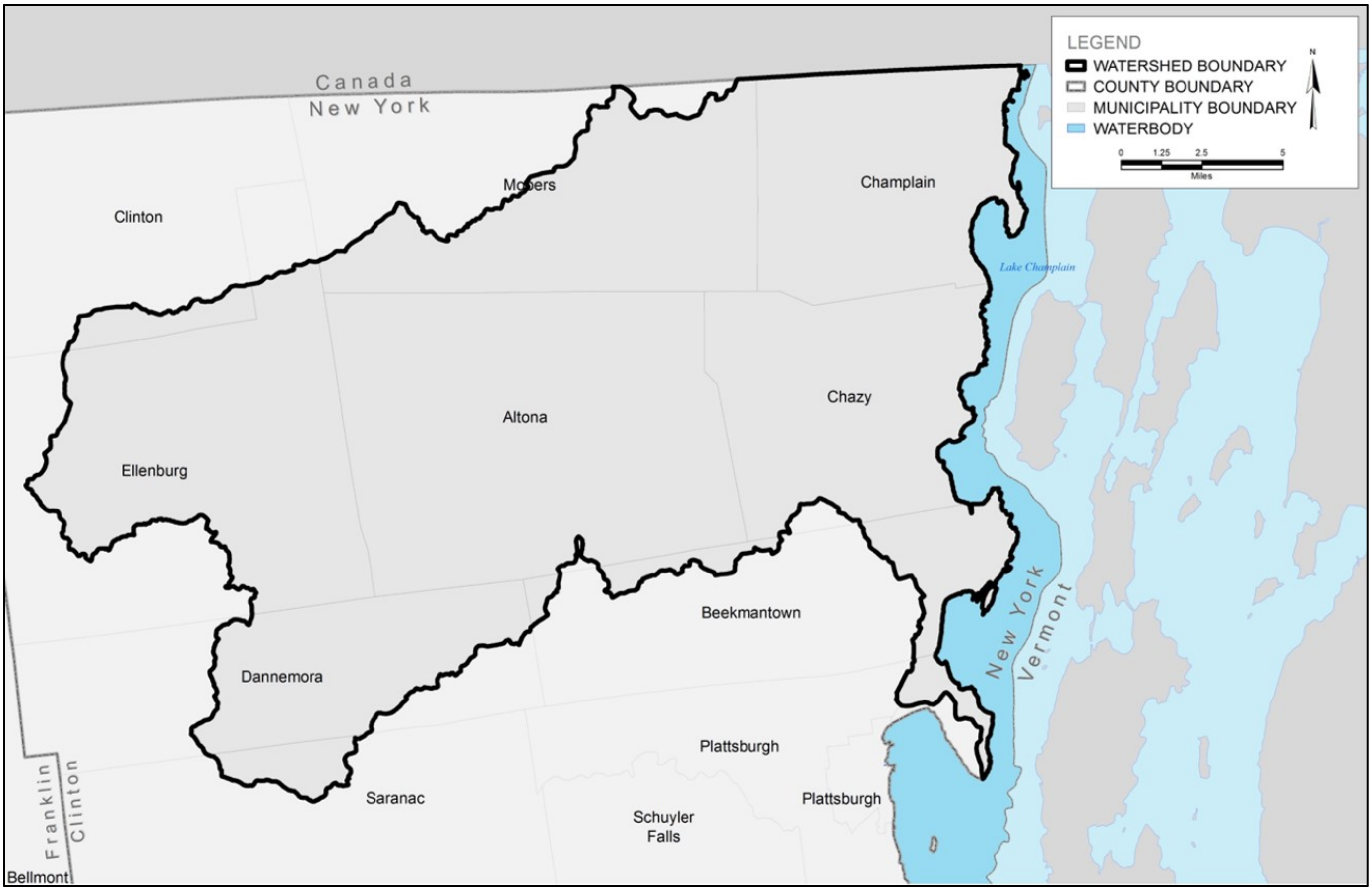


Figure 3. Political boundaries within the Isle La Motte subwatershed.

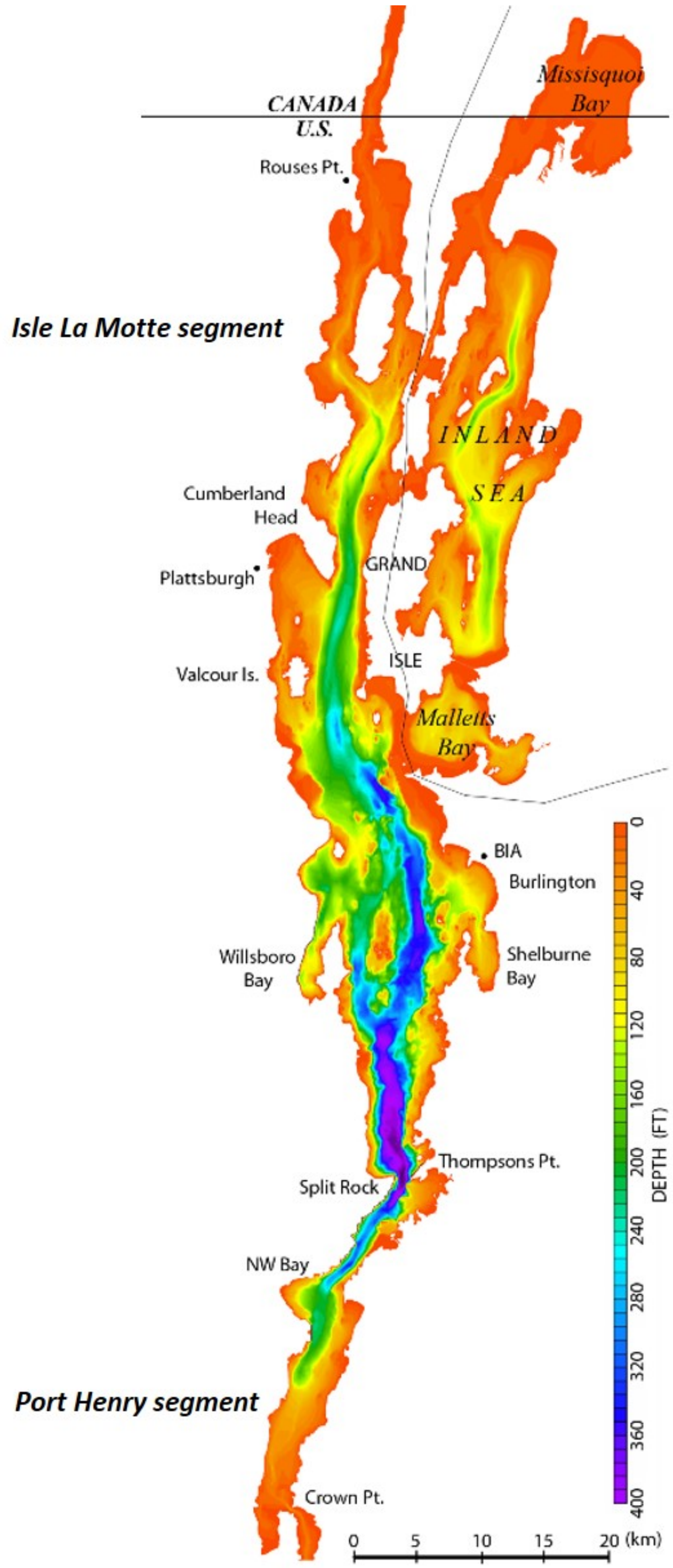


Figure 4. Bathymetric map of Lake Champlain (Source: Middlebury College).

Wind rose figures for the Port Henry and Isle La Motte segments of Lake Champlain indicate that stronger prevailing wind directions were generally from the north and south from 2012 to 2017 during the months of June through November, as measured from the Middlebury State Airport, VT (Port Henry) and Plattsburgh International Airport (Isle La Motte) (**Appendix A**). This pattern of prevailing winds can generate large fetch lengths, and influence spatial distribution of HABs (when they occur). Specifically, the northern and southern extents of Lake Champlain may experience accumulation of HABs during blooms, with implications for public health and recreation (see **Sections 3.2** and **3.3**). The Port Henry section contains Bulwagga Bay at the southern extent which may accumulate buoyant cyanobacteria during blooms and a prevailing wind from the north. Similarly, the small bays in the Isle La Motte section may also accumulate buoyant cyanobacteria during blooms with either a prevailing north or south wind.

2.4 Hydrology

Lake Champlain's average annual water level is 95.5 feet, with a record high of 103.57 feet and record low of 92.4 feet. Typically, the lake's water levels can vary about six feet annually between high and low average water levels. The water retention time, or the amount of time water spends in a lake, varies by lake segment. The retention time is highest in the Main Lake segment (about three years), and shortest in the South Lake segment (less than two months) (LCBP 2018a). Long hydrologic retention allows for the accumulation of nutrients and increased temperatures that can promote HABs, particularly in shallower areas and embayments. Sub-basins to Lake Champlain are named after their larger tributaries and consist of the following (UVM Watershed Alliance 2016, Gilles 2018, NYSDEC 2018a,):

<u>New York: 2,889 square miles</u>

- South Lake B = 378 square miles
- South Lake A (Lake George watershed) = 372 square miles
- Port Henry = 93 square miles
- Otter Creek = 4 square miles
- Boquet/Ausable /Salmon basin = 994 square miles
- Cumberland Bay/Saranac River = 659 square miles
- Isle LaMotte/Chazy basin = 389 square miles

<u>Vermont/Province of Quebec: 4,920 square miles</u>

- Poultney-Mettawee/South Lake basin = 498 square miles
- Otter/Lewis basin = 1,098 square miles
- Winooski basin = 1,161 square miles
- Lamoille basin = 870 square miles
- Missisquoi/Pike basin (58% VT, 42% Province of Quebec) = 1,199 square miles
- Grand Isle basin = 94 square miles

From Lake Champlain's outlet at the Richelieu River in Quebec, the water joins the St. Lawrence River, which eventually drains into the Atlantic Ocean at the Gulf of St. Lawrence.

2.5 Lake Origin

The Lake Champlain region has been formed over billions of years by plate tectonics and glacial activity. Over a billion years ago, shifts in the tectonic plates formed the precursors of the Adirondack mountains. These eventually eroded away and continental plates pulled apart between 600 and 370 million years ago, thereby forming a warm, shallow sea (LCBP 2018b). Continental collisions between 450 and 370 million years ago created the Green and Taconic mountains and closed this shallow sea. Shoreline sedimentary rocks and the continental shelf later folded and faulted, forming the Green Mountains (LCBP 2018c).

Glaciation between approximately 3 million years and 12,000 years ago covered the area in a mile-thick sheet of ice, and as the glaciers receded, ocean waters flowed in from the Atlantic. As the land surface rebounded, the lake water surface elevation was raised above sea level, and saltwater was replaced by fresh water from tributaries, eventually forming what is now Lake Champlain (LCC 2018a).

3. Designated Uses

3.1 Water Quality Classification – Lake and Major Tributaries, General Lake Champlain

Both the northern (including Isle La Motte) and middle portions of Lake Champlain's Main Lake from the Canada border to Crown Point Bridge have a classification of Class AA(T) for open water areas and Class A(T) for reaches out to ¼ mile or thirty feet deep according to the New York Codes, Rules, and Regulations (6NYCRR Part 830.6); however, specific segments and portions of bays within the northern and middle Main Lake segments may be designated other than Class A based on unique characteristics within these lake sub-areas. Class A waterbodies are best utilized for drinking water, culinary or food processing purposes, primary and secondary contact recreation, and fishing. They are suitable for fish propagation and survival and, if subjected to approved treatment, will meet New York State Department of Health drinking water standards (NYSDEC 2009). Except for the specific portions of the northern and middle Main Lake that are classified other than "A", the northern and middle sections of the Main Lake are also trout waters ("T"), whereby any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies. Bulwagga Bay, within the Port Henry section, is designated in the NYCRR as a Class B watercourse. Class B waters are best used for fish, shellfish and wildlife propagation, with best usages noted as primary and secondary contact recreation, and fishing.

Major tributaries to Lake Champlain and their New York state water quality classifications are identified and described below.

- Great Chazy River, for the majority of its length, is classified as Class C waters. Class C waters are best used for fishing, fish propagation and survival, and primary and secondary contact recreation, although other factors may limit the use for these purposes. A segment of the Great Chazy from Champlain water works dam (1.6 miles upstream from Lake Champlain) to the North Branch Great Chazy River is classified as A. As discussed above, the NYCRR indicates that the best usages of Class A waters are: 1) with proper treatment, as a water supply source for drinking or food processing purposes, 2) primary and secondary contact recreation, and 3) fishing. Class A waters are also considered suitable for fish, shellfish and wildlife propagation and survival.
- Poultney River and Mettawee River are Class C waterbodies based on NYCRR classifications. Class C waters have best usages for fishing, fish propagation and survival, and suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.
- Ausable River and Boquet River are Class C(T) waterbodies according to NYCRR, meaning they have best usages for fishing, fish propagation and survival, primary and secondary contact recreation. These waterbodies are also must meet water quality standards set for survival of trout.
- Saranac River is classified as C(TS) according to NYCRR, meaning it is designated for trout spawning. This classification pertains to the river from Imperial Dam 3.4 miles upstream from the mouth downstream through the City of Plattsburgh to approximately 0.3 miles upstream of its confluence with the lake, where the water use classification changes to C.

In Vermont, the primary tributaries to Lake Champlain, and their corresponding water use classifications per Vermont Water Quality Standards (VTDEC 2014), include:

- Lamoille River, Missisquoi River, Otter Creek, and Lewis Creek: Class B. Class B waters have good aesthetic value and are suitable for swimming and other forms of water-based recreation. They are suitable for the irrigation of crops and other agricultural uses without treatment and sustain aquatic biota and wildlife by high quality aquatic habitat. Class B waterbodies are acceptable for public water supply with filtration and disinfection.
- Winooski River: Class B, including a reach with a waste management zone. A waste management zone is a specific reach of Class B waters designated by a permit to accept the discharge of properly treated wastes that prior to treatment contained organisms pathogenic to human beings (VTDEC 2014).

3.1.1 Lake Champlain at Port Henry

The following New York tributaries and corresponding use designations are described for Lake Champlain in the Port Henry region based on information provided in 6 NYCRR 830.6:

- Mill Brook: 6 NYCRR 830.6 identifies Mill Brook as a Class C waterbody under New York state's water quality classification system (NYSDEC 2009).
- Stony Brook: NYCRR identifies Stony Brook in Port Henry as Class C.
- McKenzie Brook: McKenzie Brook is a designated Class C from Lake Champlain to 2 miles upstream, where it changes to C(TS) for the rest of the reach to its source according to the NYCRR.
- Two unnamed tributaries to the lake 0.3 miles and 0.7 miles south of Mill Brook are classified as Class C and D, respectively, according to the NYCRR. A small unnamed tributary approximately 0.3 miles north of Mill Brook is designated as Class C(T), indicating it is designated for trout survival.

3.1.2 Lake Champlain at Isle La Motte

The following New York tributaries and corresponding use designations are described for Lake Champlain in the Grand Isle Basin in the vicinity of Isle La Motte based on information provided in in 6 NYCRR 830.6 and NYSDEC's Environmental Resource Mapper (NYSDEC 2018):

- Great Chazy River: The Great Chazy River enters Lake Champlain from the northwest and 1.4 miles southeast of hamlet of Coopersville. It discharges to the lake immediately south of King Bay, and is designated as Class C waterbody for the majority of its length, except from the Champlain Village water works dam to the North Branch Great Chazy River where it is designated Class A, as discussed in **Section 3.1**.
- Little Chazy River: The Little Chazy River enters Lake Champlain from northwest 1.2 miles north of Chazy Landing. The river reach adjacent to the lake is designated as Class C, and thus is suitable for primary and secondary contact recreation unless other factors limit the use for these purposes.
- Seven other streams drain to the lake from the New York mainland in the vicinity of Isle La Motte, five of which are unnamed. Guay Creek, Riley Brook and three of the six unnamed tributaries are classified as Class C. Two of the unnamed tributaries are designated as Class D. Several other tributaries are located further south, including an unnamed tributary from Woodruff Pond (Class C), which drains to Allens Bay, south of Treadwell Bay and two unnamed tributaries which drain near Martin Point on Cumberland Head (one Class C, one Class D).

Six tributaries along the western shoreline of Isle La Motte (VT) discharge to the western portion of Lake Champlain. Twelve additional tributaries discharge from the northern and eastern portions of the island to the lake. All Vermont waters in the Northern Champlain Basin (Basin #5), which encompass the Isle La Motte region, are designated as Class B. Vermont Class B waters are designated as such to achieve and maintain a level of quality that fully supports aquatic biota and habitat, aesthetics, irrigation/agricultural use, and primary and secondary contact recreation, and to meet specific water quality criteria (VTDEC 2014).

More information about New York State's waterbody classification system is provided in **Appendix B**.

3.2 Potable Water Uses

Lake Champlain provides drinking water for approximately 145,000 people (20% of the basin's population), which stresses the need to protect water quality and limit the frequency and occurrence of HABs. Approximately 20 million gallons of water are pumped from the lake daily to supply drinking water to 100 public water supplies (**Figure 5**). Almost all of the 145,000 people obtain their water from these supplies. Four municipalities in New York are supplied drinking water from Lake Champlain. It is also reported that a small number of shoreline residences and seasonal dwellings still draw untreated water directly from the lake for potable purposes (LCBP 2015; 2018d), although the NYSDOH does not recommend use of these individual unauthorized water intakes for potable water without proper treatment. As HABs increase in frequency around Lake Champlain, public water suppliers have improved their water treatment effectiveness to maintain the integrity and quality of drinking water (LCBP 2018d). As recommended by the NYSDOH, it is never advisable to draw drinking water from a surface source unless it has been properly treated by a public drinking water system regardless of the presence HABs. Surface waters may contain other bacteria, parasites or viruses that can cause illness. If you choose to explore in-home treatment systems, you are living with some risk of exposure to blue-green algae and their toxins and other contaminants. Those who desire to reduce HAB toxin levels in home treated water for non-potable household uses should work with a water treatment professional who should evaluate for credible third-party certifications such as National Sanitation Foundation standards (NSF P477; NYSDOH 2017).

Lake Champlain in the Port Henry region does not contain potable water supply intakes (**Figure 5**). Drinking water for the hamlet of Port Henry is supplied by Bartlett Brook, located approximately two miles north of Port Henry (Port Henry-Moriah.com 2015). Since no documentation of a HABs has been reported in Bartlett Brook, no HABs-related impacts to drinking water in the Port Henry area are expected.

In the Isle La Motte region, a lake intake is present at North Hero Island (VT), southeast of Isle La Motte, that supplies water to the North Hero Water System. Algal blooms have been reported in the vicinity of this intake, prompting testing for cyanobacterial toxins here (and at other water intakes in the lake) (VTDOH 2018a). A water intake servicing the Rouses Point Village water supply is also located in the Northern portion of the Isle La Motte region.

The U.S. Environmental Protection Agency (USEPA) sets health advisories to protect people from being exposed to contaminants in drinking water. As described by the USEPA: “The Safe Drinking Water Act provides the authority for EPA to publish health advisories for contaminants not subject to any national primary drinking water regulation. Health advisories describe nonregulatory concentrations of drinking water contaminants at or below which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one-day, 10-days, several years, and a lifetime). HAs are not legally enforceable federal standards and are subject to change as new information becomes available.”

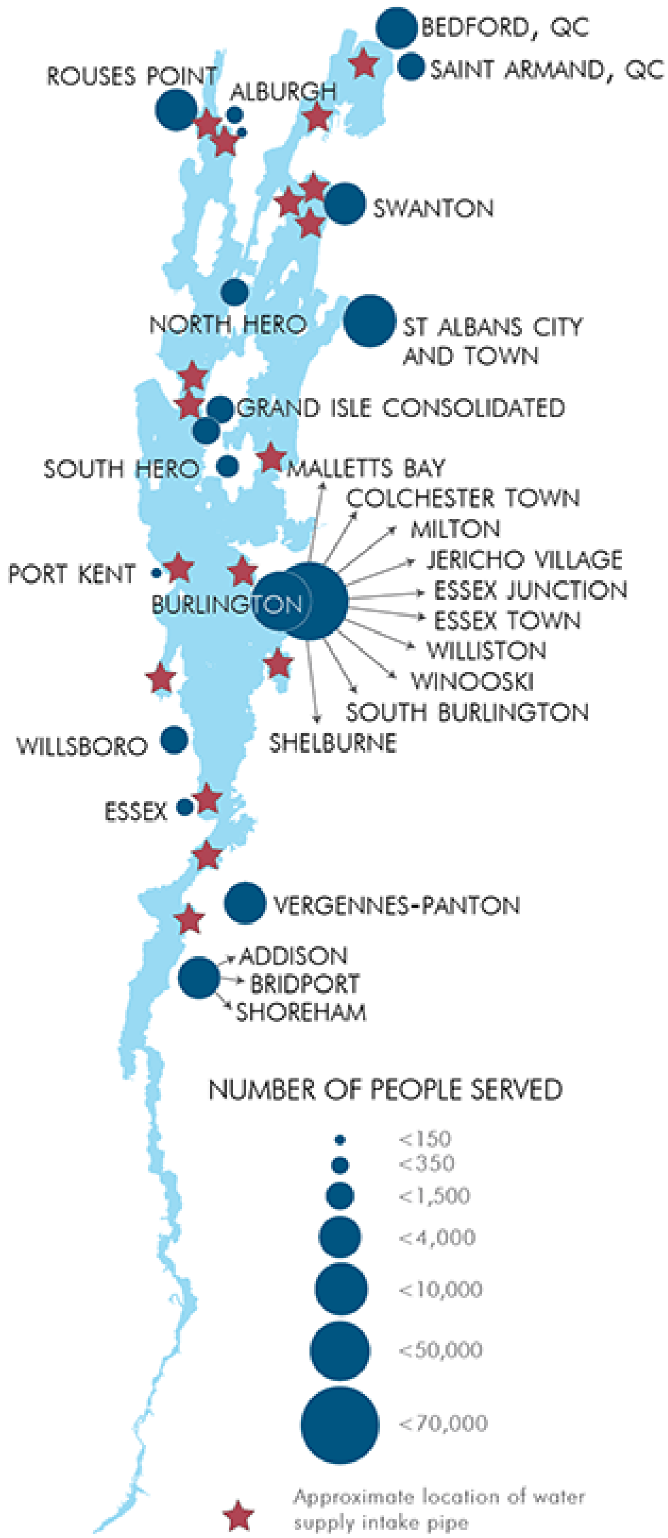


Figure 5. Lake Champlain major public water supply intakes (Source: LCBP 2015).

Health advisories are not bright lines between drinking water levels that cause health effects and those that do not. Health advisories are set at levels that consider animal studies, human studies, vulnerable populations, and the amount of exposure from drinking water. This information is used to establish a health protective advisory level that provides a wide margin of protection because it is set far below levels that cause health effects. When a health advisory is exceeded, it raises concerns not because health effects are likely to occur, but because it reduces the margin of protection provided by the health advisory. Consequently, exceedance of the health advisory serves as an indicator to reduce exposure, but it does not mean health effects will occur.

In 2015, the USEPA developed two 10-day drinking water health advisories for the HAB toxin microcystin: 0.3 micrograms per liter (mcg/L) for infants and children under the age of 6, and 1.6 mcg/L for older children and adults. (USEPA 2015). The 10-day health advisories are protective of exposures over a 10-day exposure period to microcystin in drinking water, and are set at levels that are 1000-fold lower than levels that caused health effects in laboratory animals. The USEPA's lower 10-day health advisory of 0.3 mcg/L is protective of people of all ages, including vulnerable populations such as infants, children, pregnant women, nursing mothers, and people with pre-existing health conditions. The NYSDOH has used the health advisory of 0.3 mcg/L as the basis for recommendations, and a do not drink recommendation will be issued upon confirmation that microcystin levels exceeds this level in the finished drinking water delivered to customers.

In 2015, the USEPA also developed 10-day health advisories for the HAB toxin cylindrospermopsin. (USEPA 2015). Although monitoring for cylindrospermopsin continues, it has not been detected in any of the extensive sampling performed in New York State. New York State HAB response activities have focused on the blooms themselves and microcystin given it is by far the most commonly HAB toxin found.

Figure 6. Lake Champlain beaches (Source: LCBP 2018e).

Water system operators should conduct surveillance of their source water on a daily basis. If there is a sign of a HAB, they should confer with NYSDOH and NYSDEC as to whether a documented bloom is known. The water system operator, regardless of whether there is a visual presence of a bloom, should also be evaluating the daily measurements of their water system. If there is any evidence—such as an increase in turbidity, chlorine demand, and chlorophyll—then the water system operator should consult with the local health department about the need to do toxin measurement. The local health department should consult with NYSDOH central office on the need to sample and to seek additional guidance, such as how to optimize existing treatment to provide removal of potential toxins. If toxin is found then the results are compared to the EPA 10-day health advisory of 0.3 µ/L, and that the results of any testing be immediately shared with the public. NYSDOH also recommends that if a concentration greater than the 0.3 µg/L is found in finished water, then a recommendation be made to not drink the water. NYSDOH has templates describing these recommendations that water system operators and local officials can use to share results with customers. Additionally, public water systems that serve over 3,300 people are required to submit Vulnerability Assessment /Emergency Response Plans (VA/ERP); in situations where a water system is using surface waters with a documented history of HABs, NYSDOH will require water system operators to account for HABs in their VA/ERP (which must be updated at least every five years).

3.3 Public Bathing Uses

According to the Lake Champlain Basin Program (LCBP), a total of 54 beaches are located along the New York and Vermont lake shorelines (LCBP 2018e). Of these 54 beaches, 22 are identified as “public”, 23 as “private”, and nine are identified as “occasionally closed” (**Figure 6**). Collectively, the beaches are visited by nearly one million people annually. Between 1994 and 2000, some of the municipal beaches were closed due to concerns over fecal coliform levels. Local municipalities have implemented measures to control pathogens in swimming areas. Beaches on the Quebec portion of Missisquoi Bay (north), St. Albans Bay (VT) and within New York, including those located in the Port Henry, NY and Isle La Motte regions (see **Section 7.2**), have been closed in recent years due to HABs, and health advisories have been issued in Vermont.

Sixteen (16) of the 54 beaches are located along the New York shoreline, nine of which are public and seven of which are private. Several of New York’s public beaches are located within state parks, including Point Au Roche State Park, Cumberland Bay State Park, and Ausable Point State Park.

3.3.1 Lake Champlain at Port Henry

Port Henry has two locations along Lake Champlain available for public swimming: Bulwagga Bay Park and Port Henry Beach (Champ Beach Park; **Table 1**). (Port Henry-Moriah.com 2018).

Table 1. Port Henry beaches.				
Beach Name	**Location**	**Hours**	**Lifeguard**	**Notes**
Bulwagga Bay Beach	Southern section of Port Henry, Bulwagga Bay Park and Campground	Summer 9 am to 5 pm	Yes	Public beach, maintained by Town of Moriah
Port Henry Beach	Northern end of Port Henry	June-Sept	Yes	Public beach opened in 2017

As discussed in **Section 2.3**, prevailing winds are typically out of the north and south (**Appendix A**). When HABs occur and prevailing winds are from the north, buoyant cyanobacteria and potentially associated cyanotoxins and elevated toxin concentrations may accumulate in the southern portion of Lake Champlain, including the Port Henry segment. This northern prevailing wind direction during HABs can negatively impact beaches in Port Henry.

3.3.2 Lake Champlain at Isle La Motte

The LCBP have identified several beaches in the Isle La Motte section (LCBP 2018e) (**Table 2**).

Table 2. Isle La Motte beaches.				
Beach Name	**Location**	**Hours**	**Lifeguard**	**Notes**
Unnamed	North of Wool Point, NY	NA	No	Private beach
Unnamed	Wait Bay, VT	NA	No	Private beach
Point Au Roche State Park	Northern Treadwell Bay	Daily during summer 11 am to 7 pm	Yes	Large 700 ft. long beach with admission to Park

When prevailing winds are from the south (**Appendix A**), buoyant cyanobacteria may accumulate in the northern extent of Lake Champlain, including in the Isle La Motte region. Southerly winds may concentrate cyanobacteria and negatively impact beaches in the Isle La Motte region.

3.4 Recreation Uses

Lake Champlain supports a variety of recreational uses, including canoeing, kayaking, motorboating, sailing, swimming, boating, picnicking, fishing (both recreational and tournament fishing), and other recreational uses. Fishing is popular in the lake throughout the year, including in winter when cold air temperatures permit ice fishing opportunities. Landside recreational uses along the lake shorelines include picnicking, birding, hiking, camping, bicycling, rock climbing, and horseback riding (LCBP 2018f).

Both the Port Henry and Isle La Motte regions of Lake Champlain boast numerous recreational opportunities, including the lakewide recreational uses described above. Both areas also contain State and/or township parks, marinas, and boat launches (**Figure 7**).

3.5 Fish Consumption/Fishing Uses

Lake Champlain is reported to contain 93 species of fish and is considered one of the best recreational bass fishing lakes in the United States (LCBP 2018g; LCLT 2018). The lake supports an assemblage of both coldwater and warmwater species, several of which are important recreationally and may be taken for consumption. Sought after species include (LCBP 2018g):

Warmwater

- Largemouth bass (*Micropterus salmoides*)
- Smallmouth bass (*Micropterus dolomieu*)
- Walleye (*Sander vitreus*)
- Northern pike (*Esox lucius*)
- Chain pickerel (*Esox niger*)
- Yellow perch (*Perca flavescens*)
- Channel catfish (*Ictalurus punctatus*)
- Brown bullhead (*Ameiurus nebulosus*)

Coldwater

- Atlantic salmon (*Salmo salar*)
- Lake trout (*Salvelinus namaycush*)
- Rainbow (Steelhead) Trout (*Oncorhynchus mykiss*)
- Brown trout (*Salmo trutta*)
- Rainbow smelt (*Osmerus mordax*)

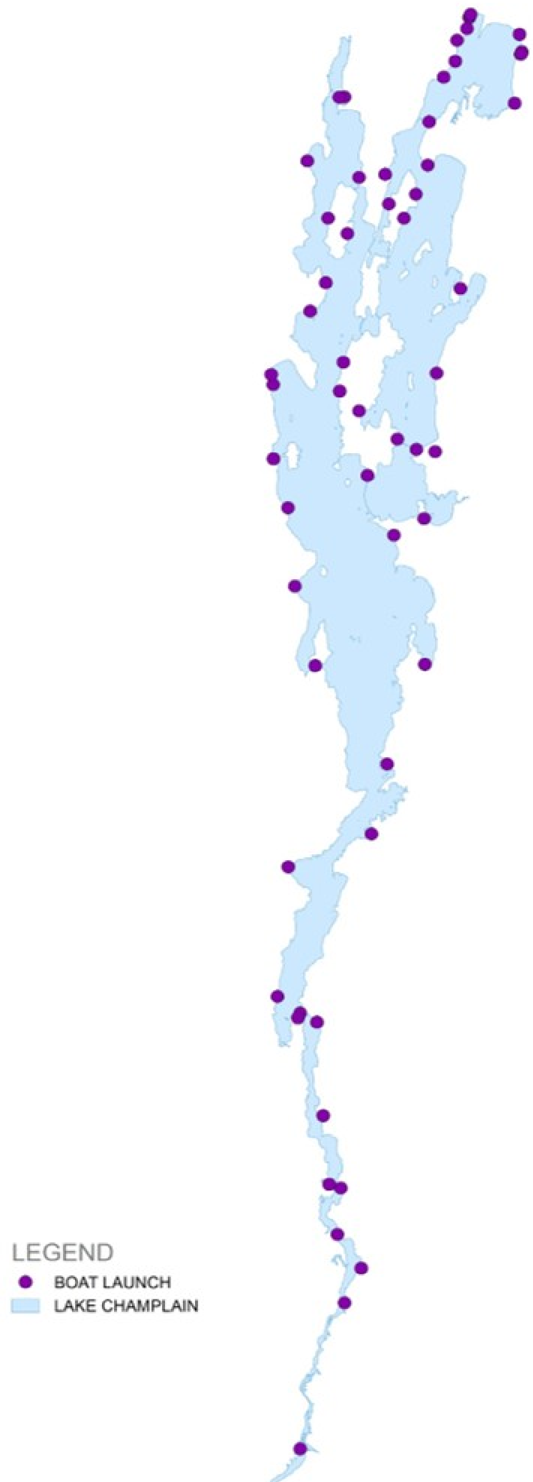


Figure 7. Boat launch access locations in Lake Champlain (Source: LCBP 2018f).

A reciprocal agreement between New York and Vermont went into effect in

2004, allowing anglers with either a New York or Vermont fishing license to fish most of the lake. New York State fishing regulations are applicable to all areas of Lake Champlain for both regular fishing and ice fishing. Both Clinton County and Essex County stocked brown trout directly to Lake Champlain in 2017, and many tributaries to the lake were stocked with brook trout, brown trout, and rainbow trout (NYSDEC 2017a). Recent changes in the fish assemblage of Lake Champlain has resulted in shifts in the food web that may increase the abundance and change the community structure of cyanobacteria present in the lake (see **Section 6.3**).

Fish consumption use in Lake Champlain is impaired due to contamination from two primary contaminants, polychlorinated biphenyls (PCBs) and mercury. Since 1998, health advisories restricting the consumption of prized sport and food fish, such as lake trout and walleye, have been issued based on elevated PCBs and mercury levels stemming from contaminated lake sediments and atmospheric deposition, respectively (NYSDEC 2009). Current whole-lake advisories issued by the New York State Department of Health (NYSDOH) are as follows for men over 15 years of age and women over 50 years of age:

- Walleye: Greater than 19", up to 1 meal/month; less than 19", up to 4 meals/month (mercury)
- Lake Trout: Greater than 25", up to 1 meal/month; less than 25", up to 4 meals/month (PCBs)
- All other fish: Up to 4 meals/month (mercury and PCBs)

Children under 15 and women under 50 are recommended not to eat fish from Lake Champlain (NYSDOH 2018a). No advisories specific to the Port Henry or Isle La Motte areas have been issued. In addition, until the recent cleanup efforts focused on PCBs, it was also advised in Cumberland Bay that no meals of brown bullhead and no more than one meal per month of American eel (*Anguilla rostrata*) and yellow perch be consumed. These advisories specific for Cumberland Bay have been removed as a result of PCB remediation efforts in the bay.

Fishing should be avoided in areas where there are visible algal blooms, and fish caught in areas with visible algal blooms should not be consumed.[1]

3.6 Aquatic Life Uses

The majority of Lake Champlain's upper and middle Main Lake segments are Class A(T) waters, suitable for fish (including trout) propagation and survival. The lake's southern segment (south of Crown Point Bridge) is a Class B watercourse, also with best uses for fish propagation and survival. As described above, a variety of both

[1] New York State Department of Health – Information on chemicals in sportfish and game (https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/additional_information.htm#chemicals)

warmwater and coldwater fish species are established in Lake Champlain, with the coldwater fishery predominant in the lake's northern and middle lake segments.

3.6.1 Lake Champlain at Port Henry

No aquatic life use impairment was identified in a broader lake segment stretching from Split Rock Point near Whallonsburg, NY down to the Crown Point Bridge near Point Henry (NYSDEC 2009). As discussed above, this section of Lake Champlain is a Class A(T) water, which is best used for fish (including trout) propagation and survival.

An evaluation of aquatic life use in the tributaries associated with the Port Henry section of the lake is based on water quality assessments conducted through New York's Rotating Integrated Basin Studies' (RIBS) multi-year monitoring of benthic macroinvertebrate communities in various watercourses. A biological (macroinvertebrate) assessment of McKenzie Brook in Port Henry (at Route 22) was conducted as part of the RIBS biological screening effort in 2003. Based on the results of this study and a similar study conducted in 1998, the aquatic life use was considered to be "fully supported", although not formally categorized in NYSDEC's Waterbody Inventory/Priority Waterbody List (WI/PWL) (NYSDEC 2009). Because McKenzie Brook is one of many tributaries to Lake Champlain in Port Henry, and is representative of water quality in the area as a whole, aquatic life support was considered fully supported for the local Port Henry area.

3.6.2 Lake Champlain at Isle La Motte

The aquatic life use for the lake's northern Main Lake segment is not categorized in NYSDEC's WI/PWL (NYSDEC 2009). However, this section of Lake Champlain is a Class A(T) water, which includes a best usage of fishing (including trout). Water quality in the tributaries of this section, which stretches from the Canadian border to Cumberland Bay and encompasses the Isle La Motte area, is monitored as part of New York's RIBS program. Ongoing sampling of benthic macroinvertebrates at a location on the Richelieu River in Rouses Point, NY, considered to be representative of the upper lake segment, indicates that the aquatic life support is "fully supported". A RIBS station in the lower Great Chazy River near Route 9 in Chazy, New York also yielded benthic macroinvertebrate community results demonstrating that aquatic life uses in this watershed were being met (NYSDEC 2009).

Careful management of the sport fishery in Lake Champlain, coupled with the general absence of observable impairment to the aquatic life support in the lake and several primary tributaries, suggests that the fish species assemblage and its potential cascading regulating effects on lower trophic levels (e.g., zooplankton) is not a driver for HABs formations in Lake Champlain. However, the presence of alewife (*Alosa pseudoharengus*), an invasive alosid in the lake that forages selectively on larger prey organisms, may exert "top-down" effects on the plankton community, leading to smaller individuals of zooplankton that are less efficient feeders of phytoplankton, which can contribute to HABs. This trophic interaction is discussed in greater detail in **Section 6.3**.

3.7 Other Uses

Many wildlife including birds and mammals rely on Lake Champlain and its shoreline for foraging, roosting, and nesting. More than 300 bird species have been identified breeding, overwintering, or passing through the Lake Champlain basin during migration (LCBP 2018g). Fifty-six species of mammals are residents in the Lake Champlain basin, including six species listed as threatened or endangered in New York, Vermont, or federally. Wildlife viewing generates at least $50 million per year and many of these species are threatened by reduced water quality and loss of habitat due to pollutants (LCBA 2018g).

4. User and Stakeholder Groups

4.1 General Lake Champlain

Lake Champlain is used by all age groups, including fulltime and seasonal homeowners of shoreline properties, homeowner guests, day or extended stay recreationists, sportsman's clubs, and tourists. These user groups may engage in one or several of the recreational activities described in **Section 3.4**. Access to the lake is available to the public at many entry points, including municipal, city, and state parks, marinas, public boat launches, and public beaches. Shoreline residents and their guests may also access the lake directly via private docks, piers, and boat launches.

The LCBP reports that more than 40 local and regional watershed associations and environmental organizations actively participate in addressing various issues within the Lake Champlain Basin. These groups rely primarily on volunteers to advance their work, from education and public outreach to filing to tree plantings (LCBP 2018h). Twenty (20) of these organizations are located in New York.

The mission of the LCBP, located in Grand Isle, VT, is to protect and restore Lake Champlain and its surrounding watersheds for future generations. These protection and restoration efforts are guided by a lake management plan (*Opportunities for Action: An Evolving Plan for the Lake Champlain Basin*, LCBP 2017), which is periodically updated in response to recent data and changing lake issues. The program is administered cooperatively by several agencies, including the following:

- USEPA New England (Region 1)
- USEPA Region 2
- NYSDEC
- Vermont Agency of Natural Resources (VTANR)
- Québec Ministry of Sustainable Development, Environment, Fauna and Parks
- New England Interstate Water Pollution Control Commission

The cooperation of these stakeholders is governed through a Memorandum of Understanding, whose central tenets include, among others:

"…cooperative management of Lake Champlain and its watershed to enhance and preserve the character of the Lake and its environs…"

The LCBP plays a major role in addressing potential HABs in the lake through interventions across the lake's watershed that reduce pollutant loads contributing to HABs, and monitoring and tracking the extent of HABs when they occur (LCBP 2017).

In addition to the LCBP, other notable lake and watershed user groups include:

- Lake Champlain Committee (LCC) – this Burlington, VT-based bi-state citizens' organization is dedicated to the protection of lake health and accessibility. The LCC enacted a lakewide cyanobacteria monitoring program in 2004 funded by the LCBP and LCC members. The volunteer monitoring program is intended to raise public awareness of HABs and to build a database of information on bloom frequency and potential health hazards (LCC 2018b).

- The Champlain Watershed Improvement Coalition of New York, Inc. (CWICNY) was formed to work on more water quality improvement initiatives on the New York side of Lake Champlain. It includes representatives from the five county Soil and Water Conservation Districts and the five county Water Quality Coordinating Committees adjacent to Lake Champlain as well as the Lake Champlain/Lake George Regional Planning Board and incorporates public sector/private citizen partnerships to complete projects good for the watershed as a whole. The objective of CWICNY is to reduce phosphorus loading to Lake Champlain through the implementation of numerous projects and practices throughout the New York side of the Lake Champlain watershed. These reductions can have a long-term positive impact upon the water quality and occurrence of HABs as well as the lake and watershed ecology.

- The Lake Champlain Chapter of Trout Unlimited (TU), located within the Saranac River and Isle La Motte subwatersheds, is part of a national group of approximately 300,000 members that are dedicated to conserve, protect and restore North America's coldwater fisheries and their watersheds. The potential for harmful impacts from HABs to trout and salmon, and to fishing opportunities for these species, in Lake Champlain is likely to be a key concern and conservation driver for the TU Lake Champlain Chapter.

- Friends of Northern Lake Champlain, formerly Friends of Missisquoi Bay, is a non-profit organization located in Vermont that works on finding solutions to improve water quality in northern Lake Champlain, including New York. By working collaboratively with many partners, including local communities, farmers, and government they are working to reduce polluted runoff into Lake Champlain to reduce HABs.

5. Monitoring Efforts

5.1 Lake Monitoring Activities

Water quality sampling of Lake Champlain has been conducted primarily through the Lake Champlain Long-Term Water Quality and Biological Monitoring Project (LCLTMP), which was established to "*measure overall ecosystem health of Lake Champlain based on key ecosystem indicators and to assess long-term effects of management actions and other environmental changes."* (State of Vermont 2018). The LCLTMP is co-managed by the NY and VT DECs with funding support through the LCBP. Water quality laboratory results are certified through the National Environmental Laboratory Accreditation Program (NELAP) and supported by a Quality Assurance Project Plan (QAPP).

The LCLTMP, established in the early 1990s, focuses on monitoring water quality at 15 established monitoring locations in Lake Champlain (**Figure 8**). The primary purpose of the LCLTMP has shifted through the years, beginning with a limnological survey to develop various models intended to inform nutrient loadings and food web effects. In 1995, the program shifted focus to document long-term change in Lake Champlain, and data collection efforts included those determined most indicative of changes in the lake environment. In 2006, the changes in the LCLTMP included elements of ecosystem indicators, aligning with the LCBP, which include ecological and social measures of ecosystem function.

Monitoring stations are sampled bi-weekly from late April through October. A multi-probe sonde is used to measure temperature, dissolved oxygen concentrations, conductivity, and pH. Biological data collected include chlorophyll-a concentrations and phytoplankton composition, zooplankton and mysid abundance, and zebra mussel veliger (e.g., larval stage) abundance. A suite of chemical parameters is also analyzed.

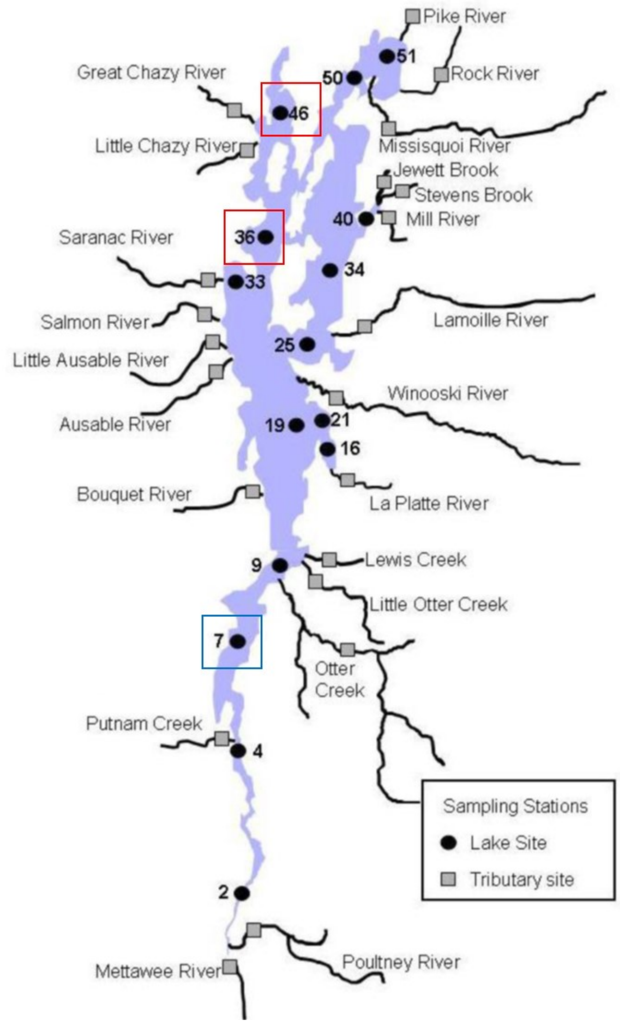


Figure 8. Monitoring stations in Lake Champlain and tributaries as part of the Lake Champlain Long-Term Water Quality and Biological Monitoring Project (LCLTMP). Figure modified from Vermont Phosphorus Total Maximum Daily Load (TMDL) for VT Segments of Lake Champlain (June 2016), sourced from the LCBP, 2013. Station 7 (blue square) is the monitoring location for data collected for Port Henry; Stations 36 and 46 (red squares) correspond to monitoring locations for Isle La Motte.

In addition to the LCLTMP monitoring program described above, Vermont has collected water quality data at approximately 20 stations in Lake Champlain since 1979 through the Lay Monitoring Program. Data collected include summer Secchi depth, TP, and chlorophyll-a concentrations. Sampling locations of the Lay Monitoring Program are all within the Vermont portions of Lake Champlain and are not included in the analyses of this report.

Various entities have documented HABs in Lake Champlain. Sources of information include status of blooms documented by NYSDEC and the NYSDOH. Since 2004, additional HAB monitoring has been conducted by the LCC, with records housed by the Vermont Department of Health (VTDOH) through the Lake Champlain Cyanobacteria Tracking map (VTDOH 2018b). The LCC annually enlists and trains volunteer to identify and report cyanobacteria blooms. The program was expanded in 2012 to include more areas of Lake Champlain and more frequent sampling, volunteers go out to a designated location once a week from mid-June through Labor Day. The information is used by health officials to assess safety of bathing beaches. This monitoring effort focuses on the Vermont portions of Lake Champlain.

5.1.1 Lake Champlain at Port Henry

Water quality and biological data are collected in the Port Henry section of Lake Champlain as part of the LCLTMP (**Figure 8**). Data collected at the Port Henry monitoring station (#7) included in this Action Plan encompass sampling from 1992 through 2016.

5.1.2 Lake Champlain at Isle La Motte

There are two monitoring stations within the Isle La Motte section of Lake Champlain (Stations 36 and 46, **Figure 8**). The monitoring results at these two stations are presented separately in subsequent sections of this Action Plan due (primarily) to differences in depth between the two locations (e.g., deeper water depth at Station 36 (164 feet) compared to Station 46 (23 feet) to the north).

5.2 Tributary Monitoring Activities, General Lake Champlain

The United States Geological Survey (USGS) gauged tributaries to Lake Champlain are also monitored through the LCLTMP (**Figure 8**). Tributary monitoring stations correspond to bridge crossings near river mouths (e.g., close to Lake Champlain). Sampling events typically are conducted throughout the open-water season during high flow events, although, a subset of base flow samples is collected at each site. In addition to the monitoring through the LCLTMP, the USGS compiles annual estimates of tributary flow and loading data, including total phosphorus (TP), total dissolved phosphorus (TDP), and total nitrogen (TN) to Lake Champlain, from 1990 to 2012 (Medalie 2014).

5.2.1 Lake Champlain at Port Henry

Tributaries to the Port Henry segment of Lake Champlain, specifically, are not monitored through the LCLTMP (**Figure 8**).

5.2.2 Lake Champlain at Isle La Motte

Tributaries monitored through the LCLTMP in the Isle La Motte segment of Lake Champlain include the Little Chazy River and the Great Chazy River (**Figure 8**).

6. Water Quality Conditions

Water quality targets for TP have been established for various lake segments in Lake Champlain. For the Port Henry and Isle La Motte segments, target TP concentrations below a threshold of 0.014 mg/L (14 μg/L) have been established (VTANR and NYSDEC 2002).

General long-term trends in water quality conditions were assessed using data from 1992 to 2016 collected by the LCLTMP. Statistical significance of time trends from 1992 to 2016 were evaluated using a Kendall's tau (τ) trend test of annual values. The nonparametric correlation coefficient Kendall's tau was calculated to determine if time trends were significantly different than zero or no trend. The value of Kendall's tau that denotes a significant difference varies depending on sample size. A significant difference is assumed for probability (p) values less than 0.05. Water quality data used in this analysis were limited to those that were collected under a State-approved QAPP, and analyzed at a NELAP-certified laboratory.

Compared to the average New York State lake, Port Henry (monitoring station 7) and Isle La Motte (Stations 36 and 46) had lower average TP concentrations; however, compared to nearby lakes (Eastern Adirondack region), TP concentrations were on average higher in the two study regions of Lake Champlain (**Table 3**). In freshwater lakes, phosphorus is typically the nutrient that limits plant growth; therefore, when excess phosphorus becomes available from point sources or nonpoint sources, primary production can continue unchecked leading to algal blooms. Note that phosphorus form is an important consideration when evaluating management alternatives (**Section 13**).

Table 3. Regional summary of surface total phosphorus (TP) concentrations (mg/L, ± standard error) for New York State lakes (2012-2017, CSLAP and LCI), and average TP concentrations (± standard error) in the three sample locations in Lake Champlain, 1992 to 2016.

Region	Number of Lakes	Average TP (mg/L)	Average TP Port Henry (mg/L) 1992 to 2016	Average TP Isle La Motte Station 36 (mg/L) 1992 to 2016	Average TP Isle La Motte Station 46 (mg/L) 1992 to 2016
NYS	521	0.034 (± 0.003)	-	-	-
NYC-LI	27	0.123 (± 0.033)	-	-	-
Lower Hudson	49	0.040 (± 0.005)	-	-	-
Mid-Hudson	53	0.033 (± 0.008)	-	-	-
Mohawk	29	0.040 (± 0.009)	-	-	-
Eastern Adirondack	112	0.010 (± 0.0004)	0.016 (± 0.0002)	0.013 (± 0.0002)	0.017 (± 0.0003)
Western Adirondack	88	0.012 (± 0.001)	-	-	-
Central NY	60	0.024 (± 0.005)	-	-	-
Finger Lakes region	45	0.077 (± 0.022)	-	-	-
Finger Lakes	11	0.015 (± 0.003)	-	-	-
Western NY	47	0.045 (± 0.008)	-	-	-

In general, Lake Champlain is considered mesotrophic (moderate productivity), although, productivity varies greatly among lake segments (VTANR and NYSDEC 2002). The South Lake A, South Lake B, Missisquoi Bay and St. Albans Bay lake segments water quality conditions are typically indicative of eutrophic conditions (high productivity) and have TP levels ranging between 0.024 – 0.058 mg/L (VTANR and NYSDEC 2002).

Target segments for this report, Port Henry and Isle La Motte, are considered mesotrophic. Water clarity (based on Secchi depth, m), TP (mg/L), and chlorophyll-a (μg/L) concentrations are used to assess trophic state using New York State criteria (**Table 4**).

Table 4. New York State criteria for trophic classifications (NYSFOLA 2009), and average values (± standard error) for the Lake Champlain sampling locations (LCLTMP).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Port Henry 1992 to 2016[1]	Isle La Motte – Station 36 1992 to 2016[1]	Isle La Motte – Station 46 1992 to 2016[1]
Transparency (m)	>5	2-5	<2	4.0 ± 0.06	5.2 ± 0.07	4.7 ± 0.06
TP (mg/L)	<0.010	0.010-0.020	>0.020	0.016 ± 0.0002	0.013 ± 0.0002	0.017 ± 0.0003
Chlorophyll a (μg/L)	<2	2-8	>8	5.5 ± 0.20	3.6 ± 0.1	3.4 ± 0.2

[1] Chlorophyll-a data from 1995 to 2016

6.1 Physical Conditions

6.1.1 Lake Champlain at Port Henry

Water clarity can be related to the amount of suspended material in the water column including sediment, algae, and cyanobacteria. Port Henry average annual water clarity, indicates mesotrophic (moderate productivity) conditions. Although water clarity tended to be lower during earlier years (early to mid-1990s), strong annual trends (e.g., increasing or decreasing water clarity over time) in water clarity were not observed (**Figure 9**). Within years, water clarity measurements were lower early in the growing season, and in a few instances, fell below 2 m (6.6 feet). Water clarity increased seasonally to greater than 5 min in all but six years between 1992 and 2016 (**Figure 9**). This general trend of lower water clarity earlier in the growing season in most years may reflect increased runoff and turbidity associated with spring snowmelt and precipitation, which could result in seasonal differences in watershed nutrient loads affecting HABs. Secchi disk transparency readings regularly exceeded the 1.2-meter (4 feet) New York State Sanitary Code requirements for siting new bathing beaches (NYSDOH 2018). However, such trophic indicators should continue to be monitored for any changes.

Long term trends in water clarity from 1992 to 2016 indicated a non-significant decrease in water clarity at the Port Henry location (p = 0.207, τ = -0.180). In general, mean annual water clarity during this time was generally over 4 m (13.1 feet). A shift to lower annual mean water clarity was observed between 2003 and 2005. Annual mean water clarity did not exceed 4 m (13.1 feet) since 2005 except in 2014 and 2016.

Seasonal water temperature (**Figure 10)** trends at the Port Henry sampling station follow typical season trends, where water temperatures increase through May and June and decrease in September and October. Additionally, surface water temperatures above 20°C have significantly increased over time (p = 0.001, τ = 0.477), suggesting that water temperatures may be becoming more favorable for HABs (Paerl and Huisman 2008); however, this increasing trend in surface water temperature may be an artifact of increased sampling frequency in more recent years.

Temperature depth profiles (1995-2005) indicate that thermal stratification is strong at the Port Henry locations throughout the growing season (May-Oct. each year). Current data do not document any mixing events during the sampling period at the Port Henry locations.

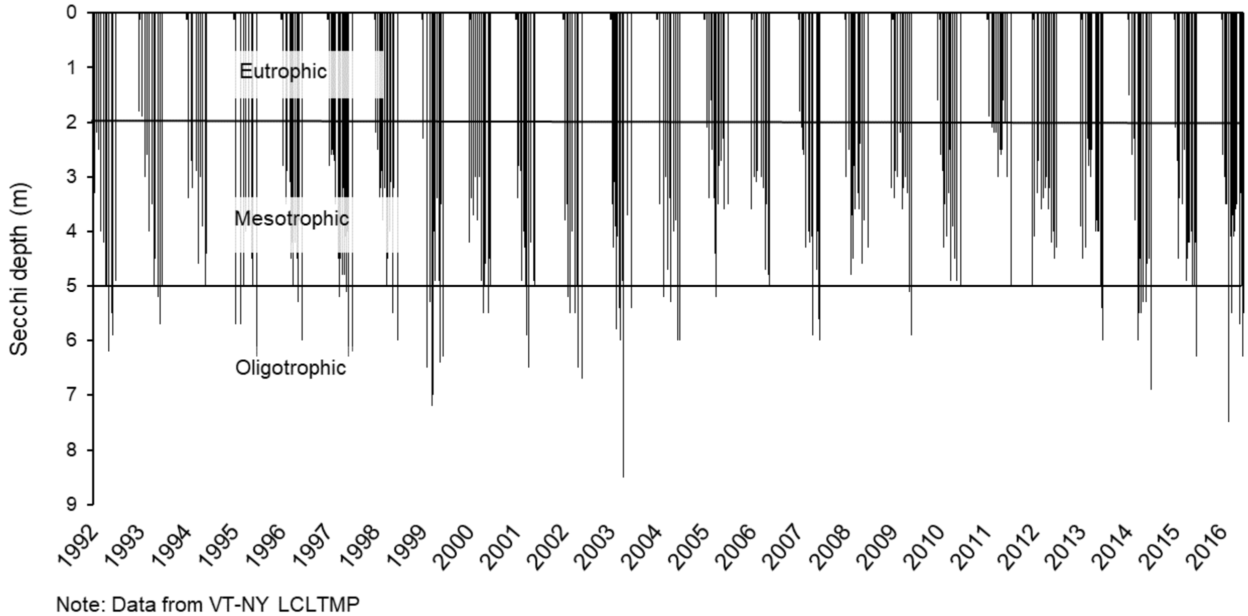


Figure 9. Port Henry water clarity from 1992 to 2016 (May through October each year), measured as Secchi depth (m).

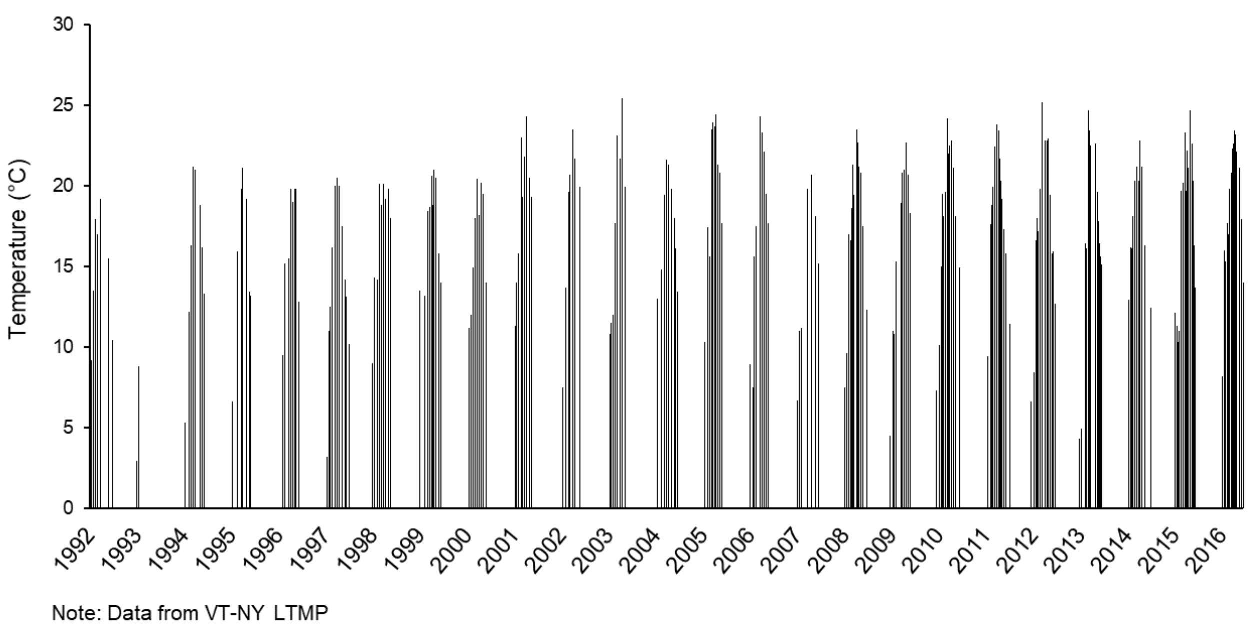


Figure 10. Surface water temperature (°C) for Port Henry, 1992 to 2016. Water temperature has significantly increased over time.

6.1.2 Lake Champlain at Isle La Motte

Water clarity measurements at Isle La Motte on average indicated oligotrophic (low productivity) conditions at both stations in this region (**Figure 11**). Within years, water clarity measurements were generally lower during the middle of the growing season, with higher clarity, typically greater than 5 m (16.4 feet), observed early and late in the growing season, (**Figure 11**). Secchi disk transparency readings regularly exceed the 1.2-meter (4 feet) New York State Sanitary Code requirements for siting new bathing beaches (NYSDOH 2018). However, such trophic indicators should continue to be monitored for any changes.

Long term trends in water clarity from 1992 to 2016 indicate that water clarity has decreased slightly at the southern location (Station 36, τ = -0.126), while remaining relatively constant at the northern location (Station 46, τ = 0.047), although these trends in water clarity were not statistically significant (p = 0.366 and p = 0.744, respectively). At Station 36, mean annual water clarity generally hovered around 5 m (16.4 feet) between 1992 to 2003 with a few years closer to 6 m and one year approaching 7 m (23 feet) average. Between 2004 to 2017 mean annual average again was generally around the 5 m (16.4 feet) depth, but with a few years with annual average less than 5.0 with one annual average less than 4 m (13.1 feet). At Station 46, mean annual water quality was low between 1992 to 1998 and 2010 to 2016 (3.5 to 4.5 m [11.5 to 14.8 foot] depth), and a bit higher in the intermediate years, from 1999 to 2009 (4.5 to 5.5 m [14.8 to 18 foot] depth).

Seasonal water temperature (**Figure 12**) trends at the Isle La Motte sampling stations follow typical season trends, where water temperatures increase through May and June and decrease in September and October. There are no obvious long-term average trends in temperature at either station between 1992 and 2016 (p-values > 0.05), with maximum water temperatures ranging from 20°C (68 °F) to 25°C (77 °F). Temperature depth profiles (1992-2016) indicate a lack of thermal stratification at the shallower Station 46 (maximum depth approximately 7 m), and strong stratification at Station 36 (maximum depth 50 m [164 feet]) throughout the growing season (May-Oct.) each year).

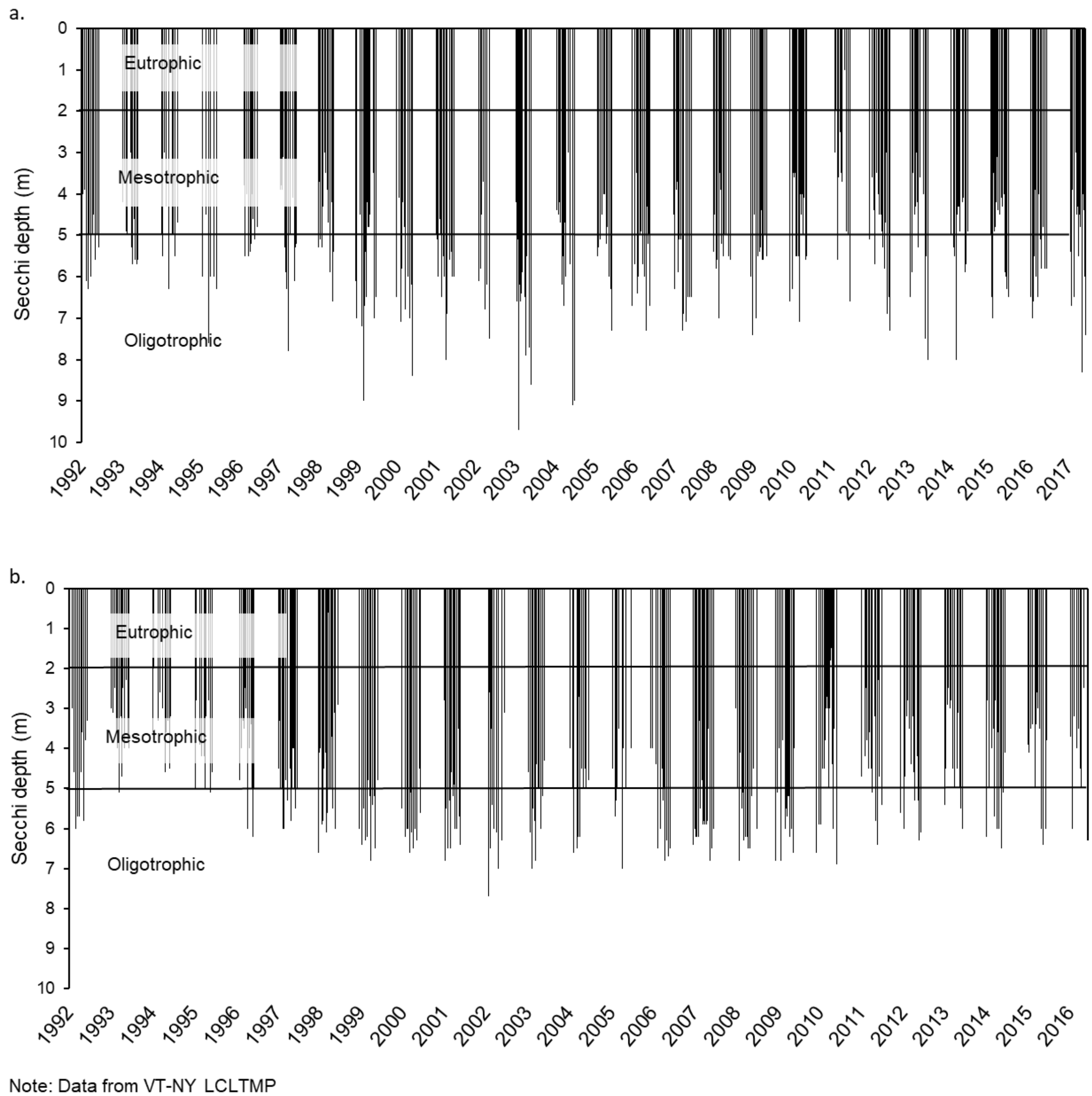


Figure 11. Water clarity, measured as Secchi depth (m), from (a) Station 36 and (b) Station 46 located in the Isle La Motte segment of Lake Champlain.

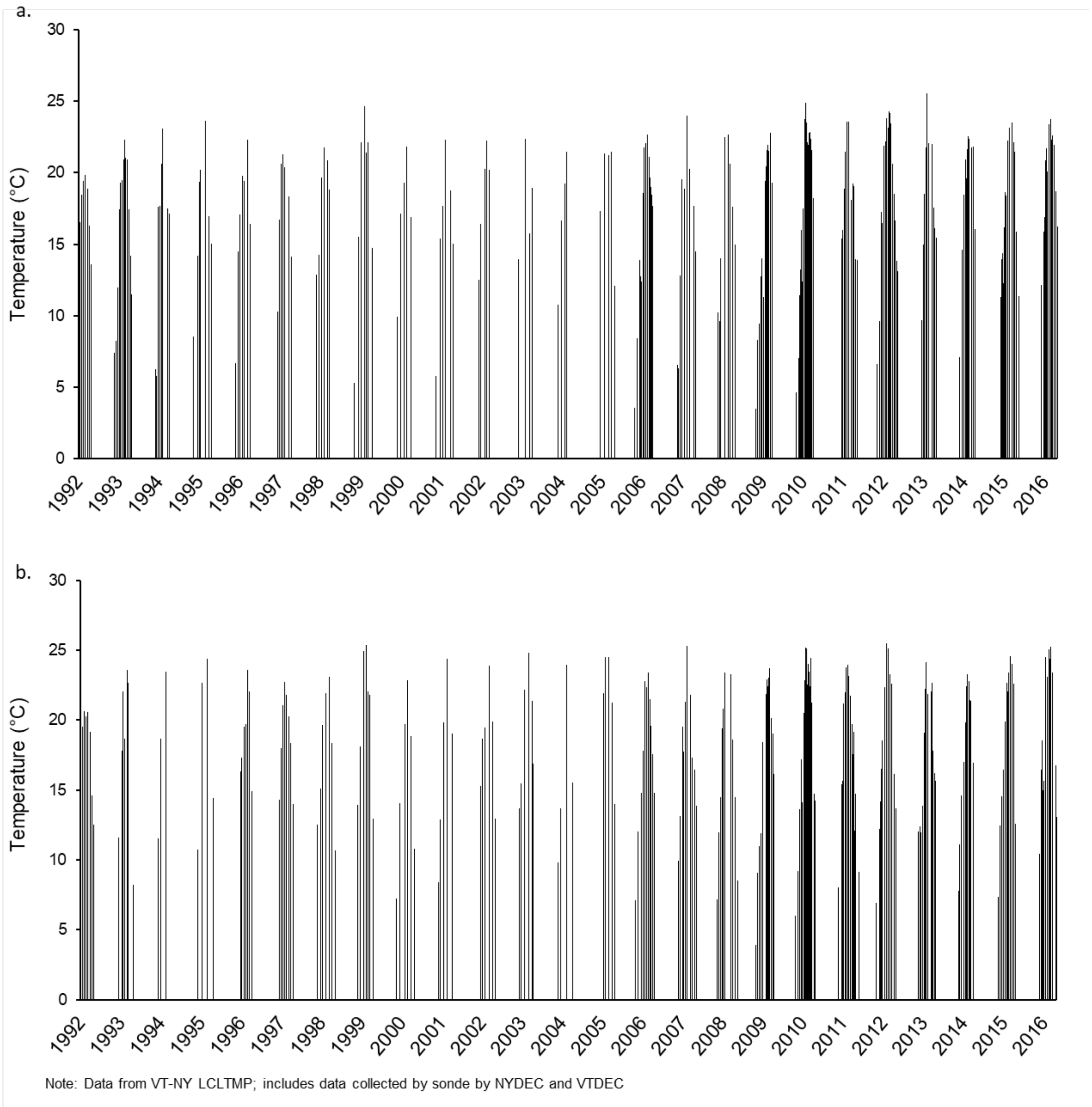


Figure 12. Surface water temperatures (°C) from (a) Station 36 and (b) Station 46 located in the Isle La Motte segment of Lake Champlain.

6.2 Chemical Conditions

6.2.1 Lake Champlain at Port Henry

Bottom concentrations of dissolved oxygen (DO, **Figure 13**) at the Port Henry location ranged from 7.8 to 13.2 mg/L. DO concentrations were higher in May and June and decreased throughout the growing season. These changes in DO concentrations are related to the lower solubility of oxygen into water at higher temperatures. The high levels of DO at increased depth indicates that hypoxic/anoxic conditions are not present at the Port Henry location.

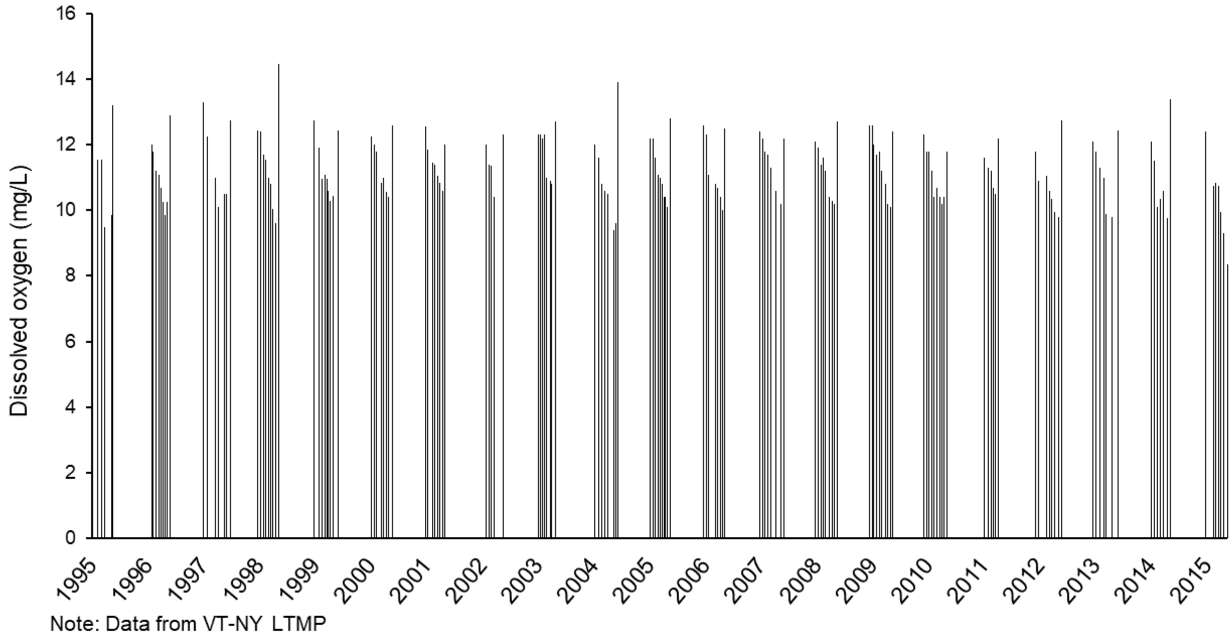
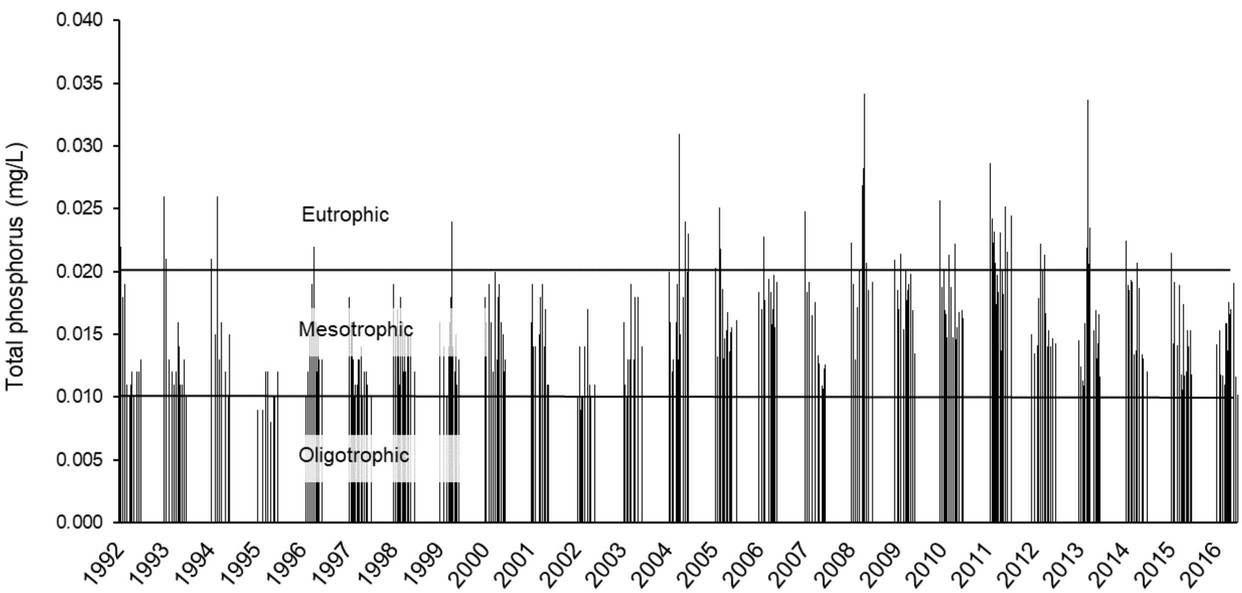


Figure 13. Dissolved oxygen (DO) concentrations (mg/L) in bottom water (44-45 m depth) for Port Henry, 1995-2016.

Total phosphorus (TP, **Figure 14**) concentrations, based on annual averages, have been indicative of mesotrophic conditions (moderate productivity). Long-term trends were observed with a significant (p = 0.027, τ = 0.330) increase in mean annual TP concentration from 1992 to 2011. Note, however, mean annual TP concentrations decreased from 2011 to 2016 (**Figure 14**). Annual maximum TP concentrations typically reach levels exceeded the state water quality guidance value (0.02 mg/L). A general seasonal trend in TP was not observed at the Port Henry location.

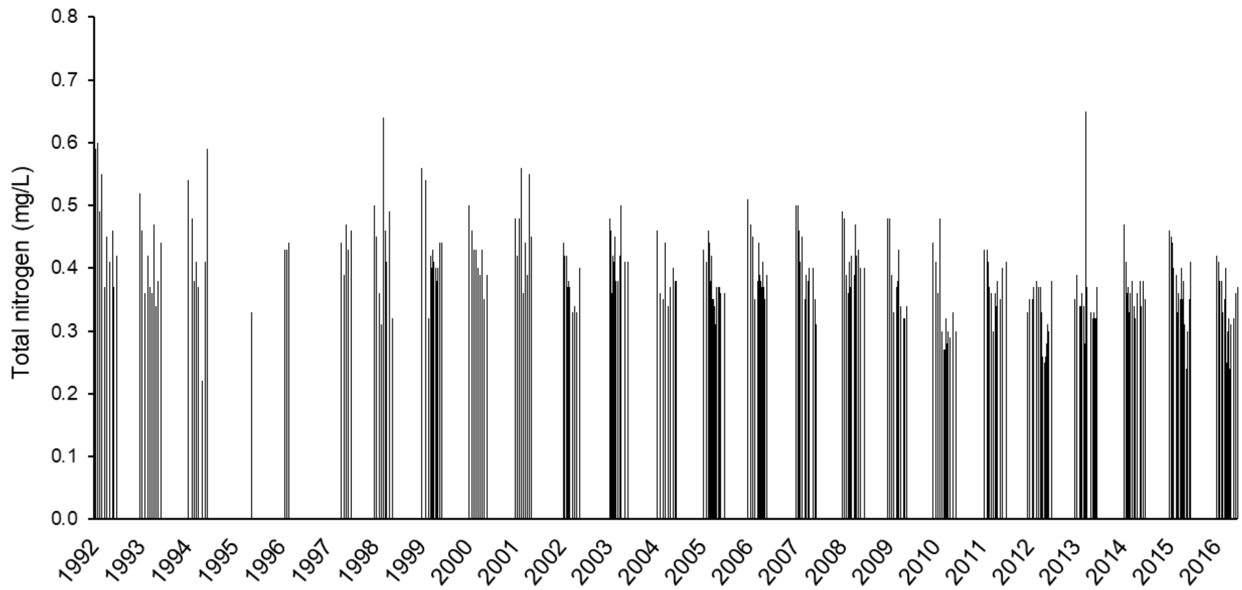
Seasonal trends in total nitrogen (TN, **Figure 15**) were not observed at the Port Henry location. Average annual TN concentrations decreased significantly (p < 0.001, τ = -0.542) between 1992 to 2016. TN concentrations were not indicative of eutrophic conditions (> 0.6 mg/L, Canfield et al. 1983) at the Port Henry location.

The total nitrogen (TN) to total phosphorus (TP) ratio (**Figure 16**) in lakes can be used as a suitable index to determine if algal growth is limited by nitrogen or phosphorus concentrations (Lv et al. 2011). Ratios of TN to TP (by mass) at the Port Henry location indicate that algal biomass is limited by phosphorus (TN:TP ratio > 17) throughout most of the growing season. A significant ($p < 0.001$, $\tau = -0.520$) decreasing long term trend in the ratio of TN to TP since 1992 was driven by decreasing TN concentrations over time. Cyanobacteria blooms are typically rare in lakes where mass based TN:TP ratios are greater than 29:1 (Filstrup et al. 2016, Smith 1983). This is thought to occur because cyanobacteria can take up and use nitrogen more efficiently than algae and thus be more competitive when nitrogen becomes limiting. This ratio is higher than the ratio when nitrogen is the limiting nutrient (TN:TP <10) because phosphorus and other micronutrients are required by cyanobacteria to perform nitrogen fixation (nitrogenase, the N-fixing enzyme requires relatively high concentrations of P to operate) (Mantzouki et al. 2016). In addition, TN:TP ratios can play a role in the community structure of cyanobacteria. When nitrogen becomes limited, nitrogen fixing cyanobacteria (e.g. *Aphanizomenon*) are typically more prevalent and blooms of these species are more likely to occur.



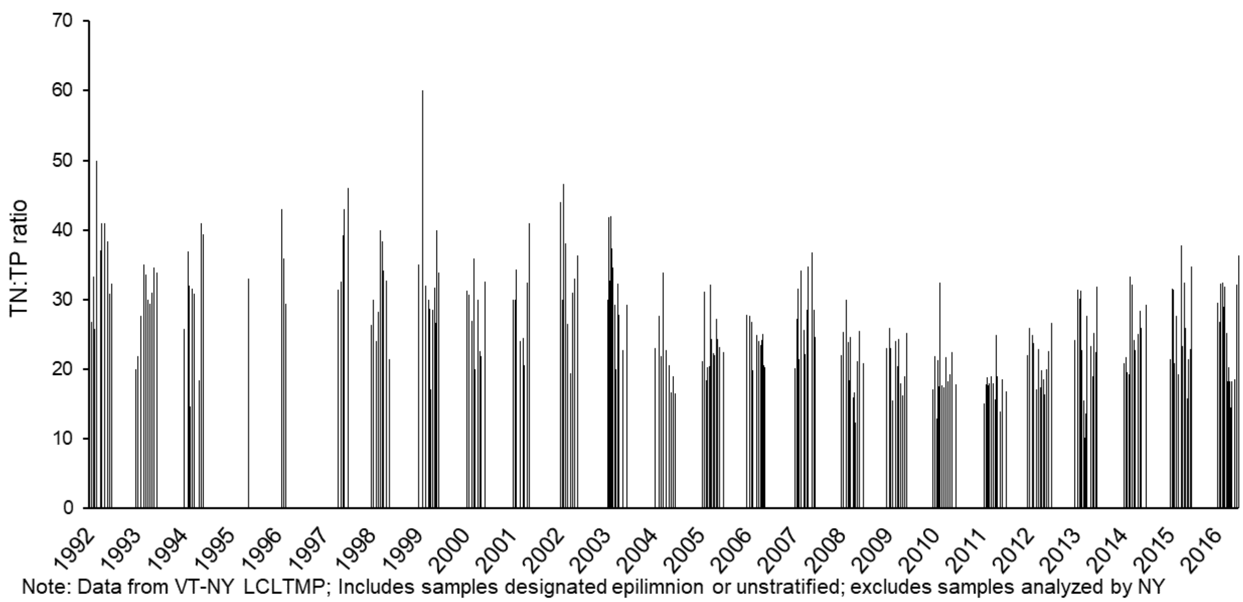
Note: Data from VT-NY LCLTMP; Includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 14. Total phosphorus (TP) concentrations (mg/L) for Port Henry, 1992 to 2016.



Note: Data from VT-NY LCLTMP; Includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 15. Total nitrogen concentrations (mg/L) for Port Henry, 1992 to 2016.



Note: Data from VT-NY LCLTMP; Includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 16. Ratio of total nitrogen (TN) to total phosphorus (TP), by mass, in Port Henry water samples from 1992 to 2016.

6.2.2 Lake Champlain at Isle La Motte

Bottom concentrations of DO **(Figure 17**) at the Isle La Motte location ranged from 6.6 to 13.2 mg/L. DO concentrations were higher in May and June and decreased throughout the growing season. Concentrations were similar between the two Isle La Motte monitoring stations (Stations 36 and 46). Long term trends in DO from 1992 to 2016 were not observed. The DO depth profile from 0 to 45 m (0 to 148 feet) did not indicate any general trends throughout the growing season. The high levels of DO at depth indicate that hypoxic /anoxic conditions are not present at either of the Isle La Motte locations.

Total phosphorus (TP, **Figure 18**) concentrations, on average, were indicative of mesotrophic conditions (moderate productivity) at the Isle La Motte region. Observed TP concentrations at Station 46 (northern location, **Figure 8**) are generally higher than Station 36. Annual maximum TP concentrations typically reached levels higher than the state water quality guidance value [0.02 mg/L]) at Station 46, but are less likely to reach this threshold at Station 36. A general seasonal trend in TP was not observed at either Isle La Motte location. Long term trends in TP concentrations were not observed at Station 36 (p = 0.051). However, a significant (p = 0.029, τ = 0.328) increasing trend was observed in TP concentrations from 1992 to 2016 at Station 46 (**Figure 18b**).

Seasonal trends in total nitrogen (TN, **Figure 19**) were not observed at the Isle La Motte locations. Significant decreasing long term trends in average annual TN concentrations were observed at Stations 36 (p < 0.001, τ = -0.571) and 46 (p = 0.018, τ = -0.338) from 1992 to 2016. TN concentrations were not indicative of eutrophic conditions (> 0.6 mg/L, Canfield et al. 1983) at either Isle La Motte location.

Ratios of TN to TP (by mass) at Station 36 (**Figure 20**) indicate that algal biomass is limited by phosphorus (TN:TP ratio > 17) throughout most of the growing season. At Station 46 (**Figure 8**), the TN to TP ratios during the later months of the growing season (August to October) were reduced compared to samples collected earlier in the season. This reduced TN:TP ratio indicates that algal biomass is more likely to be limited by nitrogen from August to September. A significant (p < 0.001, τ = -0.600) decrease in the ratio of TN to TP at Station 36 since 1992 indicates that algal growth is less likely to be limited by TP concentrations at these locations over time. The significant decrease in the TN to TP ratio at the southern location (Station 36) was primarily driven by decreases in TN concentrations, indicating that algae biomass may be more likely to be limited by nitrogen in recent years.

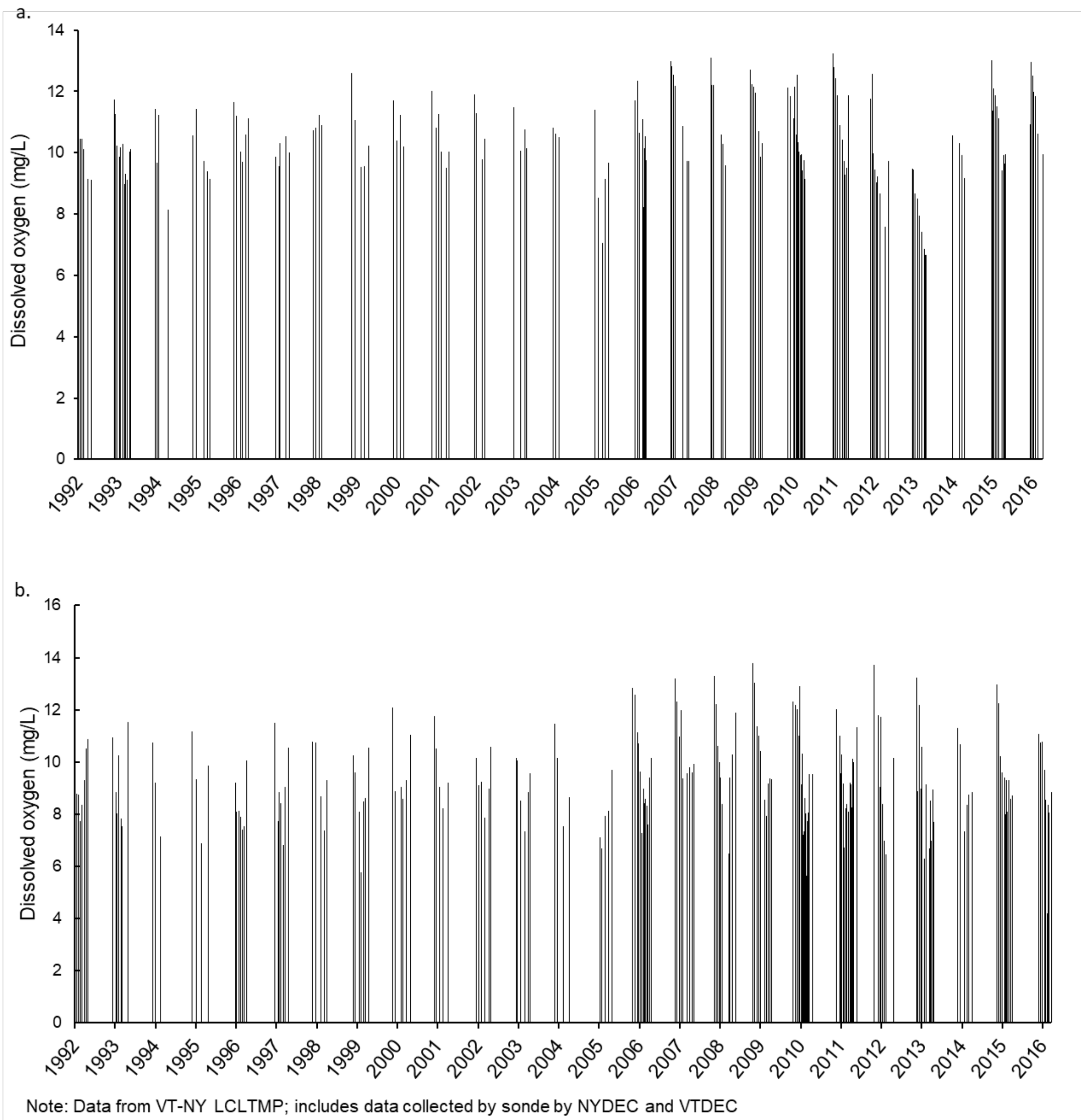
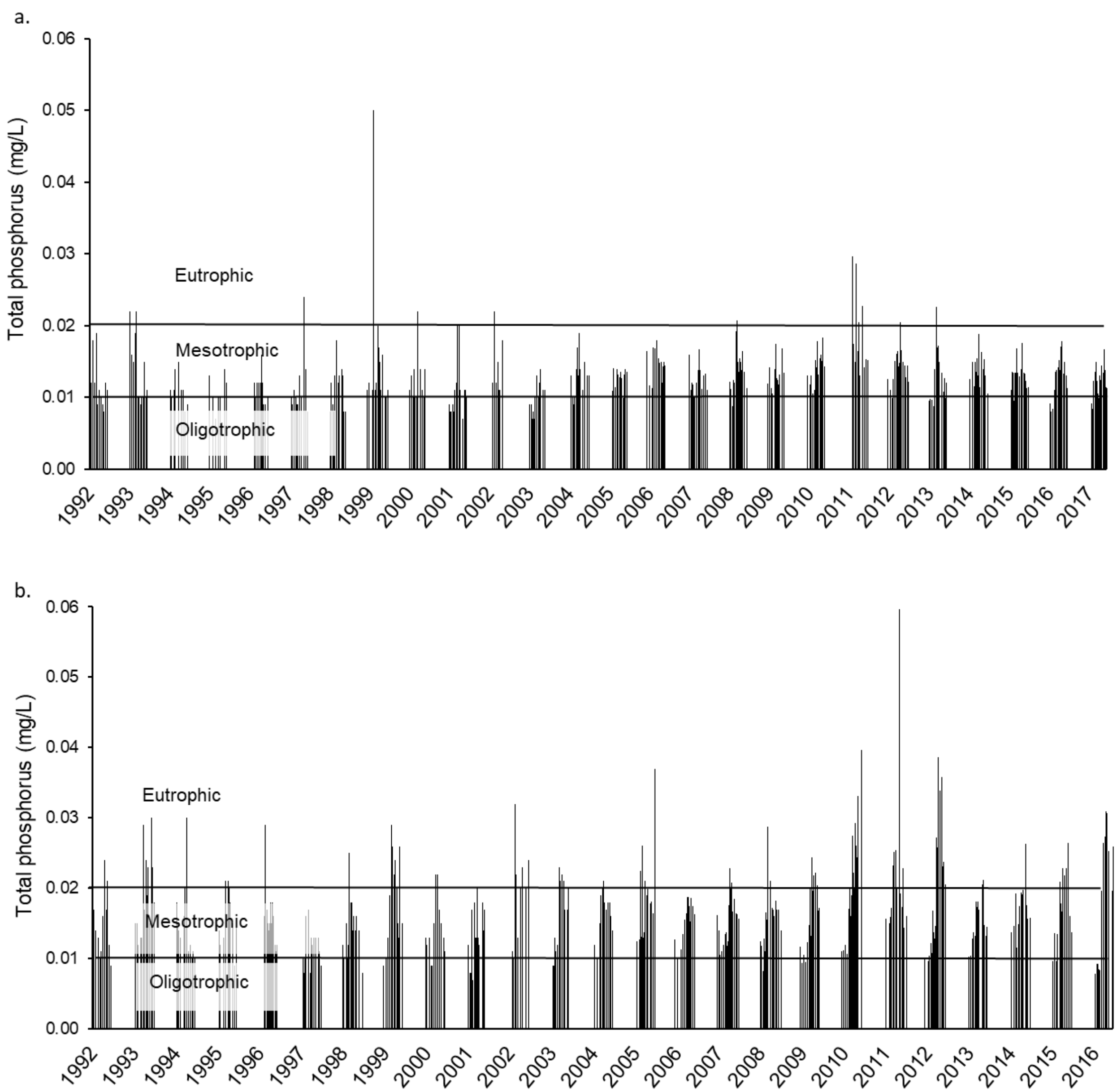
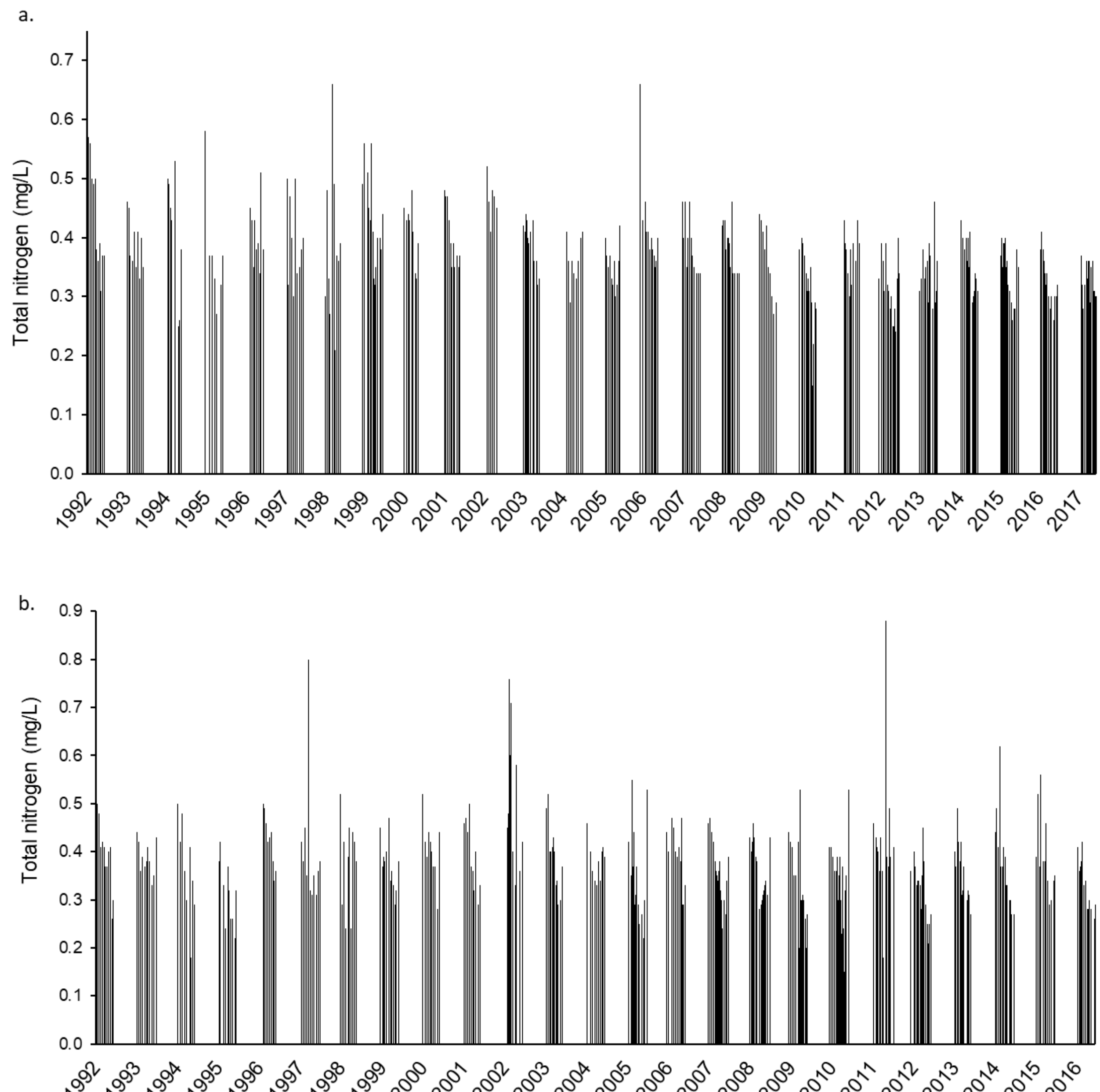


Figure 17. Dissolved oxygen (DO) concentrations (mg/L) in bottom water from (a) Station 36 (approximately 50 m) and (b) Station 46 (approximately 6 m) located in the Isle La Motte region of Lake Champlain.



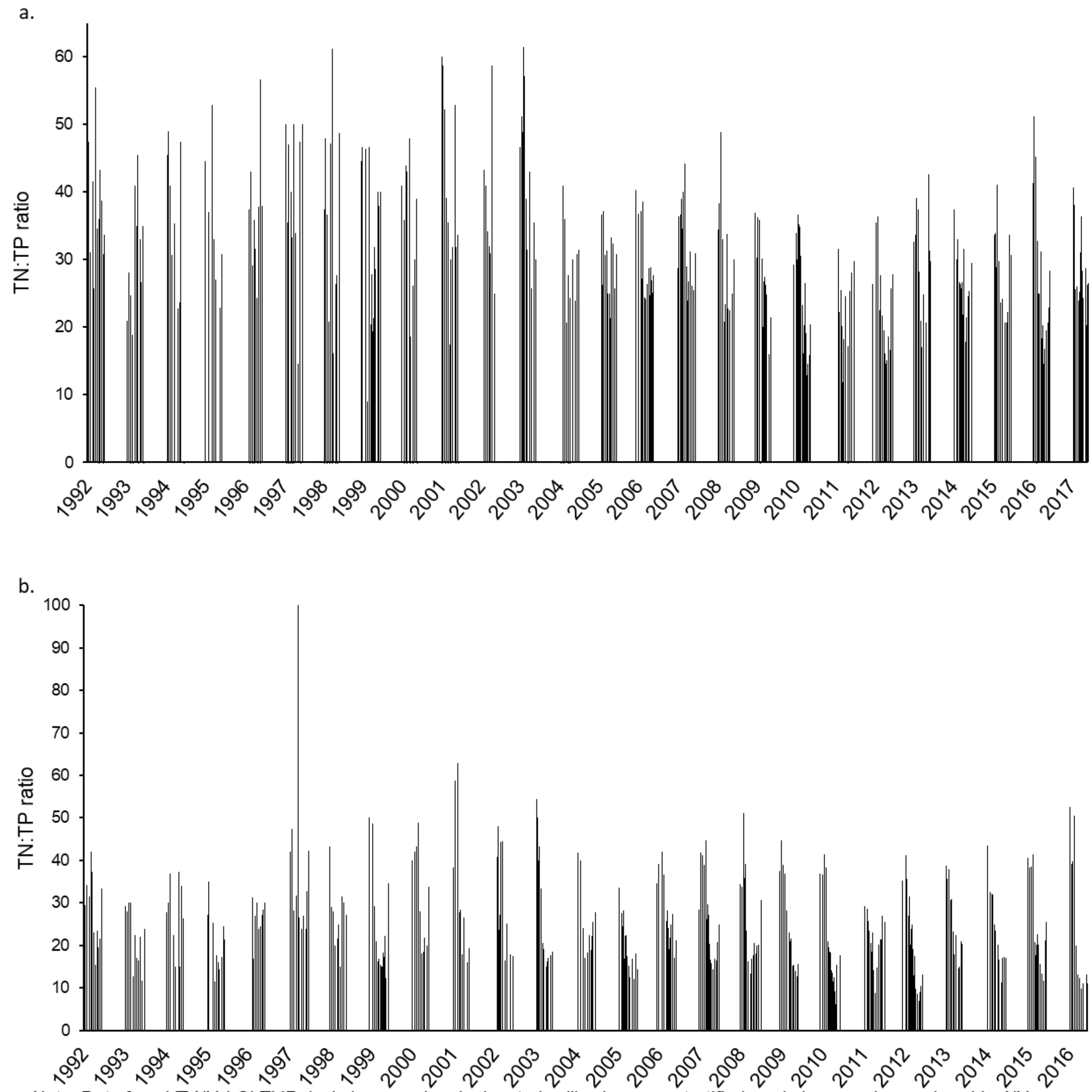
Note: Data from VT-NY LCLTMP; includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 18. Total phosphorus (TP) concentrations (mg/L) from (a) Station 36 and (b) Station 46 located in the Isle La Motte region of Lake Champlain.



Note: Data from VT-NY LCLTMP; includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 19. Total nitrogen (TN) concentrations (mg/L) from (a) Station 36 and (b) Station 46 located in the Isle La Motte region of Lake Champlain.



Note: Data from VT-NY LCLTMP; includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 20. Ratios of total nitrogen (TN) to total phosphorus (TP), by mass, from surface water samples collected at (a) Station 36 and (b) Station 46 located in the Isle La Motte region of Lake Champlain.

6.3 Biological Conditions

Lake Champlain is relatively safeguarded from the direct introduction of invasive species relative to other very large freshwater lakes (e.g., Great Lakes) due to limitations on commercial shipping (Marsden and Hauser 2009). However, as of 2014, a total of 50 nonnative species were present in Lake Champlain from secondary spread of invasive (LCBP 2015). This abundance of aquatic invasive species (AIS) is much higher than in other smaller freshwater lakes.

Certain invasive species present in Lake Champlain may influence the frequency and duration of HABs. For instance, cyprinid fish species – common carp (*Cyprinus carpio*) and European rudd (*Scardinius erythrophthalmus*) – can increase resuspension of sediment and associated nutrients to the water column based on their feeding behavior. These species feed on benthic macroinvertebrates found within the sediment, and sediment is resuspended during active feeding. Increased nutrients being suspended in the water may be utilized by cyanobacteria. Both white perch (*Morone americana*) and alewife (*Alosa pseudoharengus*) are known to graze on zooplankton, which may increase abundance of phytoplankton and cyanobacteria by decreasing densities and reducing the size distribution (Mihuc et al. 2012) of zooplankton that are present to control algae abundance. Couture and Watzin (2008) evaluated diets of white perch from Missisquoi Bay (Lake Champlain), and found that white perch consumed high numbers of *Daphnia* (a large zooplankton taxon). This decline in *Daphnia* abundance in Missisquoi Bay through white perch predation was speculated to increase cyanobacteria dominance in summer months (Couture and Watzin 2008). Similarly, Mihuc et al. (2012) evaluated the trophic response in Lake Champlain to the invasion of alewife in 2004-2005, which indicated a shift in the density and size distribution of zooplankton in Lake Champlain since 2005.

The spiny waterflea (*Bythotrephes cederstroemi*) was first documented in Lake Champlain in 2014. Although, the trophic impacts of the spiny waterflea have not been documented in Lake Champlain, numerous studied have reported on the impacts of this invasive species. The spiny waterflea is a predatory cladoceran that can greatly impact the community structure of zooplankton (Yan et al. 2001), shifting the size distribution to smaller bodied species and reducing overall abundance of other zooplankton. Spiny waterflea are known to be a large portion of the diet of alewife in Lake Ontario (Mills et al. 1992). Although this may reduce alewife feeding pressure on other zooplankton species, the increased feeding pressure from the spiny waterflea will likely result in a reduction of abundance for zooplankton. By decreasing densities and reducing the size distribution of zooplankton, it is likely that there will be an increase in phytoplankton and cyanobacteria abundances (Mihuc et al. 2012) due to reduced feeding pressures by zooplankton.

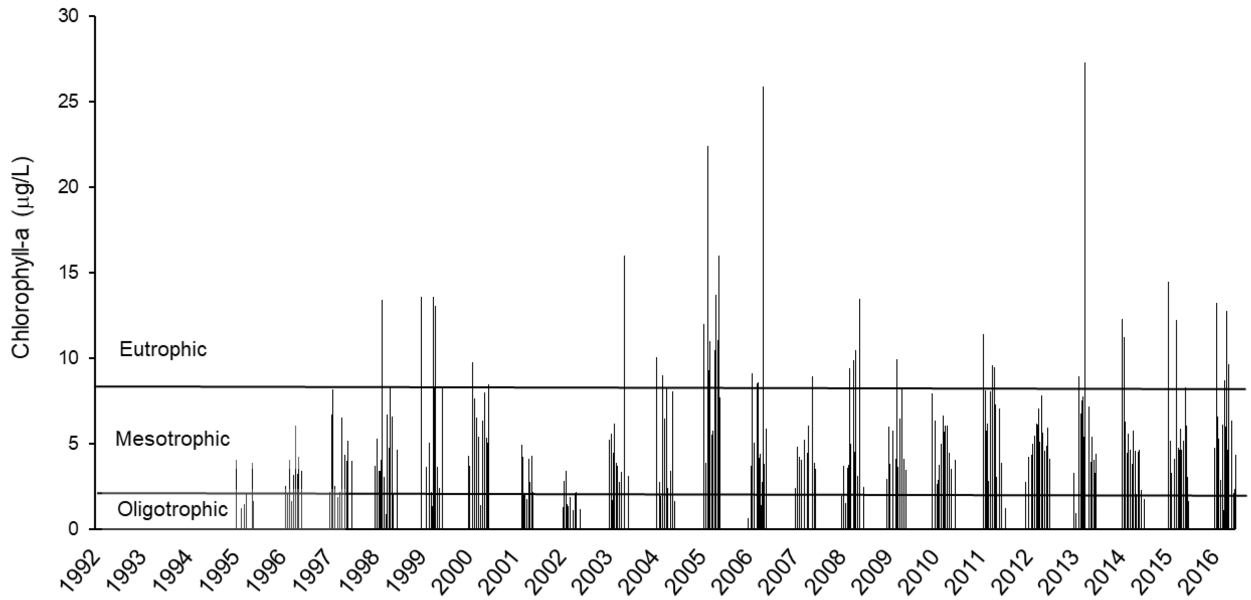
Zebra mussels (*Dreissena polymorpha*) are present in Lake Champlain and evidence suggests that these invasive mussels can selectively filter feed algae, preferentially selecting phytoplankton other than cyanobacteria, which can result in increased prevalence of cyanobacteria (Vanderploeg et al. 2001), such as *Microcystis*. Since the 1970s, the dominant cyanobacterium in Lake Champlain has shifted from *Aphanizomenon* to *Microcystis* in 2005 (MacIsaac 1996). This shift in the phytoplankton community structure is considered to be a result of eutrophication and/or the introduction of zebra mussels (Bouyea 2008). Additionally, zebra mussels are often found in nearshore zones, and coupled with their high filtration rates of algae and subsequent elimination of wastes, can concentrate nutrients (particularly soluble reactive phosphorus [SRP]) in nearshore zones (Hecky et al. 2004). Shifting nutrient concentrations to nearshore areas may result in greater incidence of shoreline HABs. Quagga mussels, a close relative of zebra mussels, have not been found in Lake Champlain. However, quagga mussels have the capacity for even greater ecosystem impacts because they colonize a wider variety of substrates and tolerate a broader range of environmental conditions.

Two invasive aquatic plant species – water chestnut (*Trapa natans*) and Eurasian watermilfoil (*Myriophyllum spicatum*) (NYSDEC 2009; Marsden and Hauser 2009) – are present in Lake Champlain. Both invasive macrophytes are of concern because they often create dense beds and outcompete native aquatic vegetation. The dense beds additionally create less suitable habitat for fish and other aquatic life and impede recreational activities such as boating, fishing, and swimming. These aquatic macrophytes also act as a nutrient pump, by bringing nutrients up from the sediment and back into the water column as plant biomass during the growing season (Smith and Adams 1986). Some of these nutrients are then released into the water column during respiration and decay of plant material. While several studies from the scientific literature discuss the role of milfoil as a potential nutrient pump, lake specific conditions can alter these dynamics including, local anoxic patches, trophic state, plant density, and plant decomposition rates (Carpenter 1983, Carpenter and Lodge 1986); further research is warranted to assess the variables on Lake Champlain.

The sea lamprey, often regarded as an invasive species in Lake Champlain, entered the lake during the 1800s through the Hudson/Champlain Canal. Large sea lamprey populations can have a detrimental effect on population levels of sport fishes such as lake trout. Studies on the Great Lakes indicate a 40 to 60 percent mortality rate for fishes parasitized by sea lamprey (NYSDEC 2018c). It is not known if predation by lampreys on large fishes such as lake trout has cascading trophic effects to cyanobacteria productivity.

6.3.1 Lake Champlain at Port Henry

Average annual concentrations of the photosynthetic pigment chlorophyll-a (**Figure 21**) indicate that the Port Henry location is mesotrophic (moderate productivity, **Table 4**). However, individual sampling date chlorophyll-a concentrations frequently approach and increase 8 μ*g/L*. In general, chlorophyll-a concentrations have increased from 1995 to 2016 (τ = 0.255), although this trend was not statistically significant (*p* = 0.096). No strong seasonal trends in chlorophyll-a concentrations were observed at the Port Henry location. Long term trends suggest an overall increase in productivity at the Port Henry location since 1995. General increases in chlorophyll-a, an indicator of algal biomass, coincide with increases in TP concentrations and TN to TP ratios more favorable to N-fixing cyanobacteria at the Port Henry location. Chlorophyll-a increases also suggest that algal biomass is contributing to general decreases in water clarity at this location.



Note: data from VT-NY LCLTMP; includes samples designated epilimnion or unstratified; excludes samples analyzed by NY laboratory due to potential differences

Figure 21. Chlorophyll-a concentrations (µg/L) at Port Henry, 1995 to 2016.

6.3.2 Lake Champlain at Isle La Motte

Chlorophyll-a concentrations at the Isle La Motte stations (**Figure 22**) were generally indicative of mesotrophic conditions. Average chlorophyll-a concentrations at Stations 36 and 46 were typically less than those observed at the Port Henry location. Long term trends observed at Stations 36 and 46 indicate a non-significant increase in average annual chlorophyll-a concentration (Station 36 – $p = 0.054$, $\tau = 0.289$; Station 46 – $p = 0.167$, $\tau = 0.212$). In general, trends from 1992 to 2016 suggest an increase in algal biomass and a shift to more eutrophic conditions over time. Seasonal trends in chlorophyll-a concentrations were not observed at either Isle La Motte station.

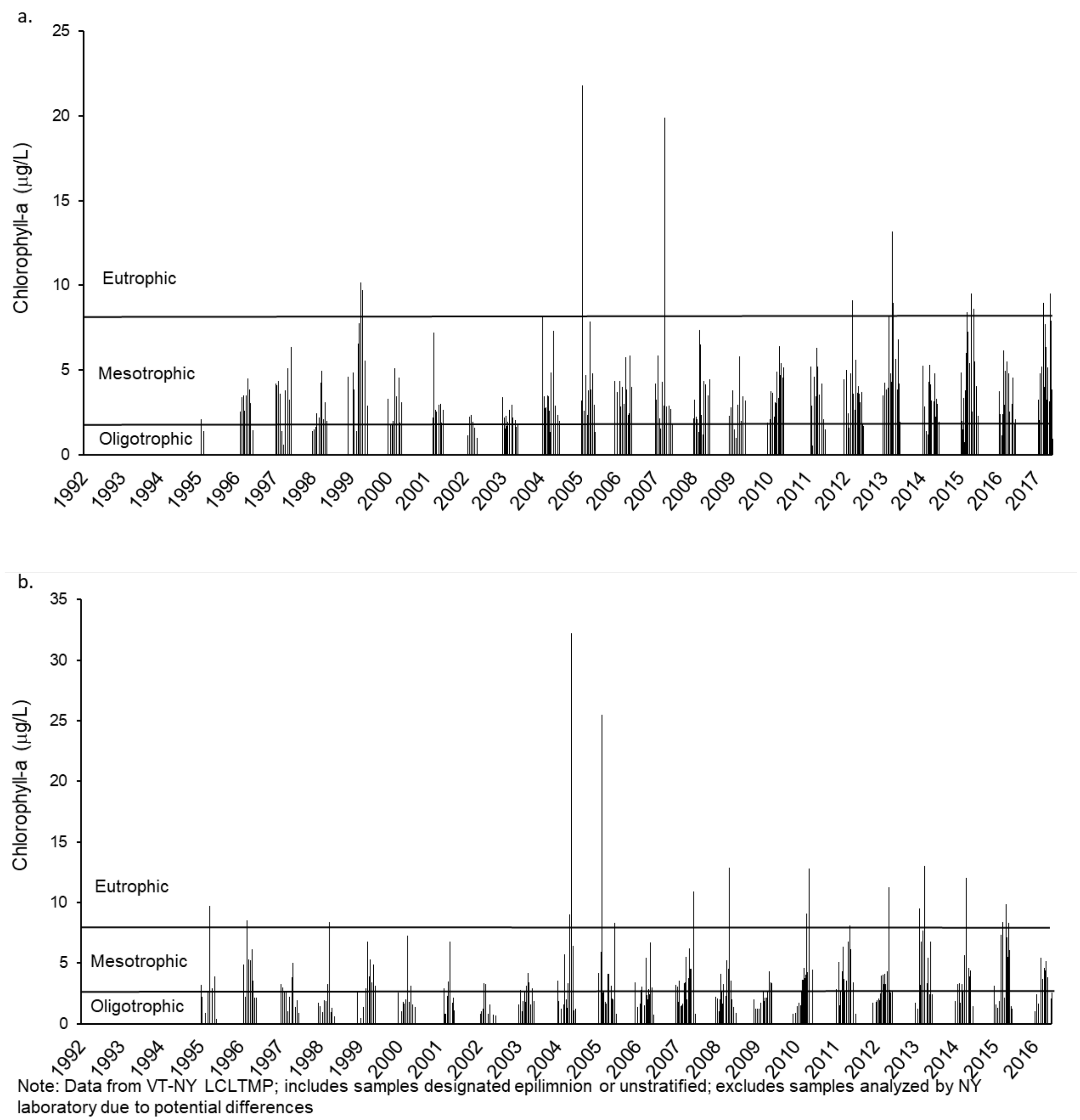


Figure 22. Chlorophyll-a concentrations (µg/L) from (a) Station 36 and (b) Station 46 located in the Isle La Motte region of Lake Champlain.

Increases in chlorophyll-a, which is an indicator of algal biomass, are associated with increases in TP concentrations and TN to TP ratios more favorable to N-fixing cyanobacteria at the Isle La Motte segment of Lake Champlain.

6.4 Other Conditions

Lake Champlain contains several threatened and endangered species, including fish, amphibians, and mussels:

Fish

- American brook lamprey (*Lethenteron appendix*) – threatened (VT)
- Channel darter (*Percina copelandi*) – endangered (VT)
- Eastern sand darter (*Ammocrypta pellucida*) – threatened (VT, NY)
- Lake sturgeon (*Acipenser fulvescens*) – threatened (NY), endangered (VT)
- Mooneye (*Hiodon tergisus*) – threatened (NY)
- Northern brook lamprey (*Ichthymyzon fossor*) – endangered (VT)
- Round whitefish (*Prosopium cylindraceum*) – endangered (NY)
- Stonecat (*Noturus flavus*) – endangered (VT)

Amphibians

- Boreal chorus frog (*Pseudacris maculata*) – endangered (VT)

Mussels (all VT)

- Black sandshell (*Ligumia recta*) – endangered
- Cylindrical papershell (*Anodontoides ferussacianus*) – endangered
- Eastern pearlshell (*Margaritifera margaritifera*) – threatened
- Fluted shell (*Lasmigona costata*) – endangered
- Fragile papershell (*Leptodea fagilis*) – endangered
- Giant floater (*Pyganodon grandis*) – threatened
- Pink heelsplitter (*Potamilus alatus*) – endangered
- Pocketbook (*Lampsilis ovata*) – endangered

McKenzie Brook, within the Port Henry sub-watershed, was previously sampled as part of the RIBS program conducted by NYSDEC. Sampling results in 2003 indicated McKenzie Brook was slightly impacted, with macroinvertebrate communities slightly altered from natural conditions compared to 1998 sampling results (NYSEC 2009). In addition, RIBS sampling in 2003 suggested that sensitive species have been lost and the overall abundance of macroinvertebrates is lower than previous assessments. Additionally, McKenzie Brook showed signs of nutrient enrichment based on a biotic index, but the support of aquatic life was concluded to be fully supported with no other water quality impacts hindering designated use of McKenzie Brook (see **Section 3.1.1**). These results indicate that the McKenzie Brook watershed is a source of nutrients, including phosphorus, to the Port Henry region and may increase the likelihood of HABs.

NYSDEC conducted a biological assessment of the macroinvertebrates of the Great Chazy River in 2008. This assessment was used to characterize water quality within the river, with the intent to assess potential impacts from two Concentrated Animal Feeding Operations (CAFOs) within the watershed (NYSDEC 2010). It was concluded that the water quality of the Great Chazy River (and its north branch) were not impacted based on the macroinvertebrate assemblage present, but agriculture in the watershed was likely causing some nutrient enrichment, particularly in the lower watershed (NYSDEC 2010). Although the nutrient enrichment in the Great Chazy River was not considered to impact aquatic life in the tributary, increased nutrients from farming activities in the watershed may increase the likelihood of HABs in the Isle La Motte region.

6.5 Remote Sensing Estimates of Chlorophyll-a Concentrations

Chlorophyll-a concentrations were estimated for the entire lake using a remote sensing chlorophyll-a model developed by the University of Massachusetts (Trescott 2012) for Lake Champlain. The analysis provides an estimate of the spatial distribution of chlorophyll-a on a particular day and is intended to supplement the field measurement programs. The model estimates of chlorophyll-a are based on the spectral properties of chlorophyll-a, and are thus a measure of green particles near the water surface. The chlorophyll-a model was developed based on data with concentrations less than 20 µg/L. The accuracy of the model for chlorophyll-a concentrations exceeding 20 µg/L has not been tested. For more information, including limitations of the model, refer to **Appendix C**.

The remote sensing analysis was conducted using satellite imagery from NASA's Landsat 8 satellite. Seasonal imagery from May to October was acquired and processed for the past three years (2015-2017). Based on the available remote sensing images shown in **Figure 23**, estimated chlorophyll-a concentrations near Port Henry and Isle La Motte tend to be less than 10 µg/L. Higher concentrations are frequently observed in the South Lake, Mallets Bay, and Missisquoi Bay. Estimated chlorophyll-a concentrations tend to be fairly constant throughout the summer season, except in Mallets Bay and Missisquoi Bay (both in Vermont) which usually peak in September and October.

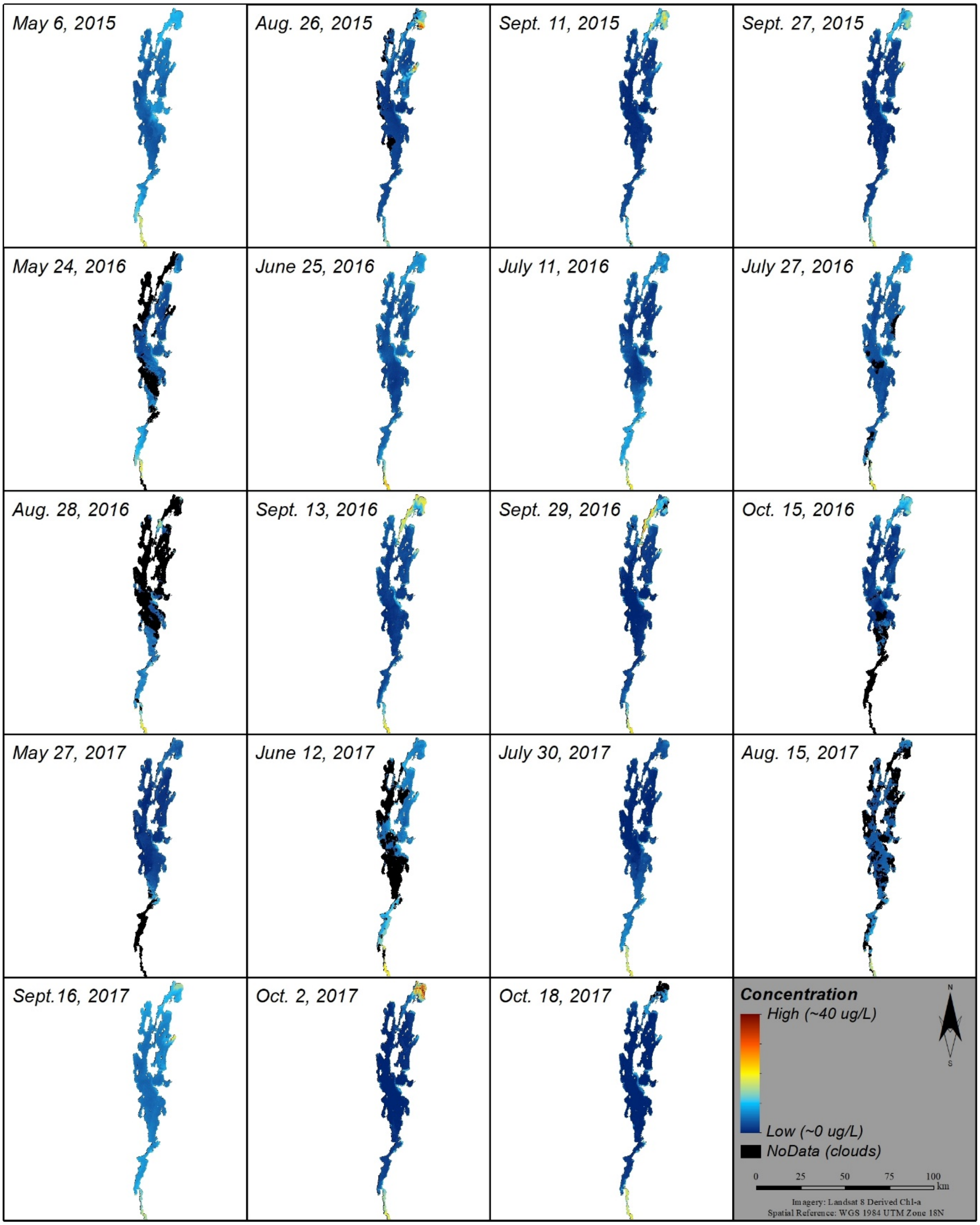


Figure 23. Estimated chlorophyll-a concentrations in Lake Champlain, 2015 to 2017.

The estimated chlorophyll-a concentrations from the remote sensing analysis were extracted at the Lake Champlain Long-Term Water Quality and Biological Monitoring Project (LCLTMP) stations for Port Henry (#7), Isle La Motte South (#36), and Isle La Motte North (#46). The location of the stations is shown in **Figure 8**.

The modelled and measured chlorophyll-a concentrations at these three stations tend to be less than 10 µg/L (**Figure 24**). Higher chlorophyll-a concentrations tend to be observed earlier in the season at Port Henry compared to the Isle La Motte stations. In general, there was relative agreement between the measured and estimated concentrations when there is coincident data. The agreement is better at Port Henry (#7) and Isle La Motte North (#46) than at Isle La Motte South (#36). The agreement between measured and modelled chlorophyll-a concentration does not appear to be related to the water depth, as Port Henry and Isle La Motte South are much deeper (over 50 m [164 ft.]) than Isle La Motte North (7 m [23 ft.]).

Figure 24. Measured (LCLTMP, blue circles) and modeled (Landsat 8, orange circles) chlorophyll-a concentrations from the (a) Port Henry, (b) Isle La Motte #36, and (c) Isle La Motte #46 sample locations of Lake Champlain, 2015 to 2017.

7. Summary of HABs

7.1 Ambient Lake HABs History, General Lake Champlain

Lake Champlain has been the focus of increasing concern by numerous state agencies, non-governmental organizations, community interest groups, lake users, and other stakeholders given the increase in the extent, duration, and impacts of HABs at various locations in the lake. The LCBP has funded cyanobacteria monitoring and research efforts by the VTDOH, the University of Vermont, the Vermont Department of Environmental Conservation (VTDEC), the LCC, and the SUNY College of Environmental Science and Forestry in conjunction with the Federal Centers for Disease Control and Prevention. Monitoring of HABs and the associated environmental conditions that potentially promote their formation and toxins has been performed since 2002 by LCBP with oversight shifted to VT DEC in 2012, working closely with the Lake Champlain Committee and the VT Department of Health (Shambaugh et al. 2017, LCBP 2018i).

Cyanobacteria sampling in Lake Champlain is conducted by both the VTDEC and by volunteers through the LCC.

VTDEC sampling typically occurs bi-weekly (from June through mid-October) at numerous open water locations in Lake Champlain, including within the Port Henry and Isle La Motte segments (Shambaugh et al. 2017). The VTDEC cyanobacteria sampling utilizes an alert framework, which combines both qualitative (visual observations of potentially toxic taxa) and quantitative (cell count, toxin analysis) approaches; see Shambaugh et al. 2017 for description of the framework levels and thresholds for elevating alerts.

The LCC cyanobacteria sampling on Lake Champlain is a network of trained volunteers that submit weekly observations of HABs status. Trained LCC volunteer reports are asked to categorize the “bloom” intensity the day of their sampling, as follows (see Appendix B in Shambaugh et al. 2017):

- 1a = Little or no BGA present – clear water
- 1b = Little or no BGA present – brown or turbid water
- 1c = Little or no BGA present – other material present
- 1d = Little or no BGA present – enjoyment of water not impaired
- 2 = BGA present – less than bloom levels
- 3 = BGA bloom in progress

The following sections provide a summary of the documented HABs at the Port Henry and Isle La Motte portions of the lake, based on LCC monitoring. However, as noted below, beach closures on the New York side of the lake are based on the New York state beach protocol.

7.1.1 Lake Champlain at Port Henry

The Port Henry lake segment of Lake Champlain is generally characterized by mesotrophic (medium productivity) conditions based on the available chemical and biological data for this area. HABs are monitored throughout the summer in three areas within the Port Henry section - at the long-term monitoring site (Site 7), and the two beaches at Bulwagga Bay Park and Port Henry Beach (Shambaugh et al. 2017). HABs have been documented by the LCBP in two primary areas, Port Henry Beach Park and Bulwagga Bay Park, from 2012 to 2014 (LCBP 2015). The documented presence of HABs in these areas contributed to beach closures on 11 occasions during the 2012-2014 time period (discussed further in **Section 7.2.1**).

HABs have also been documented in these areas in 2015, 2016, and 2017 (**Table 5**). In 2016, LCC volunteers trained in algal bloom monitoring and the VTDEC provided qualitative data on presence or absence of HABs based on visual observations at both Bulwagga Bay Park and Port Henry Beach Park. Observations taken on 17 monitoring events between late-June and late-September at Bulwagga Bay Park yielded 15 instances of “little or no BGA present” (“generally safe” conditions) and two instances of “BGA present, less than bloom levels” (“low alert”). Cyanobacteria observations at the Port Henry public beach by LCC and VTDEC indicated one instance of “little or no BGA present” (August 15) and two instances of “BGA present, less than bloom levels” (August 5 and September 7).

Table 5. Noted occurrences of HABs at Port Henry.

Date	Bloom Location	Chl-a (μg/L)	Daily avg air temp (ºC)	Water Temp (ºC)	Daily rainfall (mm.)	10-day total rainfall (mm.)	Max daily wind speed (m/s)	Length of beach closure
7/29/2015	Port Henry Beach	N/A	24.4	N/A	0	2	3.1	4
9/8/2015	Port Henry Beach	N/A	25.9	N/A	0.2	0.2	2.6	N/A
7/5/2016	Bulwagga Bay	6.11	23.6	19.8	0	23	2.6	2
8/5/2016	Port Henry Beach	N/A	25.2	N/A	0	4.6	6.7	2
9/7/2016	Port Henry Beach	N/A	23.7	N/A	0	3.5	3.6	N/A
8/1/2017	Bulwagga Bay	N/A	20.6	N/A	3.1	19.9	2.6	3
8/28/2017	Bulwagga Bay	N/A	14.7	N/A	0	20.4	0	7

7.1.2 Lake Champlain at Isle La Motte

In the Isle La Motte, NY lake area, several locations are monitored for HABs including the two long term monitoring locations (Stations 36 and 46), Point Au Roche State Park beach, Point Au Roche boat launch, Point Au Roche State Park Deep Bay, Stoney

Point, and Treadwell Bay (Shambaugh et al. 2017). HABs were reported at Port Au Roche State Park in 2016 and 2017, resulting in closures of the beach there during July and August during those years (**Table 6**; see **Section 7.2.2**). A large localized HAB was reported by the New York State Office of Parks, Recreation and Historic Preservation (OPRHP) on July 11, 2016 offshore of the park. Three "suspicious" blooms were reported by the OPRHP on July 10, 15, and 31 along park waters.

LCC and VTDEC observations between mid-July and mid-September 2016 at three sites near Point Au Roche State Park included 34 instances of "little or no BGA present" and two instances of "BGA present, less than bloom levels". Observations were also taken on 37 occasions in 2016 at Station 36 (Grand Isle) and 46 (Champlain, NY), and in Treadwell Bay and Stoney Point (south of Rouses Point, NY). "Generally safe" conditions were indicated during each monitoring event.

Table 6. Noted occurrences of HABs at Isle La Motte. Corresponding chl-a data not available for the dates in the table.							
Date	**Bloom Location**	**Daily avg air temp (ºC)**	**Water Temp (ºC)**	**Daily rainfall (mm.)**	**10-day total rainfall (mm.)**	**Max daily wind speed (m/s)**	**Length of beach closure**
8/11/2014	Pt. Au Roche Deep Bay Launch	20.4	26.2	0	18.4	4.6	N/A
8/15/2014	Pt. Au Roche Deep Bay Launch	14.8	N/A	0.8	52.9	4.1	N/A
8/18/2014	Pt. Au Roche Deep Bay Launch	17.9	23.9	0	54.8	5.7	N/A
8/25/2014	Pt. Au Roche Deep Bay Launch	19.4	26.4	0	9.1	4.1	N/A
9/2/2014	Pt. Au Roche Deep Bay Launch	22.4	24.4	0	1.5	7.7	N/A
9/8/2014	Pt. Au Roche Deep Bay Launch	15.8	23.5	0	11.7	5.7	N/A
7/21/2015	Pt. Au Roche Deep Bay Launch	20.6	25.7	7.9	19.9	6.2	N/A
7/27/2015	Pt. Au Roche Deep Bay Launch	21.6	29.1	0	20.3	5.1	N/A
7/11/2016	Pt. Au Roche State Park	17.9	N/A	0	32.2	4.6	2
7/10/2017	Pt. Au Roche State Park	20.1	N/A	0.6	40.5	4.6	0
7/15/2017	Pt. Au Roche State Park	20.4	N/A	1.6	36.2	6.7	4
7/31/2017	Pt. Au Roche State Park	20.4	N/A	0.3	28.5	4.1	8

7.2 Drinking Water and Swimming Beach HABs History, General Lake Champlain

Drinking Water

Across New York, NYSDOH first sampled ambient water for toxin measurement in 2001, and raw and finished drinking water samples beginning in 2010. Two public water supplies were sampled in a 2012 pilot study that included both fixed interval and bloom based event criteria. While microcystin has been detected in pre-treatment water occasionally, rarely have any detects been found in finished water. To date, no samples of finished water have exceeded the 0.3 µg/L microcystin HAL. Many different water systems using different source waters have been sampled, and drinking water HABs toxin sampling has increased substantially since 2015 when the EPA released the microcystin and cylindrospermopsin HALs. The information gained from this work and a review of the scientific literature was used to create the current NYSDOH HABs drinking water response protocol. This document contains background information on HABs and toxins, when and how water supplies should be sampled, drinking water treatment optimization, and steps to be taken if health advisories are exceeded (which has not yet occurred in New York State). In 2018 the EPA started monitoring for their Unregulated Contaminant Monitoring Rule 4 (UCMR 4) which includes several HAB toxins. In 2018 EPA will sample 32 public water systems in New York State. The UCMR 4 is expected to bring further attention to this issue leading to a greater demand for monitoring at PWSs. To help with the increasing demand for laboratory analysis of microcystin, the NYSDOH Environmental Laboratory Approval Program (ELAP) starting in is offering certification for laboratories performing HAB toxin analysis, and public water supplies should only use ELAP-certified labs and consult with local health departments (with the support of NYSDOH) prior to beginning HAB toxin monitoring and response actions.

As recommended by the NYSDOH, it is never advisable to drink water from a surface source unless it has been treated by a public drinking water system regardless of the presence HABs. Surface waters may contain other bacteria, parasites or viruses that can cause illness. If you choose to explore in-home treatment systems, you are living with some risk of exposure to blue-green algae and their toxins and other contaminants. Those who desire to use an intake for non-potable use, and treat their water for contaminants including HABS, should work with a water treatment professional who should evaluate for credible third-party certifications such as National Sanitation Foundation standards (NSF P477; NYSDOH 2017).

The Port Henry section of Lake Champlain is not a direct source of drinking water, however Isle La Motte and other lake regions, as presented on **Figure 5**, contain lake-fed intakes that supply drinking water for residents in New York and Vermont. Within the Isle La Motte region, two drinking water intakes are located within Lake Champlain; the North Hero water system located in VT and the Rouses Point Village water supply system located in the northern portion of the lake in NY. No data are known to be available for private water systems that may draw water from the lake. The NYSDOH recommends that it is never advisable to drink water from a surface source unless it has been properly treated by a public drinking water system, regardless of the presence HABs.

Bathing Beaches

Beach closures in the lake are often attributable to elevated coliform levels; however, the increasing prevalence of HABs in the lake has resulted in more frequent beach closures associated with cyanobacteria blooms. **Figure 25** presents beach closures in various portions of the lake due to fecal coliforms and BGA blooms for the period 2012-2014. As discussed in **Section 7.1.1**, 14 documented HABs-related beach closures occurred along New York shorelines during this three-year period, 11 of which occurred in the Port Henry area (Port Henry Beach, Bulwagga Bay Beach) (LCBP 2015).

Bathing beaches are regulated by NYSDOH District Offices, County Health Departments and the New York City Department of Health and Mental Hygiene in accordance with the State Sanitary Code (SSC). The SSC contains qualitative water quality requirements for protection from HABs. NYSDOH developed an interactive intranet tool that provides guidance to County, City and State District DOH staff to standardize the process for identifying blooms, closing beaches, sampling, reopening beaches and reporting activities. The protocol uses a visual assessment to initiate beach closures as it affords a more rapid response than sampling and analysis. Beaches are reopened when a bloom dissipates (visually) and samples collected the following day confirm the bloom has dissipated and show toxin levels are below the latest guidance value for microcystins. Sample analysis is performed by local health departments, the Wadsworth Laboratory in Albany or academic institutions.

Table 7 provides a summary of the guidance criteria that the NYSDEC and NYSDOH use to advise local beach operators.

<table>
<tr><th colspan="4">Table 7. HABs guidance criteria.</th></tr>
<tr><th colspan="4">NYSDEC Bloom Categories</th></tr>
<tr><th rowspan="2">Confirmed</th><th colspan="2">Confirmed w/ high toxins</th><th>Suspicious</th></tr>
<tr><th>Open water</th><th>Shoreline</th><th></th></tr>
<tr><td>[BGA Chl a] >25 µg/L</td><td>[Microcystin] > 10 µg/L</td><td>[Microcystin] > 20 µg/L</td><td>Visual evidence (sampling results not needed)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th colspan="4">NYSDOH Guidelines</th></tr>
<tr><th colspan="2">Closure</th><th colspan="2">Re-open</th></tr>
<tr><td colspan="2">Visual evidence (sampling results not needed)</td><td colspan="2">Bloom has dissipated (based on visual evidence); confirmatory samples 1 day after dissipation w/ microcystin < 10 µg/l or < 4 µg/l (USEPA 2016) starting in 2017.</td></tr>
</table>

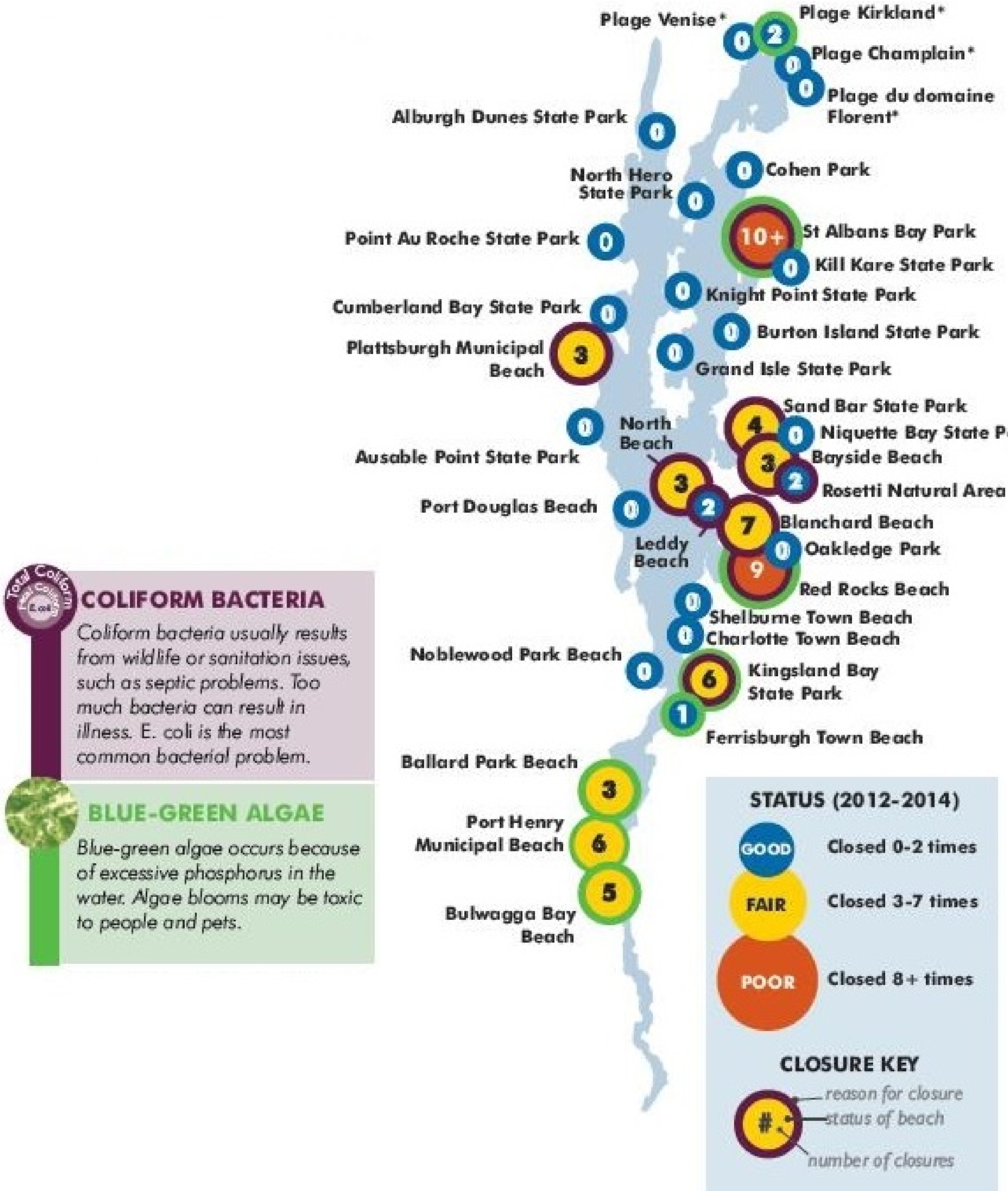


Figure 25. Beach closures throughout Lake Champlain (2012-2014) (*Source*: LCBP 2015).

Recent data compiled on beach closures in the Port Henry and Isle La Motte areas stemming from HABs formations are summarized in **Figure 26**, and described in the following sections.

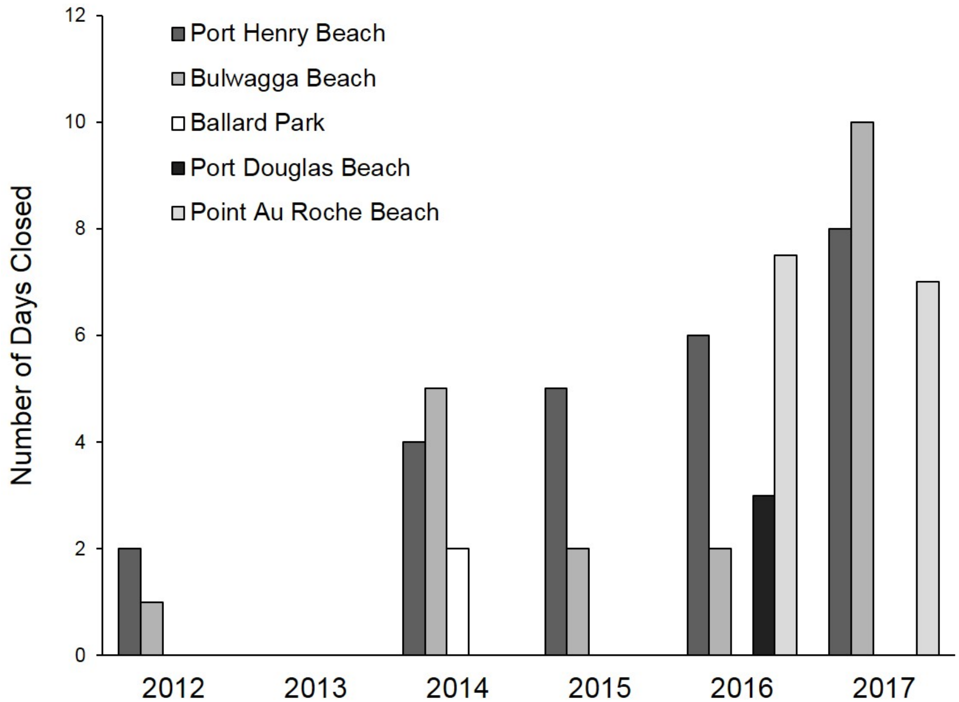


Figure 26. Documented beach closures in Lake Champlain (2014-2017) (*Source*: NYS DOH).

7.2.1 Lake Champlain at Port Henry

Based on information provided by the NYSDOH, Bulwagga Bay Beach and Port Henry Beach were closed on several occasions in 2016 and 2017. Closures from documented cyanobacteria blooms at Bulwagga Bay Beach resulted in two and ten lost beach days in July 2016 and August 2017, respectively (**Figure 26**). At Port Henry Beach, three closures occurring in July and August in 2016 were attributable to HABs, which resulted in six lost beach days. One HABs-related closure in August 2017 at this beach resulted in eight lost beach days. HABs-related closures occurred at both Bulwagga Bay and Port Henry beaches in late July-early August 2015 as reported in the NYSDOH.

7.2.2 Lake Champlain at Isle La Motte

In the Isle La Motte area, closures stemming from HABs formations were reported for the public beach at Port Au Roche State Park along the northern portion of Treadwell Bay. This beach was closed on two occasions in both 2016 and 2017 due to HABs. There were three closures in July-August 2016, resulting in 7.5 lost beach days (**Figure 26**). In 2017, the two closures were in July and August, one for three days and one for four days, resulting in seven total lost beach days.

7.3 Other Bloom Documentation

The NYSDEC and NYSDOH believe that all cyanobacteria blooms should be avoided, even if measured microcystin levels are less than the recommended threshold level. Other toxins may be present, and illness is possible even in the absence of toxins.

7.3.1 Lake Champlain at Port Henry

Cyanobacteria cell counts and/or chlorophyll-a concentrations (e.g., BGA chlorophyll a) can be used to trigger HABs alert and advisory systems. A “no-bloom” threshold for BGA of ≤ 25-30 µg/L was adopted by the NYSDEC HABs Program from a standard administered by the World Health Organization (WHO); this “no-bloom” standard was subsequently narrowed by NYSDEC to ≤ 25 µg/L (NYSDEC 2017b). For the Port Henry area, BGA concentration data are not available during known HAB events.

Microcystin, a cyanotoxin that targets the liver, is the most commonly detected cyanotoxin in New York State (NYSDEC 2017b). The 20 µg/L microcystin “high toxin” threshold for shoreline blooms was, like the BGA chlorophyll-a standard, established based on WHO criteria. The NYSDEC HABs Program has not adopted a specific concern threshold for anatoxin-a, a HAB toxin that targets the central nervous system.

No cyanotoxin information is available specific to the Port Henry area. Additionally, information regarding specific algal taxa present during blooms is unavailable.

7.3.2 Lake Champlain at Isle La Motte

Concentration data specific to BGA chlorophyll-a and corresponding to HAB events are not known to be available in the Isle La Motte segment of the lake. Additionally, cyanotoxin data corresponding to HABs events is also unavailable. Detectable microcystin levels quantified during non-HABs monitoring in 2010 and 2011 at the Point Au Roche State Park beach were 0.03 and 0.008 µg/L, respectively, below USEPA’s 2016 draft human health recreational swimming advisory threshold of 4 µg/L (USEPA 2016). Sample results below this threshold value are consistent with what is currently prescribed by NYSDOH guidance to allow a regulated bathing beach to reopen.

Cyanobacteria identified during routine monitoring (non-bloom conditions) in 2016 at Station 36 included the following genera:

- *Aphanothece* – unicellular, may form colonies
- *Dolichospermum* (formerly *Anabaena)* – filamentous, nitrogen-fixing
- *Aphanizomenon* – filamentous, nitrogen-fixing, buoyancy regulating
- *Microcystis* – unicellular, buoyancy regulating
- *Pseudanabaena* – filamentous

In addition, *Dolichospermum*, *Microcystis*, and *Gloeotrichia*, a colonial filamentous cyanobacterium, were identified at Station 46 in 2016.

7.4 Use Impacts

Beaches at Port Henry were closed due to HABs every year from 2014 to 2017; similarly, so for in 2016 and 2017 for beach at Isle La Motte (Point Au Roche State Park). Public bathing and other recreational uses of the lake in the northern Main Lake segment, which includes Isle La Motte, and the southern Main Lake segment, which includes Port Henry, were assessed as “threatened/stressed” by invasive aquatic species (water chestnut, Eurasian watermilfoil, zebra mussel) and elevated nutrient (phosphorus) levels contributing to excessive algae growth (NYSDEC 2009). Drinking water impacts from HABs are relevant for the Isle La Motte area, given that the North Hero Water System (VT) draws water directly from Lake Champlain.

7.5 HABs and Remote Sensing

Remote sensing results were plotted together with hourly rainfall, wind speed and direction, locations of recreational beaches, locations of wastewater treatment plants, and locations of the detected HABs recorded within three days of the remote sensing images. Hourly rainfall at Plattsburg, NY is plotted with hourly air temperature. The weekly average and long-term average (11 years) air temperature are shown to provide context. Hourly wind is presented using stick plots that provide direction and magnitude. Each arrow is pointing in the compass direction the wind is blowing towards; up is north. The magnitude is indicated by the length of the line; a scale line is provided for reference. A full set of these figures is provided in **Appendix C**. Select examples from the past three years are discussed below.

Within the New York State border, the highest estimated chlorophyll-a concentrations occurred in May in the South Lake segment. The estimated chlorophyll-a concentrations in this region were approximately 20-25 µg/L (**Figure 27**). Areas on the New York side susceptible to elevated chlorophyll-a concentrations include Port Henry to Essex, Port Kent, and the region near Isle La Motte. Higher chlorophyll-a concentrations were observed in bays, near tributaries, and adjacent to agricultural regions.

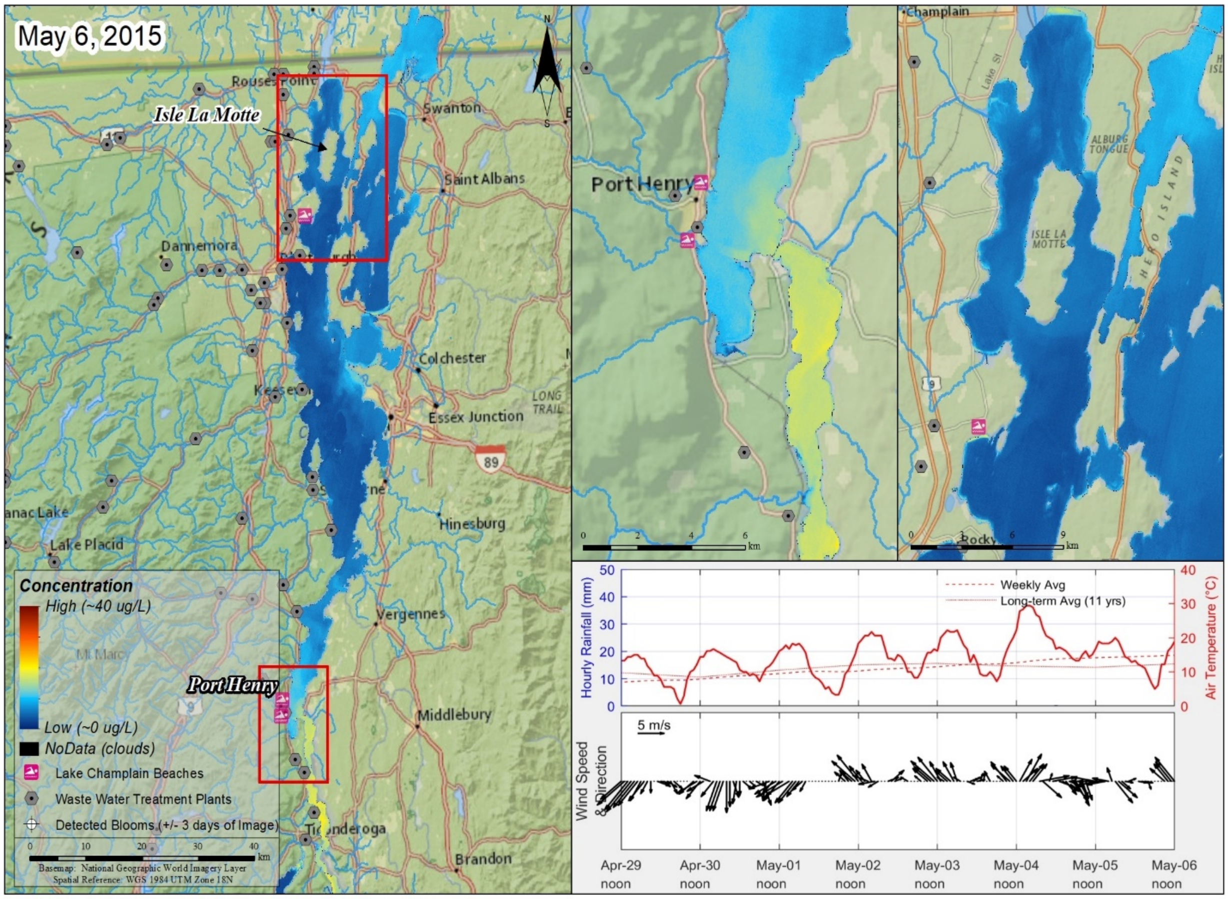


Figure 27. Estimated chlorophyll-a concentrations on May 6, 2015 in Port Henry and Isle La Motte segments.

A HAB was reported at Point Au Roche State Park on July 11 (marked with a circle and cross in **Figure 28**). The remote sensing image on this day shows elevated chlorophyll-a concentrations (approximately 20 µg/L) near beaches and bays near Isle La Motte. It appears that the higher chlorophyll-a concentrations in this area may be related to rainfall earlier that week and strong winds from the south east.

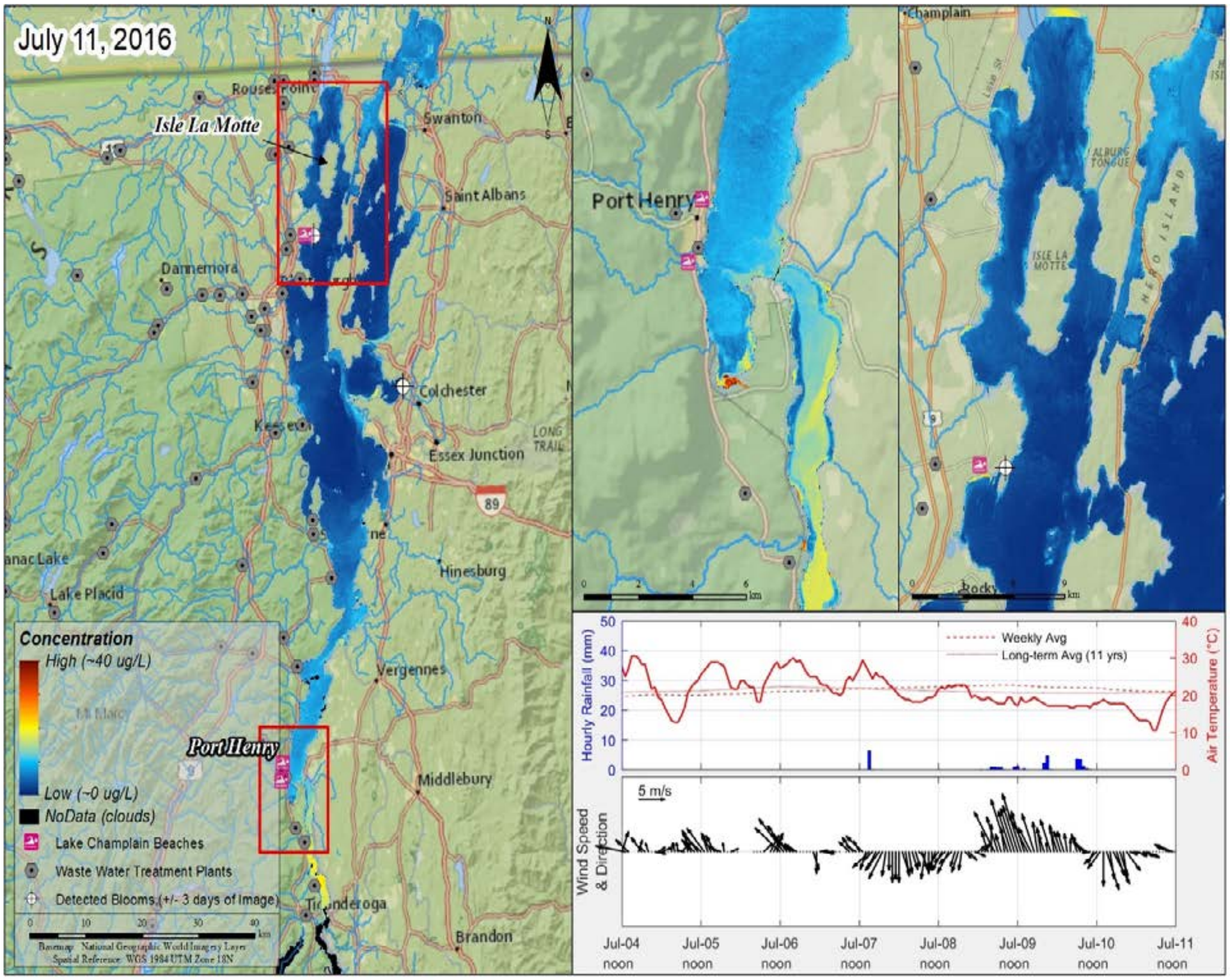


Figure 28. Estimated chlorophyll-a concentrations on July 11, 2016 in Port Henry and Isle La Motte segments.

In 2017, five suspicious HABs were reported in Lake Champlain. The HABs occurred in July and August and the remote sensing image for July 30, 2017 is shown in **Figure 29**. The location of two of the HABs are marked with a circle and cross (Point Au Roche State Park, NY and Port Henry, NY). Similar to the previous year, the HABs were preceded by rain earlier that week and strong winds. The highest chlorophyll-a concentrations tend to be localized at the beaches, with lower concentrations offshore.

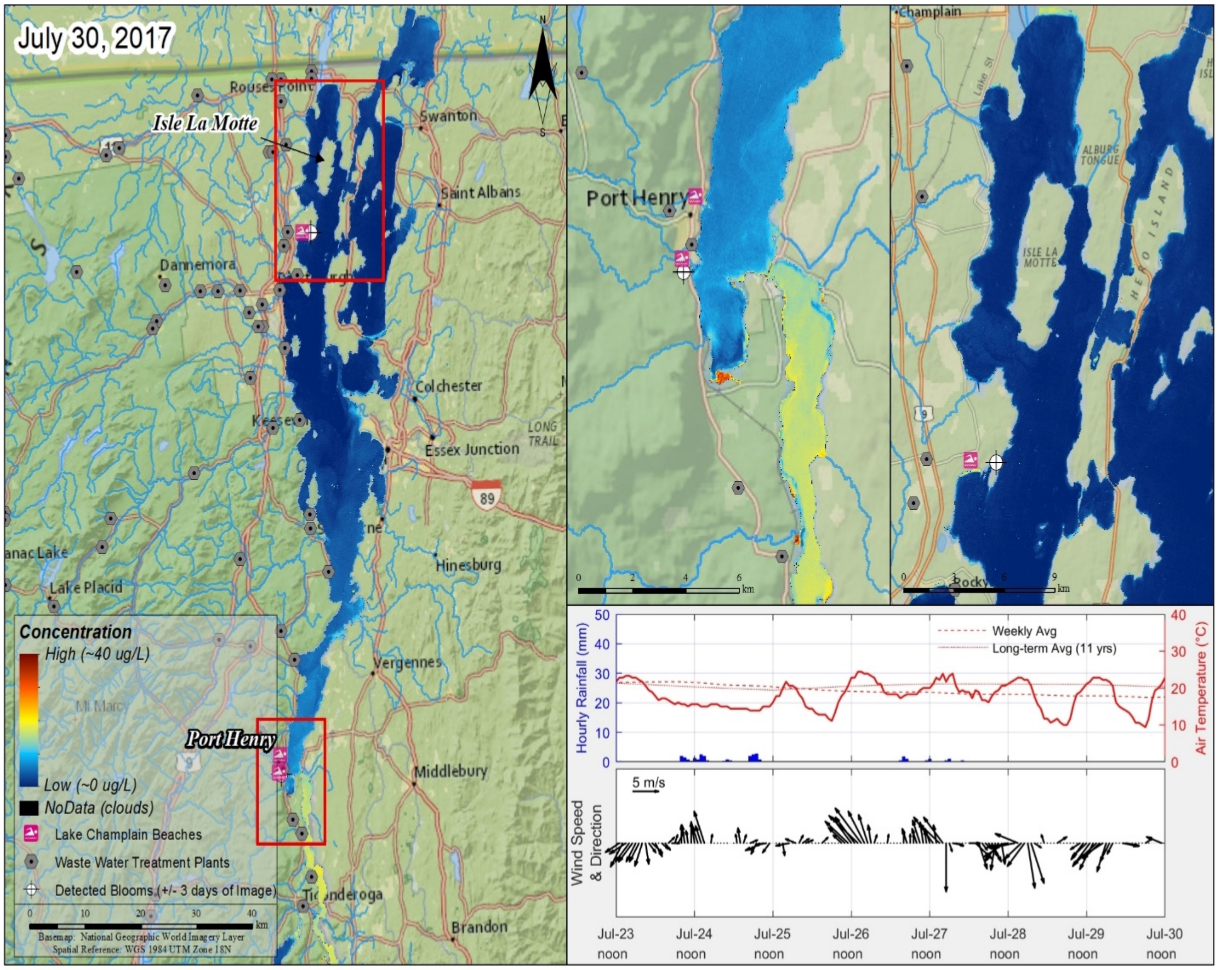


Figure 29. Estimated chlorophyll-a concentrations on July 30, 2017 in Port Henry and Isle La Motte segments.

In summary, the remote sensing data indicate that estimated chlorophyll-a concentrations tend to be higher in the South Lake segment, and areas adjacent to Vermont. Estimated chlorophyll-a concentrations in New York waters (north of the South Lake) tend to be approximately 10 µg/L or less. The HABs locations correspond to small and localized areas with higher estimated chlorophyll-a concentrations. Elevated chlorophyll-a concentrations tend to occur near tributaries, adjacent to agricultural areas, and bays. The higher chlorophyll-a concentrations observed in some bays appear to be the result of wind pushing algae nearshore. Estimated chlorophyll-a concentrations were not observed to increase over the summer on the New York side of the lake but did at several locations in Vermont and Quebec.

The percentage of the Lake Champlain surface area with an estimated chlorophyll-a concentration greater than 10 µg/L and 25 µg/L is summarized in **Table 8**. Cyanobacteria cell counts and/or chlorophyll-a concentrations (e.g., BGA chlorophyll-a) less than 25 µg/L is NYSDEC's criteria for "no-bloom" (see **Section 7.2**). However, the relationship between measured chlorophyll and satellite-estimated chlorophyll shown in

Appendix C (**Figure C2**) suggests that some waterbodies may exhibit bloom conditions at satellite-estimated chlorophyll levels as low as 10 µg/L.

Table 8. Percent (%) of water surface area with an estimated chlorophyll-a concentration (mg/L) above and below 10 mg/L and 25 mg/L in Lake Champlain.

Date	% of surface area less than		% of surface area greater than or equal		% No data
	10 µg/L	25 µg/L	10 µg/L	25 µg/L	
2015-05-06	86	99	13	0	1
2015-05-22	51	58	7	0	42
2015-08-26	82	91	10	1	8
2015-09-11	89	98	10	0	1
2015-09-27	88	99	11	0	1
2016-05-24	53	60	7	0	40
2016-06-25	90	99	9	0	1
2016-07-11	89	97	8	0	3
2016-07-27	84	91	8	0	9
2016-08-28	24	30	6	0	70
2016-09-13	84	99	15	0	1
2016-09-29	85	97	12	0	3
2016-10-15	69	75	6	0	25
2017-05-27	84	86	2	0	14
2017-06-12	40	52	12	0	48
2017-07-30	92	98	6	0	2
2017-08-15	47	52	5	0	48
2017-09-16	86	99	13	0	1
2017-10-02	78	87	11	2	12
2017-10-18	76	82	6	0	18

8. Waterbody Assessment

The Waterbody Inventory/Priority Waterbodies List (WI/PWL) is an inventory of water quality assessments that characterize known/and or suspected water quality issues and determine the level of designated use support in a waterbody. It is instrumental in directing water quality management efforts to address water quality impacts and for tracking progress toward their resolution. In addition, the WI/PWL provides the foundation for the development of the state Section 303(d) List of Impaired Waters Requiring a TMDL.

The WI/PWL assessments reflect data and information drawn from numerous DEC programs (e.g. CSLAP) as well as other federal, state and local government agencies, and citizen organizations. All data and information used in these assessments has been evaluated for adequacy and quality as per the NYSDEC Consolidated Assessment and Listing Methodology (CALM).

8.1 WI/PWL Assessment

The current WI/PWL assessment for Lake Champlain (**Appendix D**) is captured in five segments of the lake: Lake Champlain, Main Lake, North; Cumberland Bay; Lake Champlain, Main Lake, Middle; Willsboro Bay; and Lake Champlain, Main Lake, South. The assessments reflect monitoring data collected from 1992 through 2017.

Isle La Motte is included in the Lake Champlain, Main Lake North segment and Port Henry makes up the majority of the Lake Champlain, Main Lake South segment. All five segments are categorized as impaired waterbodies.

Fish consumption is impaired (**Table 9**, see **Section 3.5**) in all segments of the lake due to a lake-wide health advisory.

Table 9. Waterbody Inventory/Priority Waterbodies List (WI/PWL) severity of use impact categorization (*Source*: NYSDEC 2009).

Impairment Classification	Description
Precluded	*Frequent/persistent* water quality, or quantity, conditions and/or associated habitat degradation *prevents all aspects* of a specific waterbody use.
Impaired	*Occasional* water quality, or quantity, conditions and/or habitat characteristics *periodically prevent* specific uses of the waterbody, or; Waterbody uses are not precluded, but some aspects of the use are *limited or restricted*, or; Waterbody uses are not precluded, but *frequent/persistent* water quality, or quantity, conditions and/or associated habitat degradation *discourages* the use of the waterbody, or; Support of the waterbody use *requires additional/advanced* measures or treatment.
Stressed	Waterbody uses are not significantly limited or restricted (i.e. uses are *Fully Supported*), but *occasional* water quality, or quantity, conditions and/or associated habitat degradation *periodically discourage* specific uses of the waterbody.
Threatened	Water quality supports waterbody uses and ecosystem exhibits no obvious signs of stress, however *existing or changing land use patterns* may result in restricted use or ecosystem disruption, or; *Data reveals decreases in water quality* or presence of toxics below the level of concern.

Throughout the lake, metals (mercury), priority organics (PCBs), nutrients (phosphorus) and problem species were listed as known pollutants. Contaminated sediments are the main sources of mercury and PCBs to the lake. Atmospheric deposition was also listed as a known source of mercury contamination. Problem species in the lake consist of numerous invasive species including water chestnut, sea lamprey (*Petromyzon marinus*) and zebra mussels. A description of the impacts of water chestnut and zebra mussels can be found in **Section 6.3** of this report. Agricultural runoff is listed as the main known source of phosphorus throughout the lake. Municipal and urban/storm runoff are considered possible sources of high phosphorus levels. The Plattsburgh wastewater treatment plant (WWTP) was identified as a source of nutrients in Cumberland Bay.

8.2 Source Water Protection Program (SWPP), General Lake Champlain

The NYSDOH Source Waters Assessment Program (SWAP) was completed in 2004 to compile, organize, and evaluate information regarding possible and actual threats to the quality of public water supply (PWS) sources based on information available at the time. Each assessment included a watershed delineation prioritizing the area closest to the PWS source, an inventory of potential contaminant sources based on land cover and the regulated potential pollutant source facilities present, a waterbody type sensitivity rating, and susceptibility ratings for contaminant categories. The information included in these analyses included: GIS analyses of land cover, types and location of facilities, discharge permits, CAFOs, NYSDEC WI/PWL listings, local health department drinking water history and concerns, and existing lake/watershed reports.

A source water assessment program (SWAP) report for Lake Champlain is not available despite use of the lake as a source of potable water. A general assessment of the drinking water supply use is conducted by the WI/PWL assessments for waterbodies where *Drinking Water Supply* is designated as the best usage (i.e., Class A and AA waterbody classifications). The evaluation of Drinking Water Supply use includes data on administrative closures and restrictions, degree of treatment necessary for a water supply to be used for drinking water, water contamination levels and an estimate of susceptibility to contamination developed by the SWAP. No known impairments or imminent threats to the Lake Champlain drinking water supply use were identified during the 2009 WI/PWL (NYSDEC 2009). In addition, the most recent groundwater assessment for the Lake Champlain watershed (2009) described ground water quality in.

Currently, the state is meeting with a working group of stakeholders to develop the SWPP structure and potential tools (e.g., templates, data sets, guidance and other resources) that will be pilot tested in municipalities. Following the pilot, the state will roll out the program and work with municipalities as they develop and implement their individual SWPP and associated implementation program. The goal of the SWPP is for municipalities to not merely assess threats to their public water supply but to take action at the local level to protect public drinking water.

8.2.1 Lake Champlain at Port Henry

Although temperature depth profiles indicate strong thermal stratification at the Port Henry location, dissolved oxygen concentrations remain high throughout the water column and phosphorus release from the sediments is unlikely to occur. Water quality conditions in Bulwagga Bay and other bays within the Port Henry segment of Lake Champlain are unknown and additional data need to be collected to determine if these bays could be a source of internal loading due to releases of phosphorus from sediments. Nutrient availability in the Port Henry segment of Lake Champlain is influenced by the South Lake segment nutrient concentrations. Water quality conditions in the South Lake segment are typically eutrophic (high productivity, **Table 4**) with TP concentrations typically ranging between 0.04 to 0.06 mg/L (VTANR and NYSDEC 2002).

8.2.2 Lake Champlain at Isle La Motte

Similar to Port Henry, temperature depth profiles from the Isle La Motte segment of Lake Champlain indicate strong thermal stratification with high dissolved oxygen concentrations throughout the water column, hence phosphorus release from the sediments is also unlikely at this location. Water quality conditions in Treadwell, Trombley, and King bays as well as other smaller bays within the Isle La Motte segment of Lake Champlain are unknown and additional data need to be collected to determine if these bays could be a source of internal loading of phosphorus from sediments.

Nutrient availability in the Isle La Motte segment is influenced by many different portions of Lake Champlain including the Main Lake to the south and Malletts Bay, Inland Sea, and Missisquoi Bay to the east. The South Lake, Malletts Bay, and Inland Sea lake segments typically have water quality conditions that indicate mesotrophic (moderate productivity, **Table 4**) conditions with TP concentrations ranging from 0.01 to 0.02 mg/L (VTANR and NYSDEC 2002). The Missisquoi Bay segment typically has water quality conditions that indicate eutrophic conditions with TP concentrations ranging from 0.04 to 0.06 mg/L. Nutrient availability in the northern portion of the Isle La Motte segment (Station 46, **Figure 8**), which typically has higher TP concentrations compared to the southern portion (Station 36, **Figure 8**), is likely to be more influenced by Missisquoi Bay.

9. Conditions triggering HABs

Resilience is an important factor in determining an ecosystem's ability to respond to and overcome negative impacts (Zhou et al. 2010), including the occurrence and prevalence of HABs. Certain lakes may not experience HABs even though factors hypothesized to be “triggers” (e.g., elevated P concentrations) are realized (Mantzouki et al. 2016), and conversely, lakes that have historically been subject to HABs may still be negatively affected even after one or more triggers have been reduced. Thus, the pattern by which an outcome (presence or absence of HABs) lags behind changes in the properties causing it (triggers) has been observed for ecological phenomena, including phytoplankton dynamics (Faassen et al. 2015). Further, unusual climatic events (*e.g.*, high TP input from spring runoff and hot calm weather in fall) may create unique conditions that contribute to a HAB despite implementation of management strategies to prevent them (Reichwaldt and Ghadouani 2012).

Ecosystems often exhibit a resistance to change that can delay outcomes associated with HABs management. This system resilience demands that prevention and management of these triggers be viewed long-term through a lens of both watershed and in-lake action. It may take significant time following implementation of recommended actions for the frequency, duration, and intensity of HABs to be reduced.

A dataset spanning 2012 to 2017 of 163 waterbodies in New York State has been compiled to help understand the potential triggers of HABs at the state-scale (CSLAP data). This dataset includes information on several factors that may be related to the occurrence of HABs, e.g., lake size and orientation (related to fetch length, or the horizontal distance influenced by wind); average total phosphorus and total nitrogen concentrations; average surface water temperatures; as well as the presence of invasive zebra and quagga mussels (i.e., dreissenid mussels). This data set has been analyzed systematically, using a statistical approach known as logistic regression, to identify the minimum number of factors that best explain the occurrences of HABs in NYS. A minimum number of factors are evaluated to provide the simplest possible explanation of HABs occurrences (presence or absence) and to provide a basis for potential targets for management. One potential challenge to note with this data set is that lakes may have unequal effort regarding HABs observations which could confound understanding of underlying processes of HABs evaluated by the data analysis.

Across New York, four of the factors evaluated were sufficiently correlated with the occurrence of HABs, namely, average total phosphorus levels in a lake, the presence of dreissenid mussels, the maximum lake fetch length and the lake compass orientation of that maximum length. The data analysis shows that for every 0.01 mg/L increase in total phosphorus levels, the probability that a lake in New York will have a HAB in a given year increases by about 10% to 18% (this range represents the 95% confidence interval based on the parameter estimates of the statistical model). The other factors, while statistically significant, entailed a broad range of uncertainty given this initial analysis. The presence of dreissenid mussels is associated with an increase in the annual HAB probability of 18% to 66%. Lakes with long fetch lengths are associated with an increased occurrence of HABs; for every mile of increased fetch length, lakes are associated with up to a 20% increase in the annual probability of HABs. Lastly, lakes with a northwest orientation along their longest fetch length are 10% to 56% more likely to have a HAB in a given year. Each of these relationships are bounded, i.e., the frequency of blooms cannot exceed 100%, meaning that as the likelihood of blooms increases the marginal effect of these variables decreases. While this preliminary evaluation will be expanded as more data are collected on HABs throughout New York, these results are supported by prior literature. For example, phosphorus has long known to be a limiting nutrient in freshwater systems and a key driver of HABs, however the potential role of nitrogen should not be overlooked as HABs mitigation strategies are contemplated (e.g., Conley et al. 2009). Similarly, dreissenid mussels favor HABs by increasing the bioavailability of phosphorus and selectively filtering organisms that may otherwise compete with cyanobacteria (Vanderploeg et al. 2001). The statistically-significant association of fetch length and northwest orientation with HABs may suggest that these conditions are particularly favorable to wind-driven accumulation of cyanobacteria and/or to wind-driven hydrodynamic mixing of lakes leading to periodic pulses of nutrients. While each of these potential drivers of HABs deserve more evaluation, the role of lake fetch length and orientation are of interest and warrant additional study.

There is continuing interest in the possible role of nitrogen in the occurrence and toxicity of HABs (e.g., Conley et al. 2009), and preliminary analysis of this statewide data set suggests that elevated total N and total P concentrations are both statistically significant associates with the occurrence of toxic blooms. When total N and total P concentrations are not included in the statistical model, elevated inorganic nitrogen (NH_4 and NO_x) concentrations are also positively associated with toxic blooms. The significant association of inorganic N forms with toxic blooms may provide a more compelling association than total N, which may simply be a redundant measure of the biomass associated with toxins.

At Port Henry, elevated levels of TP and chlorophyll-a from the South Lake may provide an additional source of TP to this area. The outfall of the Port Henry WWTP is proximal to the Port Henry and Bulwagga Bay Park beaches, and represents a point source for total and dissolved phosphorus that may increase the frequency and duration of HABs in these beach areas.

9.1 Other Contributing Factors

In addition to phosphorus, other potential contributing influences may facilitate the formation of HABs or exacerbate the range and/or intensity of HABs. One physical parameter that often strongly aligns with HABs is elevated water temperature. Other factors that may contribute to HABs include nutrient pulses from anoxic water layers and intense rainfall events, quiescent conditions, and low zooplankton abundance.

9.1.1 Lake Champlain at Port Henry

As described in **Section 6.1.1**, thermal stratification is strong at the Port Henry location throughout the growing season (May-October). Strong lake stratification may contribute to oxygen depletion in the hypolimnion (deeper cooler zone of a stratified lake), permitting formerly non-mobile phosphorus in lake sediments to be released to the water column and subsequently consumed by cyanobacteria, other algal taxa, sometimes resulting in HABs. Oxygen depletion was not observed in the deeper portions of the Port Henry segment. Based on comparisons of HABs events and NYSDOH-supplied water temperature data for the Port Henry segment, BGA bloom occurrences in 2014-2016 coincided with surface water temperatures ranging from 19.8-23.3°C. No trend between HABs and dissolved oxygen was available based on the data available.

9.1.2 Lake Champlain at Isle La Motte

Strong stratification is observed at Station 36 of the Isle La Motte region of the lake (near Point Au Roche State Park) throughout the growing season; conditions favorable for HABs. A comparative assessment of thermal data for Station 36 and HABs events at Port Au Roche State Park indicate elevated surface water temperatures (20.0-22.7°C) during HABs events in July 2016. Notable, however, is that surface water temperatures at Station 36 exceeded 23.7°C when no cyanobacteria blooms were reported, suggesting that HABs formations here are not necessarily limited by water temperature, and that other factors (in addition to elevated phosphorus) may contribute to HABs.

10. Sources of Pollutants triggering HABs

Existing data and model estimates indicate that much of the nutrient loading (e.g., TP) to Lake Champlain is derived from nonpoint sources. Nutrients from nonpoint and point sources enter the lake directly from the surrounding watersheds via overland flow, tributaries, WWTP discharges, and other sources, where they can be used by cyanobacteria and aquatic plants, or deposited and stored in lakebed sediments. In general, phosphorus concentrations in Lake Champlain tend to be greater in the southern portion of the lake and decrease towards the north (VTANR and NYSDEC 2002).

Two different analyses have documented phosphorus loading to Lake Champlain and its sub-watersheds (Port Henry and Isle La Motte):

- 2002 Phosphorus TMDL (VT Natural Resources and NYSDEC 2002)
- Loading Estimator of Nutrient Sources (LENS) screening tool (NYSDEC, undated), which is described further in **Section 10.2**.

Note that in 2016, USEPA released the Vermont phosphorus TMDLs for sub-watersheds within its jurisdiction (USEPA 2016). The external and internal phosphorus sources presented below are specific to the Port Henry and Isle La Motte (NY) sub-regions of Lake Champlain.

10.1 Land Uses

10.1.1 Lake Champlain at Port Henry

The Port Henry sub-watershed has an area of approximately 35,400 acres. NYSDEC's LENS tool (NYSDEC, undated) indicates the following watershed land use percentages for the Port Henry sub-watershed (**Figure 30a**):

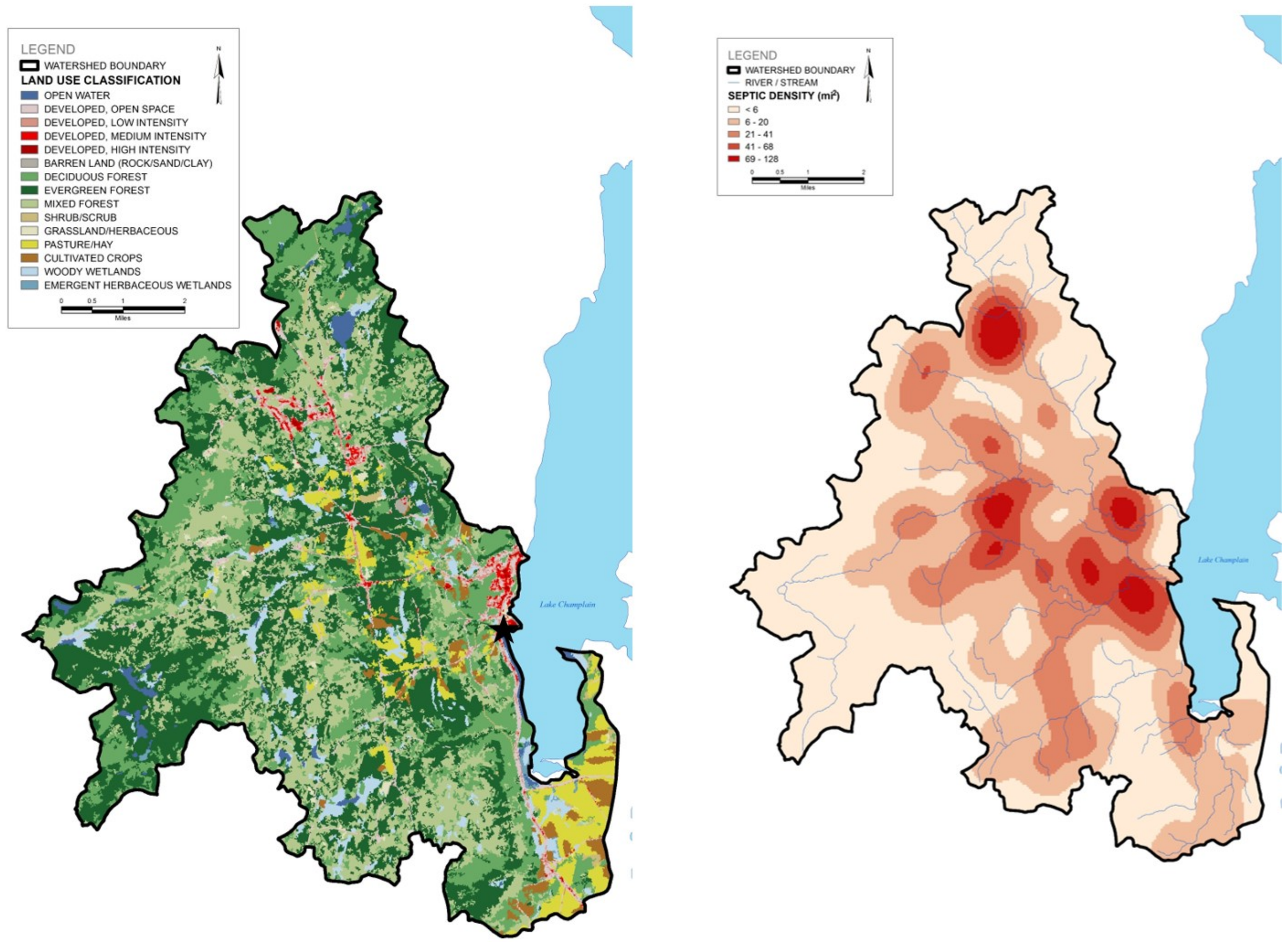
- Natural areas = 83%

- Agricultural = 11%
- Developed land = 5%
- Open water = 1%

Natural areas include forests, shrublands, grasslands, and wetlands.

(a) Watershed land use

(b) Septic system density



★ = Location of point source discharge (approximate)

Figure 30. (a) Watershed land use and (b) septic system density for the Port Henry sub-watershed. Municipal wastewater districts for Port Henry/Moriah service areas are not shown on this figure.

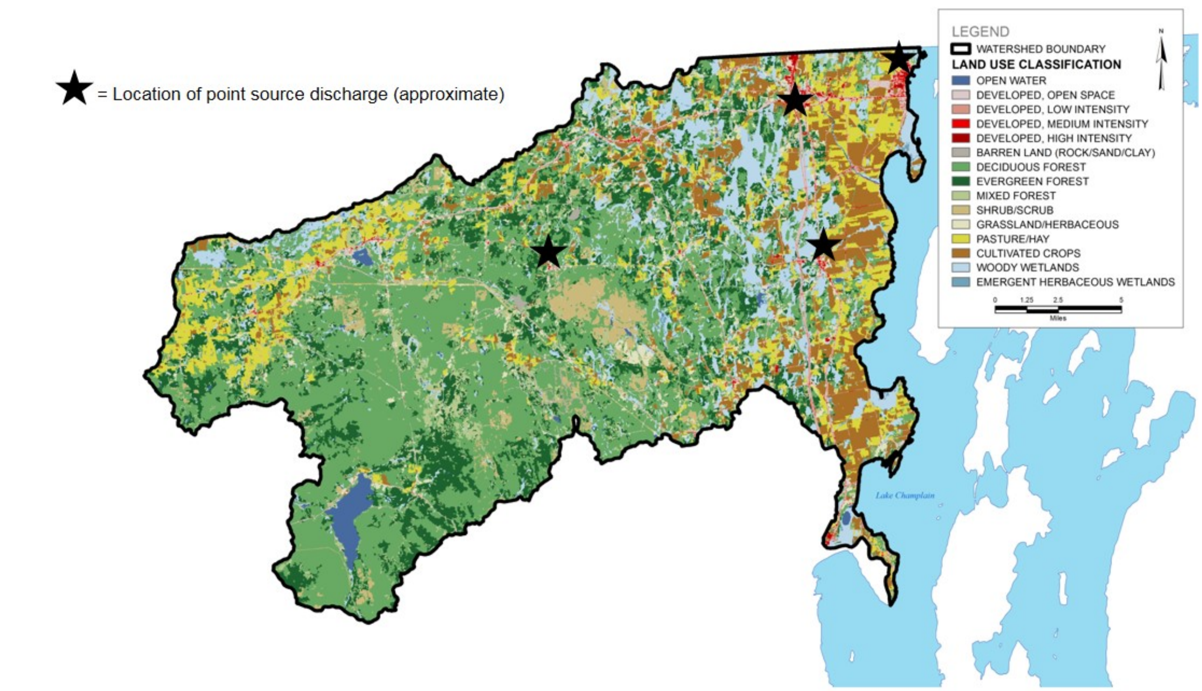
10.1.2 Lake Champlain at Isle La Motte

The Isle La Motte sub-watershed encompasses approximately 248,000 acres, and comprises the following land use types (**Figure 31a**):

- Natural areas = 75%
- Agricultural = 19%
- Developed land = 5%
- Open water = 1%

Natural areas include forests, shrublands, grasslands, and wetlands.

(a) Watershed land use



(b) Septic system density

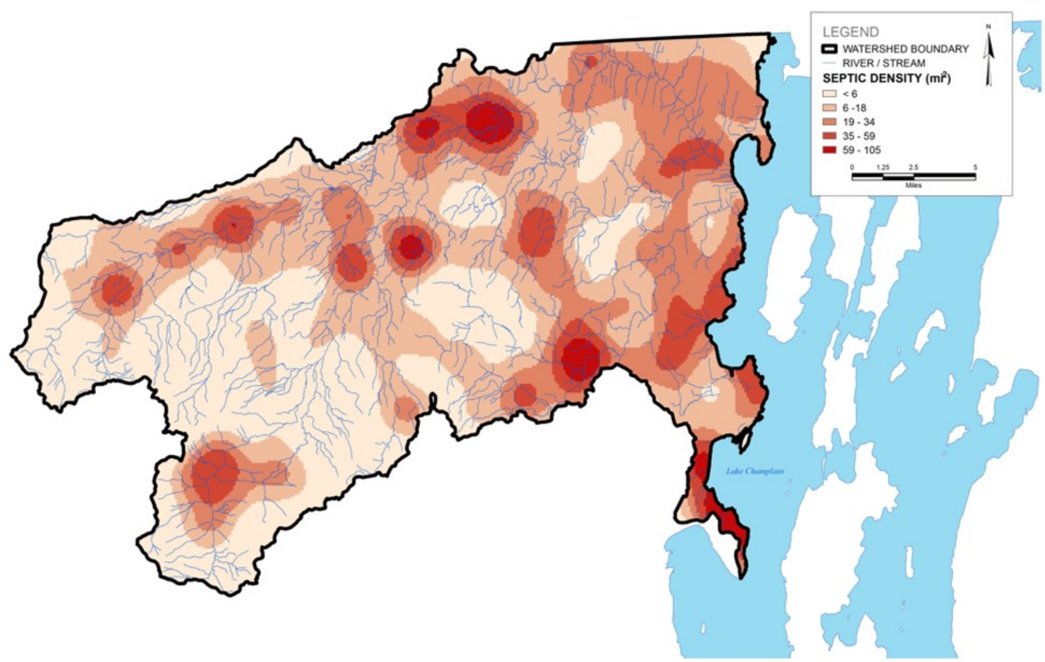


Figure 31. (a) Watershed land use and (b) septic system density for the Isle La Motte sub-watershed.

10.2 External Pollutant Sources

NYSDEC's LENS tool is a simple watershed model that uses average, assumed meteorological conditions, estimated average annual loading rates from nonpoint sectors based on accepted literature values, and estimates of point source contribution. It employs the most recent data from the National Land Cover Dataset, septic density information collected by NYS Office of Real Property and Tax, and State Pollution Discharge Elimination System (SPDES) permits. LENS is a screening tool, used by the NYSDEC, intended to assess the relative load contributions by watershed source to help determine the most appropriate watershed management approach (i.e., a TMDL or 9E plan; https://www.dec.ny.gov/docs/water_pdf/dowvision.pdf) and, for purposes of this Action Plan, support prioritization of water quality improvement projects and allocation of associated resources to mitigate HABs (presented in Section 13).

LENS is not designed to be a comprehensive watershed analysis and does not include all data requirements for a Total Maximum Daily Load (TMDL) or Nine Element (9E) Plan. Although LENS output has shown to be consistent with more comprehensive watershed analyses in New York State, there is uncertainty in the watershed loading estimates presented in this Action Plan. For example, LENS does not take into consideration: (1) other potential contributors of nutrients to the lake such as groundwater, consistently underperforming septic systems, and streambank erosion, (2) internal sources of nutrients (e.g., sediments, dreissenid mussels), and (3) existing best management practices (BMPs) and other nutrient reduction measures being implemented by the municipalities, agricultural community, Soil and Water Conservation Districts, and other stakeholders.

Therefore, LENS results discussed here and in subsequent sections should be considered a ***preliminary approximation*** of external nutrient sources to the lake. Precise quantification of nutrient sources from the watershed is needed and should be determined through: (1) a detailed inventory of nutrient sources – ***from all suspected sectors*** within the watershed, (2) complete a detailed analysis of nutrient load and budget that includes critical factors not accounted for in LENS, (3) the development of a robust land-side nutrient loading model, and (4) completion or update of a NYSDEC approved clean water plan. As appropriate, this Action Plan can be updated to reflect current and better understanding of Lake Champlain.

Phosphorous loading values presented below reflect estimates generated for each segment of this Action Plan (Port Henry and Isle La Motte). It should be noted, however, that in a large lake system such as Lake Champlain, the extent of horizontal mixing of nutrients is likely high and thus may bias regionally-based estimates. In addition, seasonal and spatial distribution of loading sources can influence the timing and extent of blooms within the lake. For instance, the proximity of the Port Henry WWTP to the Port Henry Beach is likely to increase the frequency and duration of HABs at the beach and have a larger impact of recreational uses during July and August.

10.2.1 Lake Champlain at Port Henry

The 2002 phosphorus TMDL indicated point source and nonpoint source loadings contributed 40% (1.8 metric tons [mt]/yr) and 60% (2.7 mt/yr) of annual TP loading, respectively. Point sources of phosphorus include the Port Henry WWTP, and Westport WWTP (VTANR and NYSDEC 2002). Although the Westport WWTP is outside the Port Henry region described in this report (see **Section 2**), the 2002 TMDL includes a larger geographic area that includes the WWTP. The Westport WWTP is likely to impact the Port Henry region in general due to horizontal mixing of the lake by wind and lake circulation.

Nonpoint sources identified in the 2002 phosphorus TMDL for the Port Henry sub-watershed (which utilized data from 1991) indicated TP loading by forest (13.2%), agriculture (39.4%), and urban (47.4%) land uses.

The updated LENS model suggests that annual phosphorus loading to the greater Port Henry region (includes areas outside the reach of this report, see **Section 2**) of Lake Champlain includes 9% from point sources (including Port Henry and Westport WWTPs), and 91% from nonpoint sources. The nonpoint source loadings are attributable to:

- Agricultural land use = 44%
- Natural areas = 36%
- Developed land = 10%
- Open water = 1%

While agricultural land use composes only 11% of the sub-watershed at Port Henry (see **Section 10.1.1**), it contributes nearly half of the nonpoint source annual phosphorus load. Septic system density in the Port Henry sub-watershed is low (< 6 per km^2), as depicted in **Figure 30b**, and septic inputs likely have a negligible effect on phosphorus loading. Note that South Lake, which drains directly into the Port Henry section of Lake Champlain, has high nutrient concentrations and thus likely has a direct influence on the concentrations observed in the Port Henry region.

As discussed in **Section 10**, NYSDEC's LENS screening tool was used to identify potential nutrient pollutant sources in the Port Henry sub-watershed to help support prioritization of projects. It should be noted that NYSDEC's LENS tool is screening tool and intended to be used to assess the relative load contributions by source to help determine the most appropriate watershed management approach and support prioritization of projects. The LENS tool does not include all the data requirements for detailed watershed load analysis that would be completed for a TMDL or Nine Element (9E) Plan (see **Section 12.5**). The LENS tool also does not take into consideration existing best management practices (BMPs) and other nutrient reduction measures potentially implemented by the agricultural community and other potential contributors of nutrients to the lake. Consequently, the land use and loading estimates presented above for the Port Henry sub-watershed should be interpreted with caution.

10.2.2 Lake Champlain at Isle La Motte

In the Isle La Motte region of Lake Champlain, the 2002 phosphorus TMDL estimated point sources to be 26% (7.4 mt/yr) and nonpoint sources at 74% (20.9 mt/yr) of the total annual load. Point sources of phosphorus within the Isle La Motte region: the Rouses Point WWTP, Champlain Village WWTP, Chazy municipal WWTP, and the Altona Correctional Facility (VTANR and NYSDEC 2002). The Wyeth-Ayerst/Chazy WWTP is also included in the 2002 TMDL, though, this facility is currently closed.

Nonpoint sources identified in the 2002 phosphorus TMDL for the Isle La Motte sub-watershed (using data collected in 1991) indicated TP loading by forest (4.1%), agriculture (79.6%), and urban (16.3%) land uses.

The updated LENS model for the Isle La Motte region of Lake Champlain includes 3% from point sources (four WWTPs), and 97% from nonpoint sources (NYSDEC, undated). The nonpoint source loadings are attributable to:

- Agricultural land use = 62%
- Natural areas = 25%
- Developed land = 9%
- Open water = 1%

Like Port Henry, agricultural land use in the Isle La Motte sub-watershed comprises a small portion of the watershed (relative to forest) but contributes over half of the nonpoint source loading of phosphorus. Septic system densities in the Isle La Motte sub-watershed are generally low; however, an increased number of septic systems (up to 28 per km^2) are present in the watershed near Treadwell and Cumberland Bays, as depicted in **Figure 31b**.

10.3 Internal Pollutant Sources

Internal loading estimates have not been previously included in the 2002 Lake Champlain phosphorus TMDL, or included within the LENS model.

For the Port Henry and Isle La Motte sub-regions of Lake Champlain, it is assumed that internal loading of phosphorus is negligible, at least relative to external nutrient sources, based on current oxygen depth profiles that show high concentrations of DO throughout the water column.

10.4 Summary of Priority Land Uses and Land Areas

External loadings from agricultural and natural areas (forests, shrublands, grasslands, and wetlands) predominate nonpoint source loadings in the Port Henry and Isle La Motte sub-watersheds.

11. Lake Management / Water Quality Goals

11.1 General Lake Champlain

The overarching goal of this Lake Champlain Harmful Algal Bloom Action Plan is to minimize the spatial and temporal extent of HABs in Lake Champlain though well planned, targeted nutrient reduction watershed strategies from all contributing sectors. In order to meet water quality targets for the Port Henry and Isle La Motte regions of Lake Champlain, nutrient mitigation of sources in other regions of Lake Champlain will be necessary. For the purpose of this action plan, actions focusing on nutrient mitigation and prevention of HABs are limited to the two target regions.

11.1.1 Lake Champlain at Port Henry

The target summer average TP concentration in the Port Henry segment of Lake Champlain is 0.014 mg/L (14 μg/L), per the 2002 TMDL and the 1993 open water quality agreement on in-lake criteria between states of NY and VT. This TP threshold is based off of user perception surveys that focus on broad water quality conditions. Total phosphorus concentrations below an upper threshold safeguard from potential events stemming from acute loadings of TP (e.g., runoff events) and from the potential exacerbating effects from other contributing sources of HABs (e.g., elevated water temperatures). A TP concentration threshold below the 0.014 mg/L threshold identified in the 2002 TMDL may be necessary to reduce or prevent HABs within the Port Henry region.

The 2002 phosphorus TMDL for the Port Henry sub-region included a reduction of nonpoint source loading from 2.7 mt/yr (as estimated in 1991) to 2.5 mt/yr. To achieve this nonpoint source reduction, phosphorus loading from both agricultural and urban land uses were targeted for reductions of 0.1 mt/yr each (VTANR and NYSDEC 2002).

11.1.2 Lake Champlain at Isle La Motte

Similar to Port Henry, described above, a target concentration of 0.014 mg/L (14 μg/L) has been established for TP in the Isle La Motte segment of Lake Champlain. A reduced target TP concentration is conservative to account for stochastic events, such as acute loadings of TP and for the potential for climatic factors contributing to HABs. As noted for Port Henry, a TP concentration threshold below the 0.014 mg/L threshold identified in the 2002 TMDL may be necessary to reduce or prevent HABs within this region.

The 2002 phosphorus TMDL for the Isle La Motte sub-region included a reduction of nonpoint source loading from 20.9 mt/yr to 18.9 mt/yr, achieved through reductions in agricultural (from 16.6 mt/yr as estimated with 1991 data, to 14.9 mt/yr allocated) and urban (3.4 mt/yr to 3.1 mt/yr) loadings (VTANR and NYSDEC 2002).

12. Summary of Management Actions to Date

12.1 Local Management Actions, General Lake Champlain

Numerous local management actions have been implemented by local communities along Lake Champlain in New York State. Local management actions implemented within New York State's Lake Champlain watersheds include (LCBP 2017):

- Agricultural BMPs and conservation practices
- NY Rural Roads Active Management Program and mapping of Plattsburgh stormwater sewer system
- Asset Management plans for 6 municipalities
- Septic system pump-out programs
- Stream bank stabilization
- Lake Champlain shoreline restoration

For additional information on these and other management actions refer to the LCBP website: http://www.lcbp.org/media-center/publications-library/technical-reports/.

The NY Rural Roads Active Management Program will take advantage of existing education programs, such as the NY's Emergency Stream Intervention (ESI) Training program, USC, Lake Champlain Rural Roads Active Management Program (https://www.warrenswcd.org/files/RRAMP_Manual.pdf), Cornell University, and the Cornell Local Roads program. This new program will be adaptable in all watersheds."

The improvement in phosphorus loading through the implementation of BMPs differs among tributaries within the watershed of Lake Champlain. Overall, a watershed-wide net reduction of approximately 27 metric tons per year of normalized phosphorus load has been realized through efforts in New York and Vermont (LCBP 2018). Challenges remain for certain waterways where increases in phosphorus loading have been observed (e.g., Saranac River, Ausable River), however these instances represent opportunities for significant reductions of future phosphorus loadings to Lake Champlain and its tributaries.

The Lake Champlain – Lake George Regional Planning Board (LCLGRPB), in conjunction with the Champlain Watershed Improvement Coalition of New York, prepared the *Lake Champlain Non-Point Source Pollution Subwatershed Assessment and Management Plan* (2018) to assist local and regional resource managers in identifying projects and programs to improve and protect water quality. The goal of the Plan was to identify specific planning and implementation efforts that would reduce phosphorus loadings to surface waters from various nonpoint sources. The Plan identified the following priority areas to direct management actions at:

a. Urban stormwater runoff
b. Agricultural operations
c. Streambank and roadside erosion

d. Aging public and private wastewater infrastructure.

The impetus for preparing the Plan was the levels of phosphorus in Lake Champlain that still exceed the standards set forth in the TMDL documents and to maximize the effect of available implementation funds.

The New York State Department of Agriculture and Markets (NYSDAM) and Soil and Water Conservation Committee facilitate the New York State Climate Resilient Farming (CRF) Program, which is intended to reduce the impact of agriculture on climate change (mitigation) and to increase the resiliency of local farms in the face of a changing climate (adaptation). For Lake Champlain, the State has contributed $225,000 toward CRF BMPs.

12.1.1 Lake Champlain at Port Henry

Of the 338 agricultural BMPs installed throughout the New York State Lake Champlain watershed between 2003 and 2010, 9 were installed in the Port Henry segment of the watershed. Agricultural phosphorus loading in this segment of Lake Champlain was reduced by approximately 247 lbs per year (Snell and Brower 2011). However, 22 BMPs were installed in the South Lake A (immediately south of Port Henry section) and 83 BMPs in the South Lake B (furthest south) segments with a total estimated reduction in phosphorus loading of 3,111 and 19,325 lbs per year, respectively (Snell and Brower 2011).

12.1.2 Lake Champlain at Isle La Motte

Agricultural BMPs have had the largest impact in the Isle La Motte segment of New York's Lake Champlain watershed, with approximately 131 BMPs installed (Snell and Brower 2011). Through the implementation of BMPs, the agricultural phosphorus load to the Isle La Motte segment of the Lake Champlain watershed was reduced by nearly 36,000 lbs per year.

12.2 Funded Projects

Since 2010, numerous technical and research projects, education and outreach efforts, and cultural heritage programs have been implemented within the Lake Champlain watershed (LCBP 2017). The majority of the projects contribute directly to the education, research, and management of water quality within Lake Champlain. Grants for other activities include pollution prevention and wildlife habitat conservation, aquatic invasive species spread prevention, organizational support, and community resilience (LCBP 2018k). The LCBP provided specific funding at the university, state agency, and federal agency levels for cyanobacteria monitoring and research efforts for more than 10 years (see **Section 7.1**).

As discussed in **Section 4**, a lake-wide cyanobacteria monitoring program initiated in 2004 is funded by both the LCBP and LCC members. The volunteer-driven program, now coordinated by VT DEC, is intended to educate the public on HABs and to compile data on bloom frequency and the hazards posed by HABs to human health and the environment.

Additional funding is provided through programs specifically targeting water quality improvement and the agricultural community in New York State, such as the Water Quality Improvement Program (WQIP) and the Agricultural Nonpoint Source Abatement and Control (ANSACP) program. Examples of BMP systems implemented that contribute to an improvement in water quality include pasture management, riparian buffer, erosion control, composting, nutrient management, and manure storage.

New York State Agricultural Environmental Management (AEM) program also supports farmers in their site-specific efforts to protect water quality and conserve natural resources, while enhancing farm viability (AEM 2018). AEM uses a five-tiered framework to categorize on-farm activities that have been prioritized by a committee of resource professionals and stakeholders. The following list important elements associated with each tier:

- **Tier 1** – Inventory current activities, future plans, and potential environmental concerns
- **Tier 2** – Document current land stewardship, assess and prioritize areas of concern
- **Tier 3** – Develop conservation plans addressing concerns and opportunities tailored to farm goals
    - **Tier 3A**: Component Conservation Plan
    - **Tier 3B**: Comprehensive Nutrient Management Plan (CNMP)
- **Tier 4** – Implement plans utilizing available financial, educational, and technical assistance
- **Tier 5** – Evaluate to ensure the protection of the environment and farm viability
    - **Tier 5A**: Update Tier 1 and 2
    - **Tier 5B**: Plan evaluation/update, BMP system evaluation

Many AEM-sponsored activities have been undertaken within the Lake Champlain watershed to address important environmental challenges including improving water quality (**Table 10**).

Table 10. Total number of Agricultural Environmental Management (AEM) projects conducted in the Lake Champlain watershed (2011-2017).

	Tier 1	Tier 2	Tier 3A	Tier 3B	Tier 4	Tier 5A	Tier 5B
Number of AEM Projects	42	22	20	1	26	4	0

The Lake Champlain Watershed Water Quality Management Planning and Roadside Erosion Assessment and Inventory projects were two of eleven projects in New York State that was funded through the Federal Government's American Recovery and Reinvestment Act initiative. The projects were completed through a partnership between the LCLGRPB, the Champlain Watershed Improvement Coalition of New York

(CWICNY) and the five County SWCD's. The goal of these projects was to identify eroding roadside banks that contribute significant sediment loads to streams throughout the Champlain Watershed. Data, photographs, and maps identifying erosion sites were produced for each county and township within the study area. For each site, a prioritization ranking matrix was used to determine the level of erosion; High, Moderate or Low, and potential remediation strategies and cost estimates were identified. Proposed remediation strategies included:

- Hydroseeding with tackifier and bonded fiber matrixes
- Stabilizing ditches with rock and gravel
- Installing erosion control blankets
- Constructing check dams and sediment traps
- Stabilizing bank toes and re-grading slopes and roads.

Several educational training sessions were also completed to educate local engineers and municipal staff on floodplain management, cold climate best management practices and performance, low impact development, advanced mechanisms and designs for phosphorus treatment, green roofs and pervious asphalt. County SWCD's also performed Erosion and Sediment Control trainings for local contractors.

12.3 NYSDEC Issued Permits, General Lake Champlain

Article 17 of New York's Environmental Conservation Law (ECL) entitled "Water Pollution Control" was enacted to protect and maintain the state's surface water and groundwater resources. Under Article 17, the SPDES program was authorized to maintain reasonable standards of purity for state waters. NYSDEC provides on-line information for the SPDES Permit Program for all nine regions in the state. Lake Champlain watershed is located within NYSDEC Region 5. Permits issued through the SPDES program include several to industrial and 30 wastewater treatment facilities that discharge directly into Lake Champlain or its tributaries with surface water discharges.

NYSDEC issues Multi-Sector General Permits (MSGPs) under the SPDES Program for stormwater discharges related to certain industrial activities. MSGPs have been issued for 15 active facilities in Essex County (NYSDEC 2018) and 35 in Clinton County. Many of these facilities are within the Lake Champlain watershed, and, therefore are likely to influence water quality conditions in Lake Champlain.

CAFO permits, issued under the SPDES Program, are required for animal feed programs that meet animal size (number of animal) thresholds. CAFO permits have been issued to 18 currently active facilities in Clinton County and are within the Lake Champlain watershed. Of these, 11 facilities are within the Isle La Motte region.

For more information about NYSDEC's SPDES program and to view MSGP, CAFO and Individual SPDES permits issued in the Champlain Lake watershed visit http://www.dec.ny.gov/permits/6054.html.

In 2017, NYSDEC issued two new CAFO general permits which specifically prohibit liquid manure applications on saturated soils and include additional restrictions for liquid manure applications on frozen, ice, and snow-covered soils. More information about the CAFO permits is on NYSDEC's website (https://www.dec.ny.gov/permits/6285.html).

12.4 Research Activities

The LCBP reports that since 1992, the Basin Program has funded more than 80 important research and demonstration projects and awarded more than $8 million in local grants to support research throughout the Champlain Basin (LCBP 2018k). The local grants are key to implementing its watershed management plan (*Opportunities for Action: An Evolving Plan for the Lake Champlain Basin*, LCBP 2017) at the grassroots level. The LCBP is committed to research and development projects providing the defensible science for implementing the plan.

12.5 Clean Water Plans (TMDL, 9E, or Other Plans)

Clean water plans are a watershed-based approach to outline a strategy to improve or protect water quality. Total maximum daily load (TMDL) and 9E Plans are examples of clean water plans; these plans document the pollution sources, pollutant reduction goals and recommend strategies/actions to improve water quality:

- A TMDL calculates the maximum amount of a single pollutant that a waterbody can receive and still meet water quality standards. TMDLs are developed by determining the amount that each source of a pollutant can discharge into the waterbody and the reductions from those sources needed to meet water quality standards. A TMDL is initiated by NYSDEC for waterbodies that are on the 303d impaired waters list with a known pollutant.

- Nine Element (9E) Watershed Plans are consistent with the USEPA's framework to develop watershed-based plans. USEPA's framework consists of nine key elements that are intended to identify the contributing causes and sources of nonpoint source pollution, involve key stakeholders in the planning process, and identify restoration and protection strategies that will address the water quality concerns. The nine minimum elements to be included in these plans include:

  A. Identify and quantify sources of pollution in watershed.
  B. Identify water quality target or goal and pollutant reductions needed to achieve goal.
  C. Identify the best management practices (BMPs) that will help to achieve reductions needed to meet water quality goal/target.
  D. Describe the financial and technical assistance needed to implement BMPs identified in Element C.
  E. Describe the outreach to stakeholders and how their input was incorporated and the role of stakeholders to implement the plan.
  F. Estimate a schedule to implement BMPs identified in plan.

G. Describe the milestones and estimated time frames for the implementation of BMPs.
H. Identify the criteria that will be used to assess water quality improvement as the plan is implemented.
I. Describe the monitoring plan that will collect water quality data need to measure water quality improvement (criteria identified in Element H).

9E Plans are best suited for waterbodies where the pollutant of concern is well understood and nonpoint sources are likely a significant part of the pollutant load; the waterbody does not need to be on the 303d impaired waters list to initiate a 9E Plan.

Section 303(d) of the Federal Clean Water Act required that USEPA and the states develop TMDLs for the pollutants violating applicable water quality standards/criteria and for which are responsible for impairment of the water body and its capacity to meet its designated uses. In 1998, NYSDEC added Lake Champlain to New York State's Section 303(d) list of impaired waters due to high levels of phosphorus, mercury, and PCB contamination. Lake Champlain was delisted for phosphorus in 2004 and mercury in 2008 because of the development of a Lake Champlain phosphorus TMDL and Northeast Mercury TMDL. Lake Champlain remains on the 2008 Section 303(d) list of impaired waters as a Fish Consumption Water due to PCB contamination (NYSDEC 2009). In response to Lake Champlain's inclusion on the Section 303(d) list of impaired waters in 1998 by New York and by Vermont in 2001, a joint TMDL for phosphorus was developed in 2002. An updated TMDL (USEPA 2016) for phosphorus for the Vermont portion of Lake Champlain provides additional information and recommendations for phosphorus load reductions. A detailed summary of the Lake Champlain TMDL is available in **Sections 10** and **11**.

13. Proposed Harmful Algal Blooms (HABs) Actions

13.1 Overarching Considerations

When selecting projects intended to reduce the frequency and severity of HABs, lake and watershed managers may need to balance many factors. These include budget, available land area, landowner willingness, planning needs, community priorities or local initiatives, complementary projects or programs, water quality impact or other environmental benefit (e.g., fish/habitat restoration, flooding issues, open space).

Additional important considerations include (1) the types of nutrients, particularly phosphorus, involved in triggering HABs, (2) confounding factors including climate change, and (3) available funding sources (discussed in section 13.2).

13.1.1 Phosphorus Forms

As described throughout this Action Plan, a primary factor contributing to HABs in the waterbody is excess nutrients, in particular, phosphorus. Total phosphorus (TP) is a common metric of water quality and is often the nutrient monitored for and targeted in watershed and lake management strategies to prevent or mitigate eutrophication (Cooke et al. 2005).

However, TP consists of different forms (Dodds 2003) that differ in their ability to support algal growth. There are two major categories of phosphorus: particulate and dissolved (or soluble). The dissolved forms of P are more readily bioavailable to phytoplankton than particulate forms (Auer et al. 1998, Effler et al. 2012, Auer et al. 2015, Prestigiacomo et al. 2016). Phosphorus bioavailability is a term that refers to the usability of specific forms of phosphorus by phytoplankton and algae for assimilation and growth (DePinto et al. 1981, Young et al. 1982).

Because of the importance of dissolved P forms affecting receiving waterbody quality, readers of the Action Plan should consider the source and form of P, in addition to project-specific stakeholder interest(s), when planning to select and implement the recommended actions, best management practices or management strategies in the Action Plan. Management of soluble P is an emerging research area; practices designed for conservation of soluble phosphorus are recommended in Sonzogni et al. 1982, Ritter and Shiromohammadi 2000, and Sharpley et al. 2006.

13.1.2 Climate Change

Climate change is also an important consideration when selecting implementation projects. There is still uncertainty in the understanding of BMP responses to climate change conditions that may influence best management practice efficiencies and effectiveness. More research is needed to understand which BMPs will retain their effectiveness at removing nutrient and sediment pollution under changing climate conditions, as well as which BMPs will be able to physically withstand changing conditions expected to occur because of climate change.

Where possible, selection of BMPs should be aligned with existing climate resiliency plans and strategies (e.g., floodplain management programs, fisheries/habitat restoration programs, or hazard mitigation programs). When selecting BMPs, it is also important to consider seasonal, inter-annual climate or weather conditions and how they may affect the performance of the BMPs. For example, restoration of wetlands and riparian forest buffers not only filter nutrient and sediment from overland surface flows, but also slow runoff and absorb excessive water during flood events, which are expected to increase in frequency due to climate change. These practices not only reduce disturbance of the riverine environment but also protect valuable agricultural lands from erosion and increase resiliency to droughts.

In New York State, ditches parallel nearly every mile of our roadways and in some watersheds, the length of these conduits is greater than the natural watercourses themselves. Although roadside ditches have long been used to enhance road drainage and safety, traditional management practices have been a significant, but unrecognized contributor to flooding and water pollution, with ditch management practices that often enhance rather than mitigate these problems. The primary objective has been to move water away from local road surfaces as quickly as possible, without evaluating local and downstream impacts. As a result, elevated discharges increase peak stream flows and exacerbate downstream flooding. The rapid, high volumes of flow also carry nutrient-laden sediment, salt and other road contaminants, and even elevated bacteria counts, thus contributing significantly to regional water quantity and quality concerns that can impact biological communities. All of these impacts will be exacerbated by the increased frequency of high intensity storms associated with climate change. For more information about road ditches, see **Appendix F**.

For more information about climate change visit DEC's website (https://www.dec.ny.gov/energy/44992.html) and the Chesapeake Bay Climate Resiliency Workgroup Planning Tools and Resources website (https://www.chesapeakebay.net/documents/Resilient_BMP_Tools_and_Resources_November_20172.pdf).

13.2 Priority Project Development and Funding Opportunities

The priority projects listed below have been developed by an interagency team and local steering committee that has worked cooperatively to identify, assess feasibility and costs, and prioritize both in-lake and watershed management strategies aimed at reducing HABs in Lake Champlain.

Steering committee members:

- Terry Martino, Adirondack Park Agency
- John Kanoza, Clinton County Health Department
- Albert Rascoe, Clinton County Highway Department
- Rodney Brown, Clinton County Planning Department
- Pete Hagar, Clinton County Soil and Water Conservation District (SWCD)
- Sam Dyer, Dyer Farms
- Chris Garrow, Essex County Department of Public Works
- Anna Reynolds, Essex County Office of Community Resources
- Dave Reckahn, Essex County SWCD
- Vic Putnam, Greater Adirondack Resource Conservation & Development Council
- Beth Gilles, Lake Champlain - Lake George Regional Planning Board
- Eric Howe, Lake Champlain Basin Program (LCBP)
- Tim Mihuc, Lake Champlain Research Institute at SUNY Plattsburgh
- Sarah Trumbull, Natural Resources Conservation Service
- Brian Steinmuller, NYSDAM
- Don Tuxill, NYSDEC
- Fred Dunlap, NYSDEC
- Rob Streeter, NYSDEC
- Kristen Sayers, NYSDOH
- George Laundrie, NYSDOT

- Valmekie Basil, NYSDOT
- Peyton Taylor, NYSOPRHP
- Eric Young, William H. Miner Agricultural Research Institute

These projects have been assigned priority rankings based on the potential for each individual action to achieve one of two primary objectives of this HABs Action Plan:

1. *In-lake management actions:* Minimize the internal stressors (e.g., nutrient concentrations, dissolved oxygen levels, temperature) that contribute to HABs within Lake Champlain.
2. *Watershed management actions:* Address watershed inputs that influence in-lake conditions that support HABs.

As described throughout this HABs Action Plan, the primary factors that contribute to HABs in Lake Champlain include:

Lake Champlain at Isle La Motte

- Nutrient and sediment inputs from agricultural lands within the contributing watershed
- Nonpoint source sediment and nutrient inputs from the contributing watershed (e.g., ditches)

Lake Champlain at Port Henry

- Stormwater runoff from developed areas.
- Phosphorus inputs associated with WWTP discharge.

The management actions identified below have been prioritized to address these sources. Projects were prioritized based on the following cost-benefit and project readiness criteria: local support or specific recommendation by steering committee members, eligibility under existing funding mechanisms, and expected water quality impacts as determined by the interagency team. Additionally, nutrient forms and the impacts of climate change were considered in this prioritization as described above.

The implementation of the actions outlined in this Plan is contingent on the submittal of applications (which may require, for example, landowner agreements, feasibility studies, funding match, or engineering plans), award of funding, and timeframe to complete implementation. Due to these contingencies, recommended projects are organized into broad implementation schedules: short-term (3 years), mid-term (3-5 years), and long-term (5-10 years).

Funding Programs

The recommended actions outlined in this Section may be eligible for funding from the many state, federal and local/regional programs that help finance implementation of projects in New York State (see https://on.ny.gov/HABsAction). The New York State Water Quality Rapid Response Team stands ready to assist all partners in securing funding. Some of the funding opportunities available include:

The New York State Environmental Protection Fund (EPF) was created by the state legislation in 1993 and is financed primarily through a dedicated portion of real estate transfer taxes. The EPF is a source of funding for capital projects that protect the environment and enhance communities. Several NYS agencies administer the funds and award grants, including NYSDAM, NYSDEC, and Department of State. The following two grant programs are supported by the EPF to award funding to implement projects to address nonpoint source pollution:

The Agricultural Nonpoint Source Abatement and Control Program (ANSACP), administered by the NYSDAM and the Soil and Water Conservation Committee, is a competitive financial assistance program for projects led by the Soil and Water Conservation Districts that involves planning, designing, and implementing priority BMPs. It also provides cost-share funding to farmers to implement BMPs. For more information visit https://www.nys-soilandwater.org/aem/nonpoint.html.

The Water Quality Improvement Program (WQIP), administered by the NYSDEC Division of Water, is a competitive reimbursement program for projects that reduce impacted runoff, improve water quality, and restore habitat. Eligible applicants include municipalities, municipal corporations, and Soil and Water Conservation Districts.

The Environmental Facilities Corporation (EFC) is a public benefit corporation which provides financial and technical assistance, primarily to municipalities through low-cost financing for water quality infrastructure projects. EFC's core funding programs are the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund. EFC administers both loan and grant programs, including the Green Innovation Grant Program (GIGP), Engineering Planning Grant Program (EPG), Water Infrastructure Improvement Act (WIIA), and the Septic System Replacement Program. For more information about the programs and application process visit https://www.efc.ny.gov/.

Wastewater Infrastructure Engineering Planning Grant is available to municipalities with median household income equal to or less than $65,000 according to the United States Census 2015 American Community Survey or equal to or less than $85,000 for Long Island, NYC and Mid-Hudson Regional Economic Development Council (REDC) regions. Priority is usually given to smaller grants to support initial engineering reports and plans for wastewater treatment repairs and upgrades that are necessary for municipalities to successfully submit a complete application for grants and low interest financing.

Clean Water Infrastructure Act (CWIA) Septic Program funds county-sponsored and administered household septic repair grants. This program entails repair and/or replacement of failing household septic systems in hot-spot areas of priority watersheds. Grants are channeled through participating counties.

CWIA Inter-Municipal Grant Program funds municipalities, municipal corporations, as well as soil and water conservation districts for wastewater treatment plant construction, retrofit of outdated stormwater management facilities, as well as installation of municipal sanitary sewer infrastructure.

CWIA Source Water Protection Land Acquisition Grant Program funds municipalities, municipal corporations, soil and water conservation districts, as well as not-for-profits (e.g., land trusts) for land acquisition projects providing source water protection. This program is administered as an important new part of the Water Quality Improvement Project program.

Consolidated Animal Feeding Operation Waste Storage and Transfer Program Grants fund soil and water conservation districts to implement comprehensive nutrient management plans through the completion of agricultural waste storage and transfer systems on larger livestock farms.

Water Infrastructure Improvement Act Grants funds municipalities to perform capital projects to upgrade or repair wastewater treatments plants and to abate combined sewer overflows, including projects to install heightened nutrient treatment systems.

Green Innovation Grant Program provides municipalities, state agencies, private entities, as well as soil and water conservation districts with funds to install transformative green stormwater infrastructure.

Readers of this Action Plan that are interested in submitting funding applications are encouraged to reference this Action Plan and complementary planning documents (i.e., TMDLs or 9E Plans) as supporting evidence of the potential for their proposed projects to improve water quality. However, applicants must thoroughly review each funding program’s eligibility, match, and documentation requirements before submitting applications to maximize their potential for securing funding.

There may be recommended actions that are not eligible for funding through existing programs, however, there may be opportunities to implement actions through watershed programs (https://www.dec.ny.gov/chemical/110140.html) or other mechanisms.

13.3 Lake Champlain Priority Projects

13.3.1 Priority 1 Projects

Priority 1 projects are considered necessary to manage water quality and reduce HABs in Lake Champlain, and implementation should be evaluated to begin as soon as possible.

13.3.1.1 Isle LaMotte

Short-term (3 years)

1. Implement a livestock exclusion program to minimize soil erosion and nutrient loading to aquatic habitat caused by livestock access to tributaries to Lake

Champlain. This project would be implemented by local SWCDs and other partners, and include:

   a. Installation of fencing on stable portions of the stream banks a minimum of 30-feet from the top of bank.
   b. Installation of livestock watering stations outside the limits of riparian areas.
   c. Installation of stable stream crossings to minimize livestock impacts.
   d. Establish vegetated riparian buffers within the fenced exclusion limits to inhibit or restrict nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams.
   e. Rehabilitate degraded vegetated buffers within the fenced exclusion limits to improve riparian habitat function.

2. Implement a cost-share program where the State provides financial and technical support to farmers who plant cover crops on agricultural fields to reduce soil erosion and nutrient runoff.
3. Implement roadside ditch improvement projects that are likely to contribute the greatest reduction in erosion as identified in the Lake Champlain Watershed Water Quality Management Planning project. Best management practices could include:
   a. timing of cleanout to minimize soil erosion.
   b. properly sizing culverts and channels to avoid headcuts and other erosion.
   c. use of cover crops to assist in ditch bank stabilization.
   d. Installation of check dams or other facilities to reduce flow velocities, minimize erosion, and promote sedimentation.

Mid-term (3 to 5 years)

1. Implement alternative manure management practices into animal feeding operations to reduce nutrient loadings to Lake Champlain and its tributaries:
   a. Review Agricultural Environmental Management (AEM) and Concentrated Animal Feeding Operation (CAFO) plans and identify mutually beneficial alternatives to land application of manure.
   b. Develop Comprehensive Nutrient Management Plans (CNMPs) for animal feeding operations within the watershed to identify alternative manure storage and application practices.

   c. Provide public outreach and education to discourage agricultural animal access to waterways and avoid the placement of manure in the drainage path of waterways.

13.3.1.2 Port Henry

Short-term (3 years)

1. Implement a stormwater management and reduction program within the Village of Port Henry and the Town of Moriah to reduce stormwater runoff and nutrient and sediment loading into Lake Champlain. The stormwater conveyance system (i.e., storm sewer pipes, outfalls) should be inventoried and incorporated into a database to identify system limitations, deficiencies, illicit discharges, and upgrade requirements.
   a. Best management practices could include installation of green infrastructure retrofits to replace existing stormwater management facilities that were installed prior to the promulgation of Article 17, Titles 7, 8, and Article 70 of the New York State Environmental Conservation Law. Approaches may include green roofs, permeable pavement, rain gardens, and vegetated, urban treescapes in developed areas.

Long-term (5 to 10 years)

1. Upgrade the Village of Port Henry/Town of Moriah wastewater treatment plant (WWTP) to include filtration of phosphorus consistent with the recommended actions identified in the 2014 Engineering Report (TetraTech 2014) to reduce phosphorus loading to that portion of the lake. Prior to implementation, the following will need to be completed:
   a. Feasibility study to estimate cost-benefit of the proposed upgrades. The following additional items should be pursued only if benefits outweigh costs:
      i. Final design.
      ii. Receive project approval from the Village of Port Henry and the Town of Moriah and/or approval of a referendum for long-term funding.
      iii. Apply for and receive regulatory approvals from the NYSDEC and other agencies.

13.3.2 Priority 2 Projects

Priority 2 projects are considered necessary, but may not have a similar immediate need as Priority 1 projects.

13.3.2.1 Lake Champlain at Isle LaMotte

Short-term (3 years)

1. Implement an inspection and maintenance program for near-shore septic systems:
    a. Inspection and pump-out of all septic systems located within 250-feet of the lakeshore.
    b. Replace failing systems with a 50% cost-share with individual property owners.

Mid-term (3 to 5 years)

1. Establish permanent riparian buffers where agricultural lands abut stream or lake habitat to protect banks and reduce soil erosion and nutrient loading. This may be accomplished by local SWCDs, non-profits, or other relevant stakeholders, through conservation easements and installing vegetative plantings and stream stabilization structures, to include:
    a. Establishment of vegetated riparian buffers to inhibit or restrict nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams.
    b. Restoration of degraded vegetated buffers to improve riparian habitat function.
2. Implement runoff reduction BMPs on croplands to reduce stormwater and nutrient runoff and soil erosion from agricultural lands in the watershed. This project may include:
    a. BMP Systems to promote stormwater retention and minimize concentrated runoff (e.g., rills, gullies).
    b. Stabilization of drainage swales through establishment of vegetation and/or installation of check dams.
    c. Installation of control facilities at the outlets of drainage swales (prior to entering the lake or tributaries) to promote sediment and nutrient capture.

13.3.2.2 Lake Champlain at Port Henry

Short-term (3 years)

1. Stabilize select segments of Stony Brook and establish permanent riparian buffers to protect banks and reduce soil erosion and nutrient loading. This may be accomplished through funding conservation easements and installing vegetative plantings and stream stabilization structures.

Mid-term (3 to 5 years)

1. Implement stormwater BMPs within the Mill Brook sub-watershed and re-connect Mill Brook to its floodplain in appropriate locations to minimize downstream flooding.

13.3.3 Priority 3 Projects

Priority 3 projects are considered important, but may not have a similar immediate need as Priority 1 and 2 projects.

13.3.3.1 Lake Champlain at Isle LaMotte

Long-term (5 to 10 years)

1. Complete a Watershed Management Plan for the Great Chazy River sub-watershed. The LCLGRPB has been awarded a LCBP grant to modify the workplan to include the entire Isle La Motte Lake Segment to align with the Lake Champlain TMDL and the HABs initiative.
2. Implement a stormwater management and reduction program within the Village of Rouses Point to reduce stormwater runoff and nutrient and sediment loading into Lake Champlain. Best management practices would be implemented consistent with those listed for the project described above for Port Henry and Moriah.

13.3.3.2 Lake Champlain at Port Henry

Long-term (5 to 10 years)

1. Implement Agricultural BMPs in the Port Henry Sub-Watershed consistent with those listed under Priority 1 Projects for the Isle La Motte Sub-Watershed.
2. Extend the outfall from the Village of Port Henry/Town of Moriah WWTP further into the lake to reduce impacts to near-shore areas. Prior to implementation, the following will need to be completed:
    a. Feasibility Study
    b. Final design.
    c. Apply for and receive regulatory approvals from the NYSDEC and other agencies.

13.4 Additional Watershed Management Actions

In addition to the priority actions identified above by the steering committee, the following watershed management actions could be considered:

1. Restore wetland and floodplains targeted at sediment and nutrient reduction.

2. Emphasize phosphorus source control in stormwater management planning to target areas with high levels of phosphorus runoff. Emphasis should be placed on locations within the watershed that have a combination of relatively high percentages of impervious cover, small lot sizes, and/or compacted soils.

3. Evaluate the presence of forest pests that affect hemlock (*Tsuga* spp.), ash (*Fraxinus* spp.), spruce (*Picea* spp.), and other tree species that are currently integral to watershed stabilization. Implement pro-active pest prevention and/or management to reduce the impacts of the pests.

4. Evaluate locations where animal wastes are concentrated (e.g., pet stores and animal care/boarding facilities) for illicit connections and exposure to stormwater, and provide them with tailored education and outreach materials.

5. Evaluate locations where yard or food wastes are stored (e.g., "dumpsters" serving restaurants and grocery stores, yard waste composting and disposal areas) for illicit connections and exposure to stormwater and provide them with tailored education and outreach materials.

13.5 Monitoring Actions

To help determine the stresses that lead to potential HABs in Lake Champlain and to assess improvements associated with management actions, the following monitoring actions are recommended for evaluation:

Short-term

1. Collect water quality data before, during, and following HAB events to better evaluate potential triggers or facilitators to HABs.

2. Collect lake water samples of total soluble phosphorus to quantify phosphorus bioavailability for cyanobacteria.

3. Supplement the understanding of the cyanobacteria taxa contributing to blooms. Additionally, a greater temporal resolution of algal density in Lake Champlain is needed to draw more robust seasonal trends and conclusions.

4. Supplement the understanding of the cyanobacteria taxa contributing to blooms. Additionally, a greater temporal resolution of algal density in Lake Champlain is needed to draw more robust seasonal trends and conclusions.

5. Supplement data on cyanobacteria toxin concentrations during confirmed blooms.

6. Maintain and enhance community and/or volunteer monitoring efforts of water quality conditions in the lake, particularly during the growing season. Align in-lake water quality data collection efforts with overpasses of NASA's Landsat 8 satellite (**Table 11**), to the extent possible. This alignment will allow for the effective use of satellite imagery when characterizing lake conditions based on corresponding field data.

TABLE 11. LANDSAT 8 OVERPASSES FOR LAKE CHAMPLAIN FOR MAY THROUGH OCTOBER 2018.		
MONTH	**Dates**	
MAY	May 14	May 30
JUNE	June 15	NA
JULY	July 1	July 17
AUGUST	August 2	August 18
SEPTEMBER	September 3	September 19
OCTOBER	October 5	October 21

13.6 Research Actions

To help understand the stresses that lead to and develop management strategies to prevent the potential formation of HABs in Lake Champlain, the following research actions are recommended for evaluation:

Mid-term

1. Develop fine-scale spatial estimates of internal loading to determine the influence of bay areas on nutrient concentrations. Such work would likely require field surveys (core/grab samples) to characterize the lake bed sediments in terms of grain size and phosphorus concentrations in nearshore bays.
2. Conduct localized studies of groundwater quality and hydrology. Although general information on groundwater resources, utilization, and management approaches are available on the watershed level (e.g., see *Groundwater Quality in the Lake Champlain Basin, New York* (NYSDEC 2011)), detailed assessments of near-lake groundwater nutrient levels, elevations, and lake infiltration rates are lacking.

Long-term

1. Maintain long term monitoring (decadal) programs in-lake and in the watershed to provide valuable data in the assessment of future water quality and trends.

NYSDEC should support research to better understand how to target dissolved phosphorus with traditional and innovative nonpoint source best management practices.

The NYSDEC should continue to coordinate with local organizations and research groups to maximize the efficacy of research efforts with the shared goal of maintaining the water quality within Lake Champlain. Specifically, the role of nitrogen concentrations in the production of toxins by cyanobacteria should be studied and management actions targeted at optimizing the nutrient levels to minimize the production of toxins associated with HABs.

The NYSDEC should support research to better understand how to target dissolved phosphorus with traditional and innovative nonpoint source best management practices.

This applied research would guide selection of appropriate BMPs to target dissolved phosphorus in the future.

The NYSDEC should support research to understand and identify which best management practices will retain their effectiveness at removing nutrient and sediment pollution under changing climate conditions, as well as which BMPs will be able to physically withstand changing conditions expected to occur as a result of climate change. This applied research would guide selection of appropriate BMPs in the future and determination of the likely future effectiveness of existing BMPs.

The NYSDEC should support research to investigate the role of climate change on lake metabolism, primary production, nutrient cycling, and carbon chemistry.

The NYSDEC should encourage and support research into management options for dreissenids and better understanding of their natural population cycles.

13.7 Coordination Actions

The following actions are opportunities for stakeholders, general public, steering committee members, federal state, and local partners to collaborate, improve project or program integration, enhance communication and increase implementation. The actions are intended to increase collaboration and cooperation in the overall advancement of this HABs Action Plan. These actions will likely change or expand as the Action Plan is implemented and/or research is completed, or when opportunities for coordination are identified.

Short-term

1. Encourage participation in Lake Champlain Basin Program initiatives for reducing phosphorus and documenting/tracking HABs.
2. Encourage public participation in initiatives for reducing phosphorus and documenting/tracking HABs, such as volunteer monitoring networks and/or increasing awareness of procedures to report HABs to NYSDEC.
3. Improve coordination between NYSDEC and owners of highway infrastructure (state, county, municipal) to address road ditch management; including, identify practices, areas of collaboration with other stakeholder groups, and evaluation of current maintenance practices.
4. Continue to support and provide targeted training (e.g., ditch management, emergency stream intervention, sediment and erosion controls, prescribed grazing, conservation skills, etc.) to municipal decision makers, SWCDs, and personnel in order to underscore the importance of water quality protection as well as associated tools and strategies.

Long-term

1. Pursue and identify cooperative landowners to facilitate acquisitions of conservation easements to implement watershed protection strategies, harnessing available funding opportunities related to land acquisition for water quality protection.
2. Support Land Trusts through volunteering and financial support to facilitate land protection measures and purchases/acquisitions of conservation preserves within the Lake Champlain watershed.
3. Identify opportunities to encourage best management practice implementation through financial incentives and alternative cost-sharing options.
4. Coordinate with Department of Health to support the local health departments to implement onsite septic replacement and inspection activities.
5. Identify areas to improve efficiency of existing funding programs that will benefit the application and contracting process. For example, develop technical resources to assist with application process and BMP selection, identify financial resources needed by applicants for engineering and feasibility studies.
6. Support evaluation of watershed rules and regulations.

13.8 Long-term Use of Action Plan

This Action Plan is intended to be an adaptive document that may require updates and amendments, or evaluation as projects are implemented, research is completed, new conservation practices are developed, implementation projects are updated, or priority areas within the watershed are better understood.

Local support and implementation of each plan's recommended actions are crucial to successfully preventing and combatting HABs. The New York State Water Quality Rapid Response Team has established a one-stop shop funding portal and stands ready to assist all localities in securing funding and expeditiously implementing priority projects.

Communities and watershed organizations are encouraged to review the plan for their lake, particularly the proposed actions, and work with state and local partners to implement those recommendations. Individuals can get involved with local groups and encourage their communities or organizations to take action.

Steering committee members are encouraged to coordinate with their partners to submit funding applications to complete implementation projects. For more information on these funding opportunities, please visit https://on.ny.gov/HABsAction.

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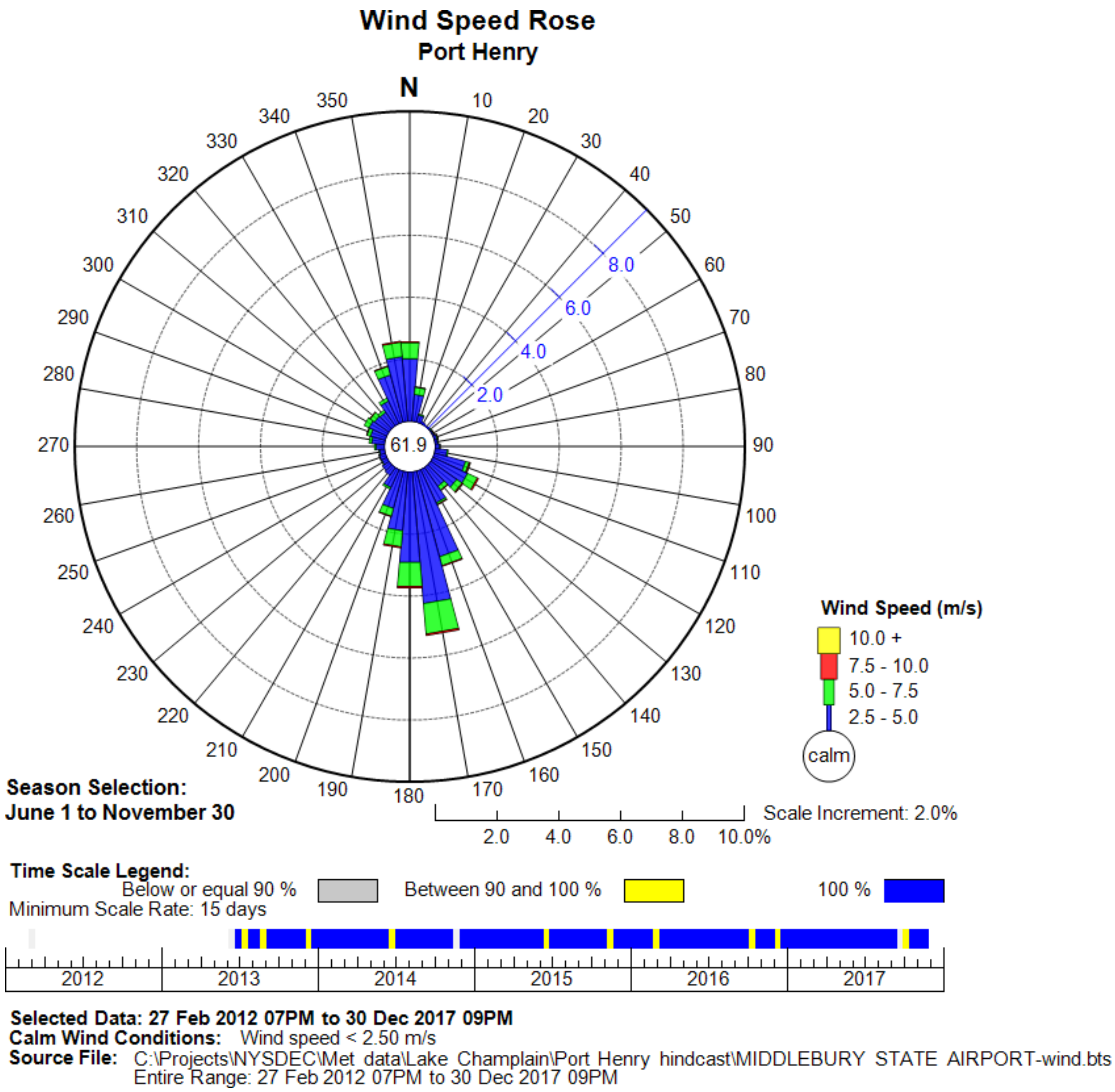
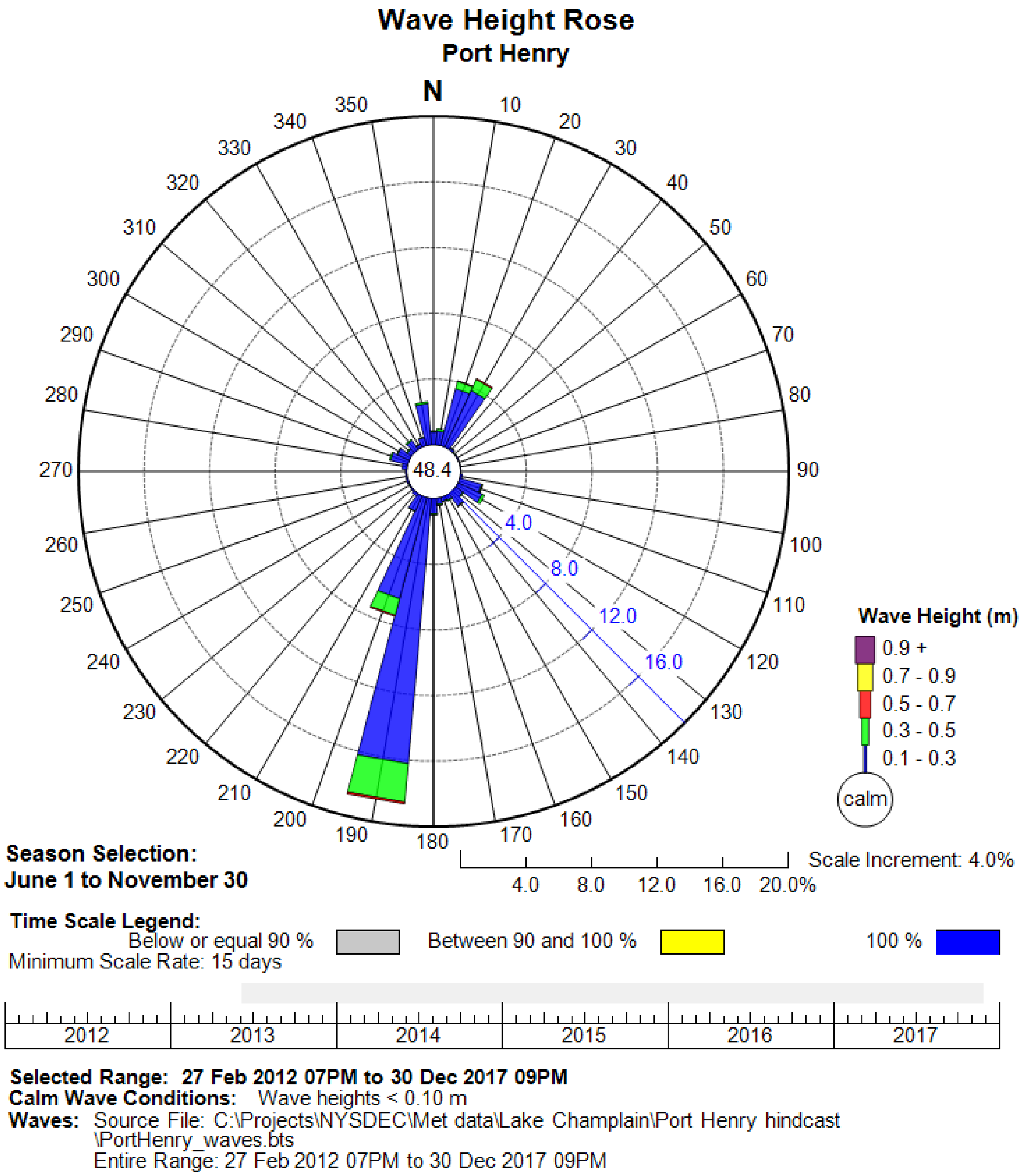
Appendix A. Wind and Wave Patterns

Port Henry – wind speed



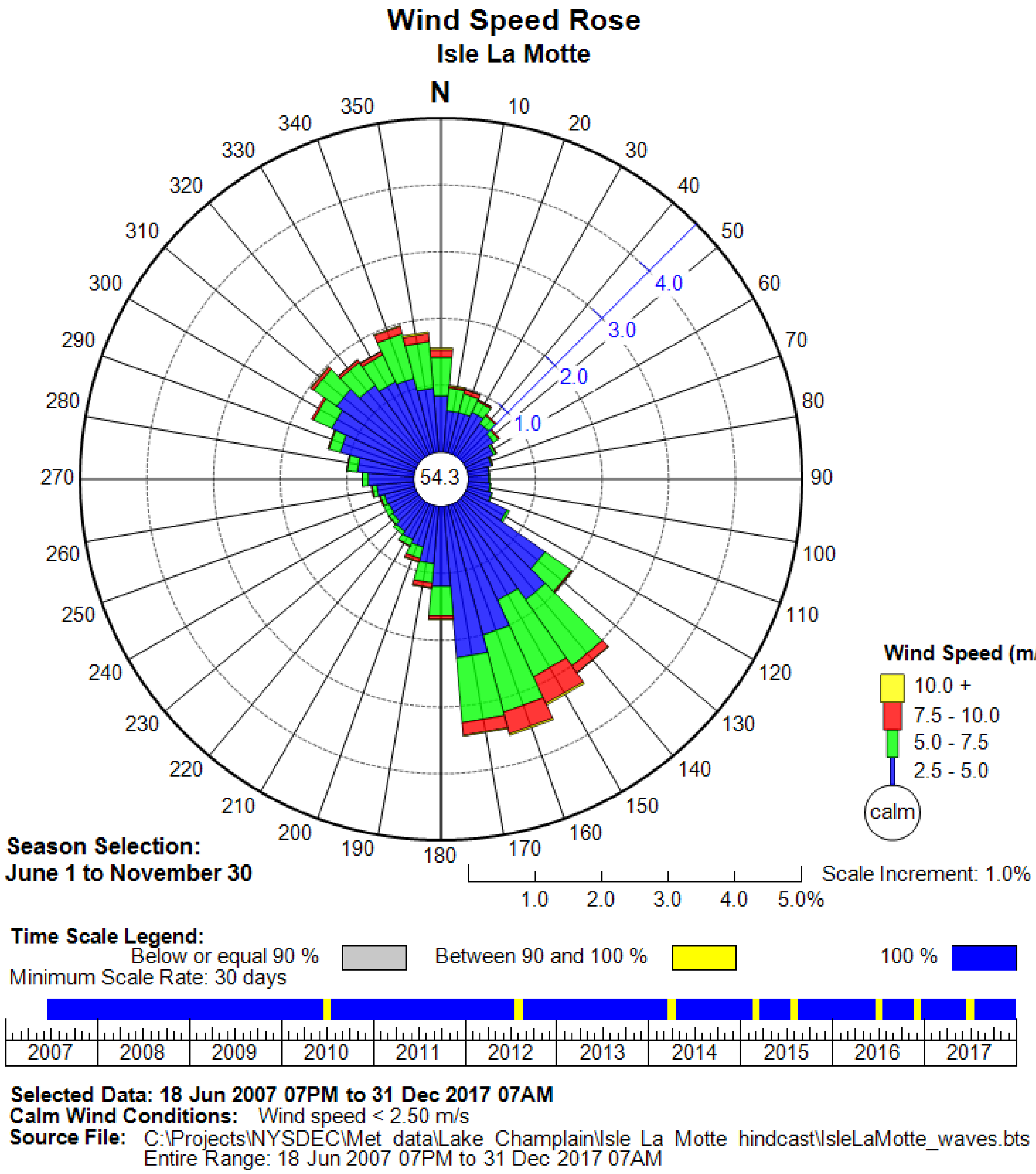
The wind speed at Port Henry segment of Lake Champlain from 2012 to 2017, during the months of June through November, indicate stronger winds were generally out of the north and south.

Port Henry – wave height



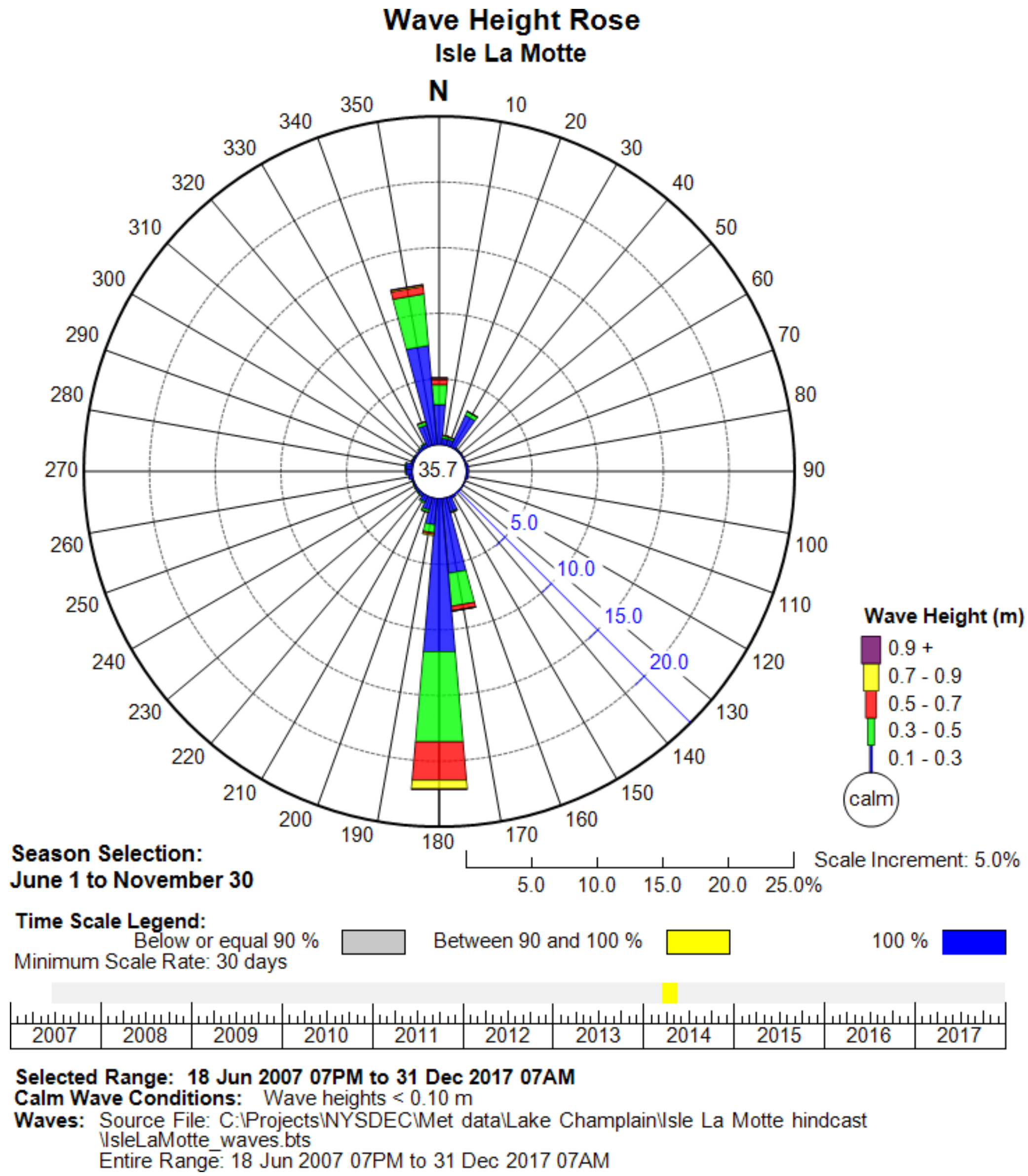
Wave height patterns at Port Henry segment of Lake Champlain from 2012 to 2017, during the months of June through November, indicate wave heights were generally greater in the southern extent of the segment.

Isle La Motte – wind speed



Wind speeds at the Isle La Motte segment of Lake Champlain from 2007 to 2017, during the months of June through November, indicate stronger winds were generally out of the southeast and northwest.

Isle La Motte – wave height



Wave height patterns in the Isle La Motte segment of Lake Champlain from 2012 to 2017, during the months of June through November, indicate wave heights were greater in the north and southern portions of the lake segment.

Appendix B. Waterbody Classifications

Class N: Enjoyment of water in its natural condition and where compatible, as source of water for drinking or culinary purposes, bathing, fishing and fish propagation, recreation and any other usages except for the discharge of sewage, industrial wastes or other wastes or any sewage or waste effluent not having filtration resulting from at least 200 feet of lateral travel through unconsolidated earth. These waters should contain no deleterious substances, hydrocarbons or substances that would contribute to eutrophication, nor shall they receive surface runoff containing any such substance.

Class $AA_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival, and shall contain no floating solids, settleable solids, oils, sludge deposits, toxic wastes, deleterious substances, colored or other wastes or heated liquids attributable to sewage, industrial wastes or other wastes. There shall be no discharge or disposal of sewage, industrial wastes or other wastes into these waters. These waters shall contain no phosphorus and nitrogen in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.

Class $A_{special}$: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These international boundary waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class AA: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These waters, if subjected to approved disinfection treatment, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class A: Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. These waters shall be suitable for fish propagation and survival. These waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, will meet New York State Department of Health drinking water standards and will be considered safe and satisfactory for drinking water purposes

Class B: The best usage is for primary and secondary contact recreation and fishing. These waters shall be suitable for fish propagation and survival

Class C: The best usage is for fishing, and fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class D: The best usage is for fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Class (T): Designated for trout survival, defined by the Environmental Conservation Law Article 11 (NYS, 1984b) as brook trout, brown trout, red throat trout, rainbow trout, and splake.

Class (TS): Designated for trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies.

Appendix C. Remote Sensing Methodology

Relative chlorophyll-a concentrations were estimated for eight water bodies using remote sensing methods. The analysis involved processing the spectral wavelengths of satellite imagery to estimate the amount of chlorophyll-a at the water surface. The analysis is based on the ratios of reflected and absorbed light for discrete spectral bands (i.e. blue, green, and red) and is thus a measure of green particles near the water surface.

The analysis was completed for seven water bodies, with dimension larger than 1 km in both length and width. These include: Conesus Lake, Honeoye Lake, Chautauqua Lake, Owasco Lake, Lake Champlain, Lake George, and Cayuga Lake.

The remote sensing analysis provides an overview of the spatial distribution and relative concentration of chlorophyll-a on specific dates. Imagery was acquired for the past three summer seasons (2015-2017) to gain a better understanding of the development of chlorophyll-a concentrations over the summer and potential Harmful Algal Bloom (HAB) triggers. This information may be used to:

- Understand the spatial extent, temporal coverage, and magnitude of historical HAB events;
- Identify regions of each lake susceptible to HABs due to the location of point source inputs, prevailing winds, etc.;
- Identify conditions which may trigger a HAB (e.g. rainfall, temperature, solar radiation, wind, water chemistry, etc.);
- Guide monitoring plans such as location and frequency of in-situ measurements;
- Guide the development of water quality assessment programs, for which HAB extent, intensity, and duration are relevant;
- Guide management plans such as prioritizing remedial actions, locating new facilities (e.g. water intakes, parks, beaches, residential development, etc.) and targeting in-lake management efforts.

At this time, the estimated chlorophyll-a concentrations are reported as a concentration index due to the limited number of in-situ measurements (+/- 1 day of the satellite images) to calibrate the method. Chlorophyll-a concentrations can be quantified using this method, but more in-situ data is required from New York State lakes to calibrate/validate the method. Once the calibration/validation is completed, the quantified chlorophyll-a concentrations would give an improved understanding of the spatial and temporal dynamics of chlorophyll-a concentrations.

Analysis could be conducted to estimate cyanobacteria in addition to chlorophyll-a. However, there are a lot less cyanobacteria measured data than chlorophyll-a. As more measured cyanobacteria concentration data becomes available, remote sensing analysis of cyanobacteria could be investigated.

Overview of the Method

Chlorophyll-a concentrations were estimated using a remote sensing algorithm/model developed by the University of Massachusetts (Trescott 2012) for Lake Champlain. The model was calibrated and cross-validated using four years of in-situ chlorophyll-a measurements from fifteen locations on the lake. The samples were collected from the water surface to a depth equal to twice the Secchi depth.

Chlorophyll-a has a maximum spectral reflectance in the green wavelength (~560 nm) and absorbance peaks in the blue and red wavelengths (~450 nm & ~680 nm). There is an additional secondary reflectance peak in the near infrared spectrum at ~700 nm that was not incorporated in the University of Massachusetts study[2]. The model was then calibrated and cross-validated to field data collected within one day of the satellite overpasses using only images with clear skies. This was done to minimize the uncertainty and complexity with atmospheric correction for the satellite imagery. The chlorophyll-a model developed for Lake Champlain using Landsat 7 color bands is shown in Eq. 1.

$$Chla = -46.51 + 105.30\left(\frac{RB_{green}}{RB_{blue}}\right) - 40.39\left(\frac{RB_{red}}{RB_{blue}}\right) \qquad [Eq. 1]$$

The model has a coefficient of determination (R^2) of 0.78, which indicates that 78% of the variation in measured chlorophyll-a can be explained by Eq. 1. The relationship between measured and modeled chlorophyll-a concentrations for Lake Champlain is shown in **Figure C1**.

[2] The accuracy of the model could potentially be improved by incorporating data from the near infrared band.

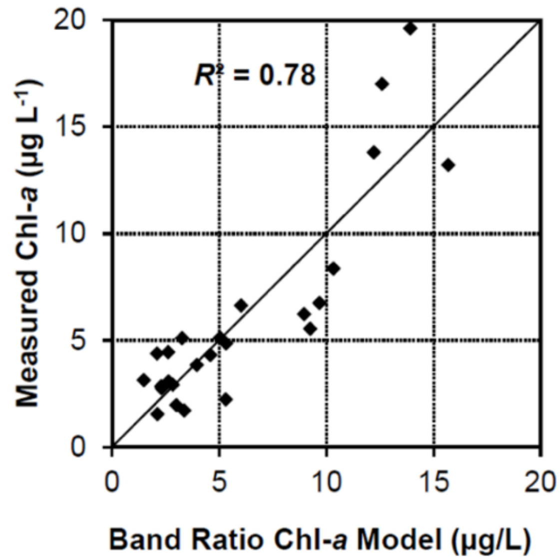


Figure C1. Measured and modeled chlorophyll-a concentrations for Lake Champlain, from Trescott 2012.

Application of the Method

Landsat 8 was launched in February 2013 and provides increased spectral and radiometric resolution compared to Landsat 7. In this study, Landsat 8 imagery were downloaded from the USGS website, Earth Explorer, for the months of May through October 2015 to 2017. These scenes were visually examined for extensive cloud cover and haze over the project lakes, discarding those that had 100% cloud coverage[3]. The selected images were processed to Top of Atmosphere (TOA) reflectance as per the Landsat 8 Data Users Handbook (USGS 2016). TOA reflectance reduces the variability between satellite scenes captured at different dates by normalizing the solar irradiance.

The TOA corrected images were processed using the chlorophyll-a model (Eq. 1) developed for Lake Champlain using Landsat 7 imagery (Trescott 2012). The blue, green, and red spectral bands are very similar for Landsat 7 and Landsat 8 and the model was used without adjustment.

The Landsat 8 Quality Assessment Band was used to remove areas designated as cloud or haze. However, this method is not able to remove the shadows of clouds that are seen in some of the images. Modeled chlorophyll-a concentrations may be lower in areas adjacent to cloud or haze due to less reflected lighted being received by the satellite sensors. The shadowed areas can be identified by their proximity, size, and shape relative areas of no data (clouds).

The modeled chlorophyll-a concentrations were clipped to the lake shorelines using a 100-m buffer of the National Hydrography Dataset (NHD) lake polygons. This step was

[3] NASA's quality assurance band algorithm was used to mask out clouds and cirrus (black/no data patches on figures).

used to exclude pixels that may overlap between land and water and possibly contain shoreline and shallow submerged aquatic vegetation. Landsat 8 spectral imagery is provided at a 30-m resolution.

A comparison of measured and modeled chlorophyll-a concentrations for five of the study lakes for 2016 and 2017 is shown in **Figure C2**. Based on the 22 field measurements that occurred within one day of the satellite imagery, the model appears to under estimate chlorophyll-a concentrations in some situations.

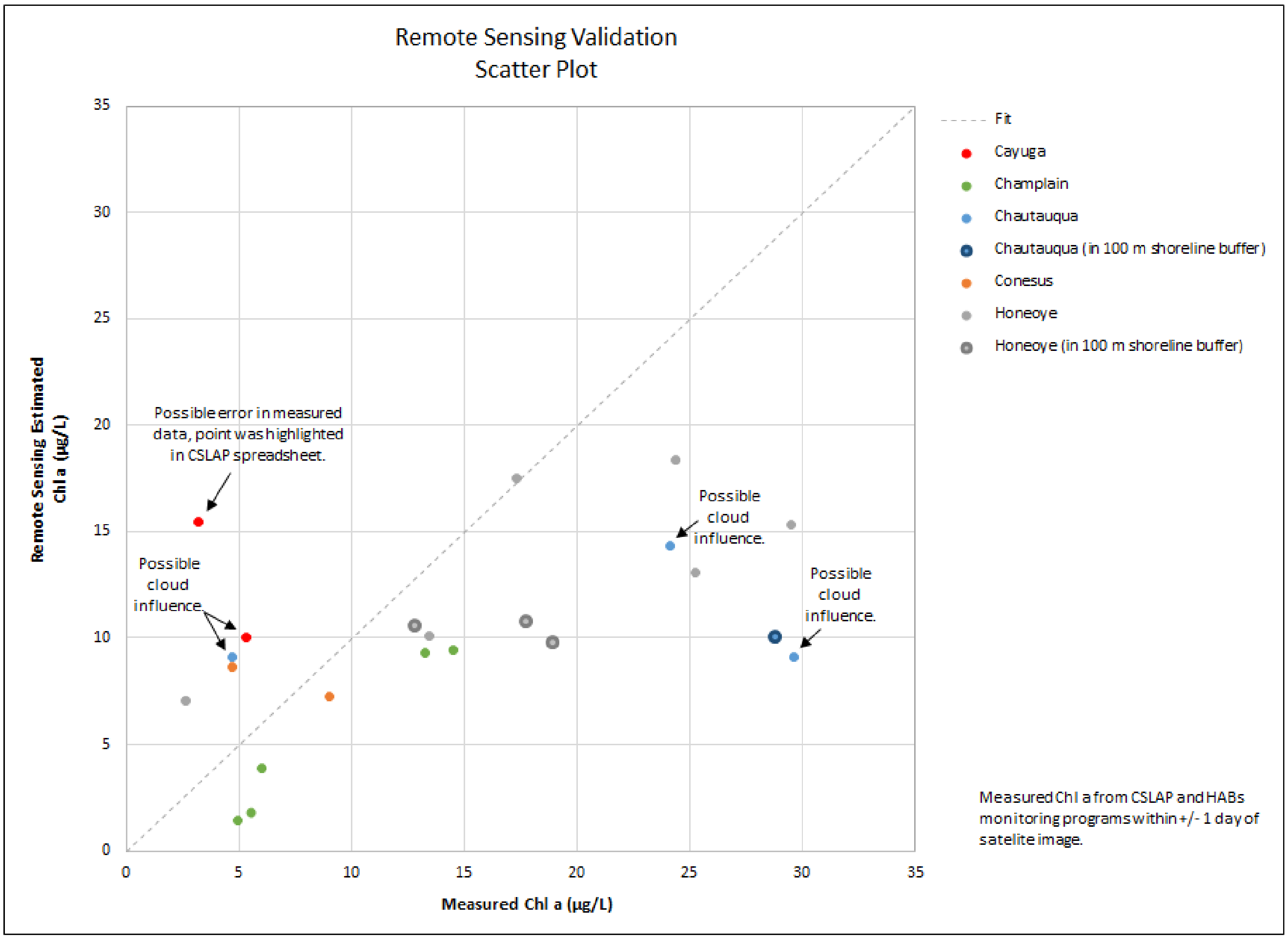


Figure C2. Measured and modeled chlorophyll-a concentrations for Cayuga Lake, Lake Champlain, Chautauqua Lake, Conesus Lake, and Honeoye Lake (2016-2017 data).

Limitations of the Method

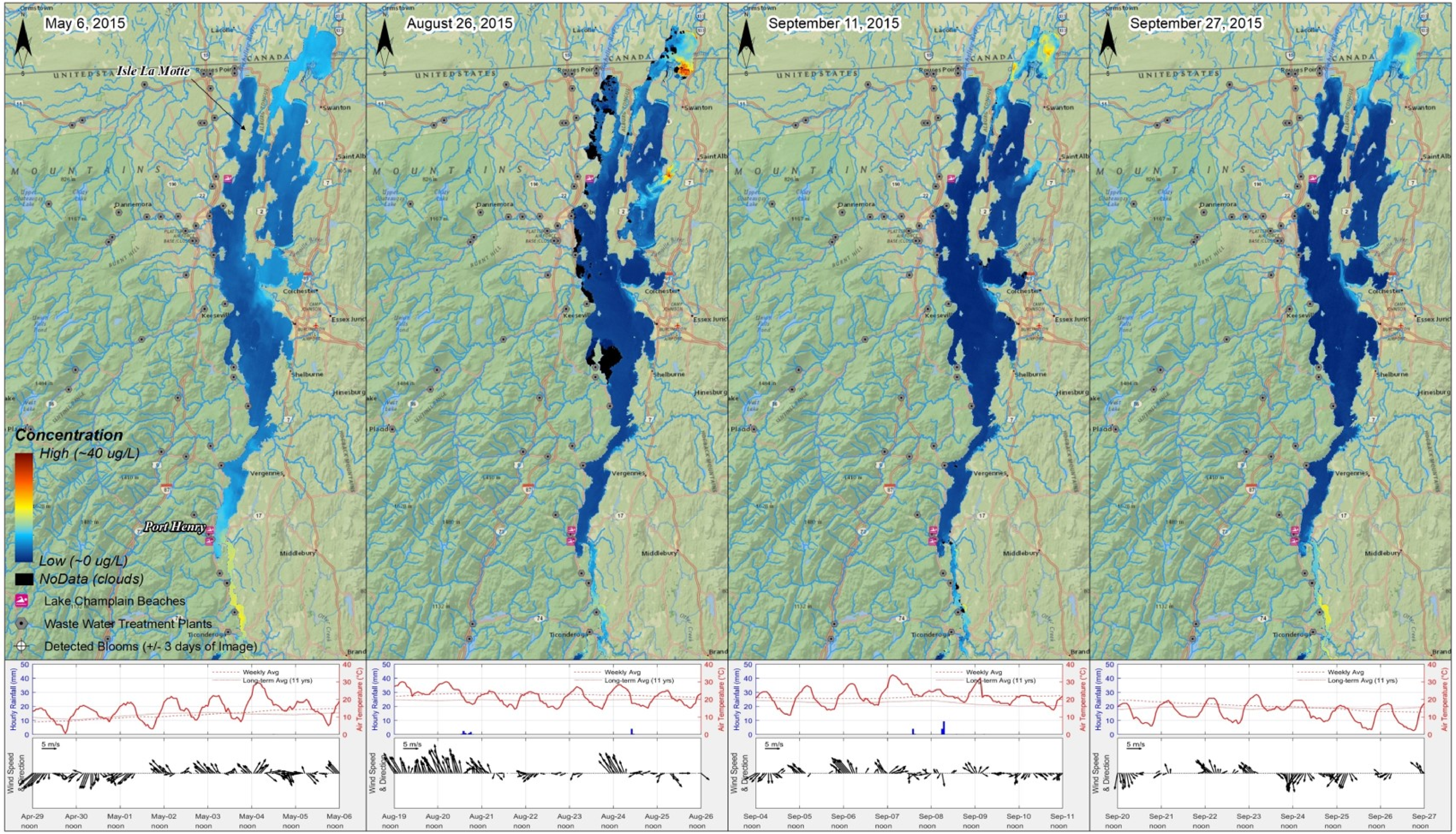
The remote sensing chlorophyll-a model was developed for Lake Champlain using four years of coincident in-situ chlorophyll-a measurements and Landsat 7 imagery. The model was calibrated and cross-validated using samples that were collected within one day of the satellite overpasses and imagery that was free of cloud and haze. The maximum in-situ chlorophyll-a concentration was 20 μg/L.

The method was applied to eight freshwater lakes in New York State (including Lake Champlain). These lakes have excess phosphorus loading from sources similar to Lake Champlain, including agricultural runoff and septic systems. The method is expected to be most accurate under clear sky conditions and chlorophyll-a concentrations less than 20 μg/L (until validated for higher concentrations).

Further development and application of the method to New York State lakes should consider the following:

- The model estimates chlorophyll-a concentrations rather than HABs species directly. Remote sensing studies tend to use abnormally high chlorophyll-a concentrations as a first step in detecting possible HABs (Trescott 2012; USGS 2016).
- The model was developed for Lake Champlain and hasn't been fully validated for other New York State lakes. In the future, field sampling should be conducted on the dates of the Landsat 8 satellite overpasses for the lakes of interest.
- Different algae species may be present in the Lake Champlain calibration dataset than in the other New York State lakes. The model may be less accurate for the other lakes if different algae species are present.
- The model was calibrated using chlorophyll-a measurements taken within one day of the satellite overpasses as wind and precipitation are expected to change the composition of the algal blooms (Trescott 2012). Measurements greater than one day could potentially be used to validate the model for other lakes if winds were calm and there was no rain over the extended period.
- The model was developed using cloud and haze-free imagery. Estimated chlorophyll-a concentrations are expected to be less accurate when clouds and haze are present.
- The model was calibrated to depth-integrated chlorophyll-a measurements (from twice the Secchi depth to the water surface). Estimated chlorophyll-a concentrations are expected to compare better with measurements taken over the depth of light transmission (i.e. Secchi depth) than measurements taken from a predefined depth (e.g. CSLAP grab samples are collected at a water depth of 1.5 m).
- Estimated chlorophyll-a concentrations are expected to be less accurate in shallow water where light may be absorbed and reflected by submerged aquatic vegetation and the lake bed.
- The influence from turbidity caused by inorganic suspended solids on the modeled chlorophyll-a concentrations was not thoroughly investigated. However, it is unlikely to affect the results since there are distinct differences in the reflection pattern of chlorophyll-a versus inorganic turbidity (Karabult and Ceylan 2005).

- The estimated chlorophyll-a concentration from the nearest remote sensing pixel was used in the validation plot (**Figure C2**) because many of the measurements were near the shoreline. A 5-by-5 pixel averaging window was used previously for Lake Champlain (Trescott 2012) to filter the satellite noise and patchiness in the algae.



1:850,000

0 5 10 15 20 Miles

0 5 10 15 20 25 Kilometers

Plots

Plots show meteorological data 7 days prior to the satellite passing over the lake.

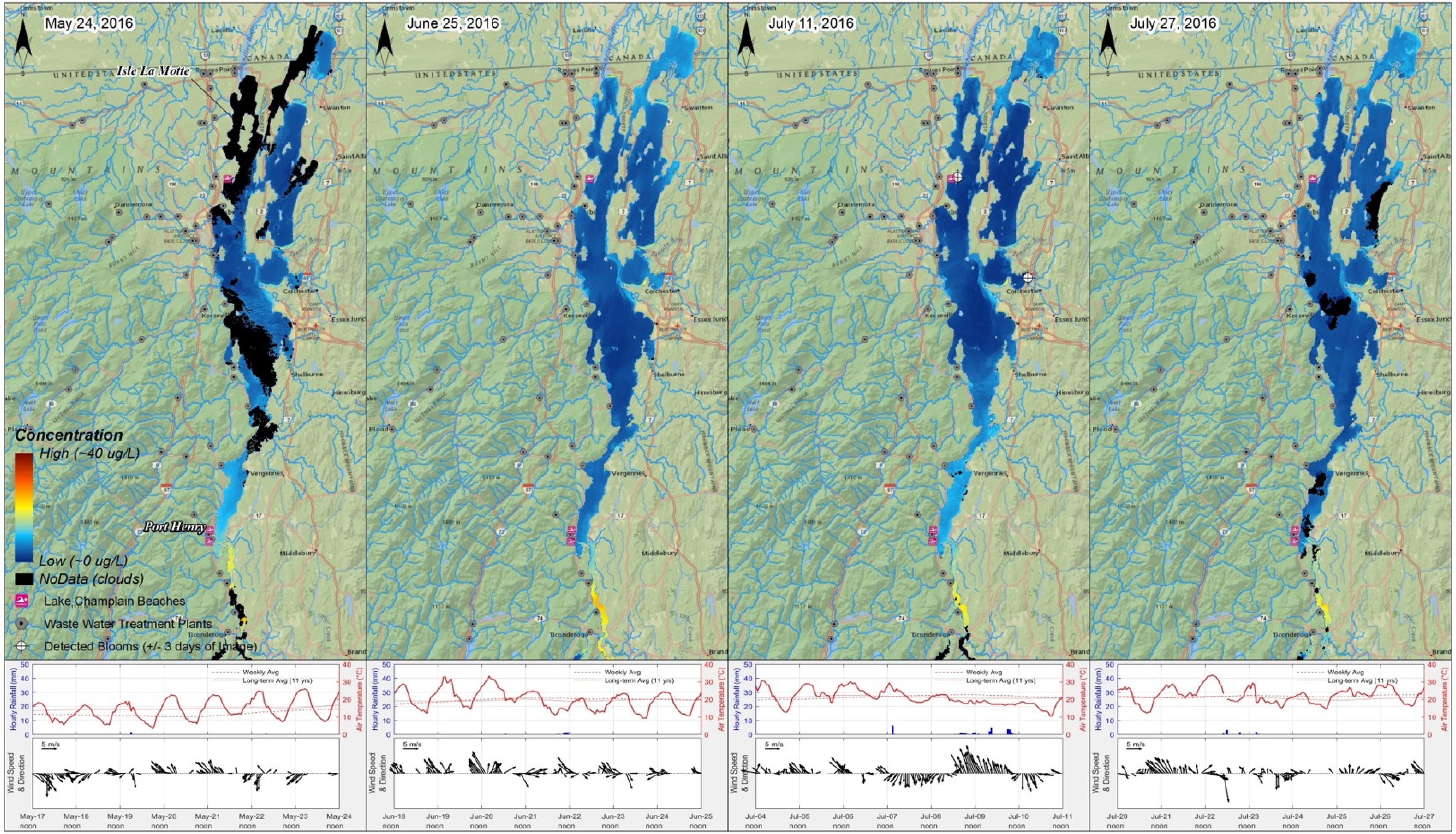
Satellite Derived Chlorophyll a

Chl-a Data is Derived from NASA's LandSat 8 Satellite
Data Gaps are Caused by Haze and Clouds

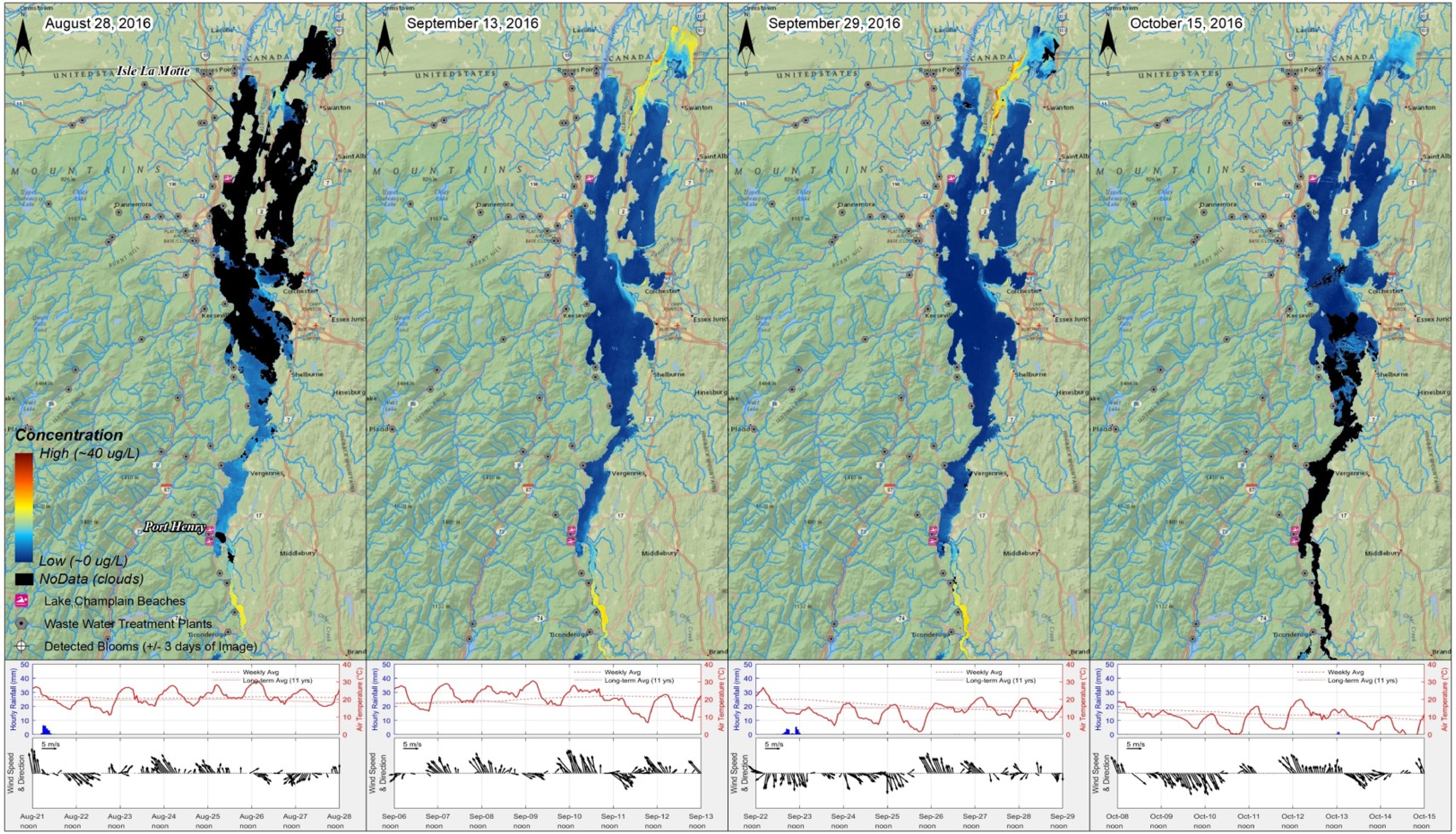
Disclaimer

These maps represent an estimate of chlorophyll-a concentration and are meant for discussion purposes to aid in management decisions and planning.

Basemap: National Geographic World Imagery Layer.
Spatial Reference: WGS 1984 UTM Zone 18N



1:850,000 0 5 10 15 20 Miles 0 5 10 15 20 25 Kilometers	**Plots** *Plots show meteorological data 7 days prior to the satellite passing over the lake.*	**Satellite Derived Chlorophyll a** *Chl-a Data is Derived from NASA's LandSat 8 Satellite* *Data Gaps are Caused by Haze and Clouds*	*Disclaimer* *These maps represent an estimate of chlorophyll-a concentration and are meant for discussion purposes to aid in management decisions and planning.* Basemap: National Geographic World Imagery Layer. Spatial Reference: WGS 1984 UTM Zone 18N



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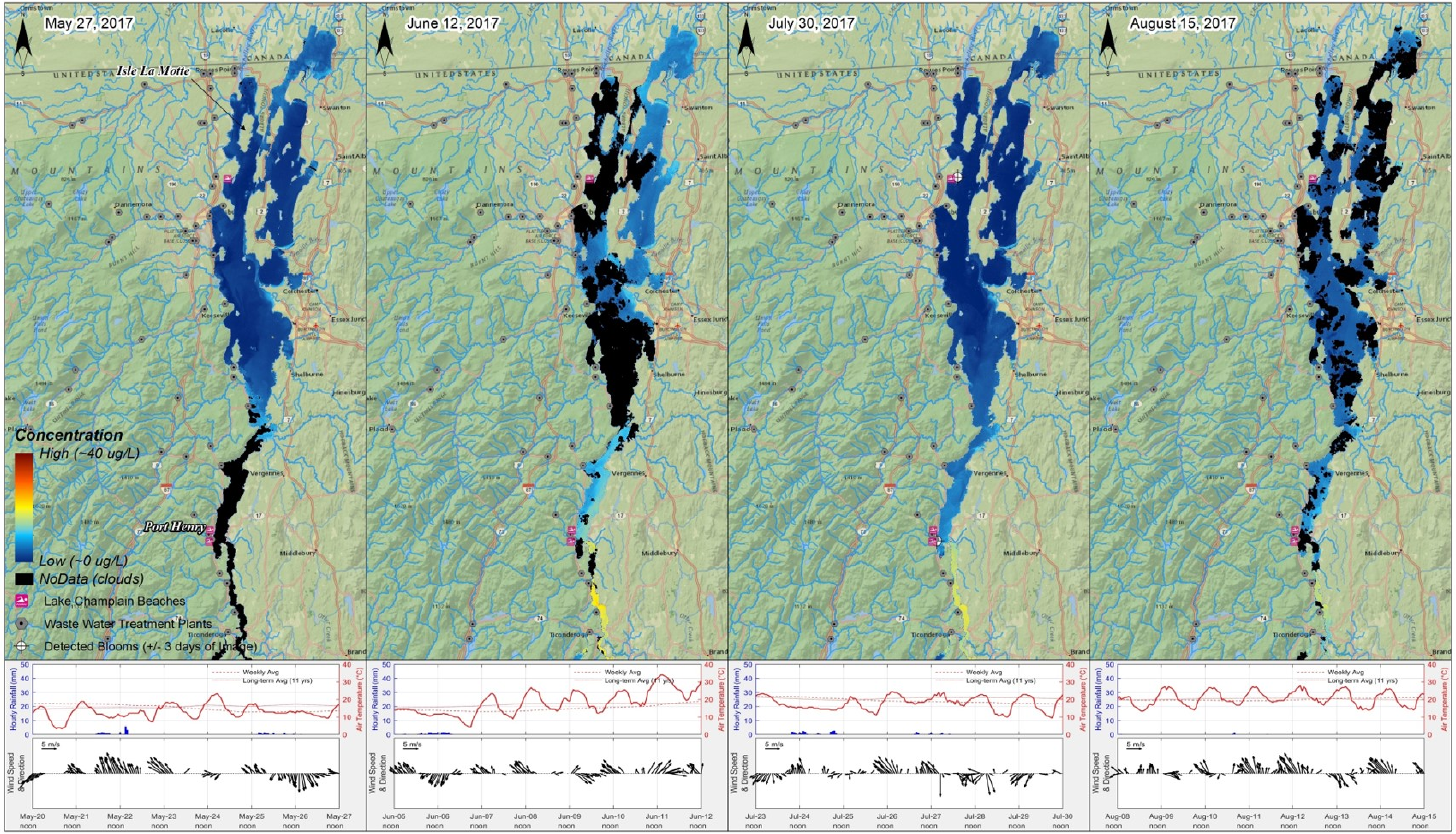

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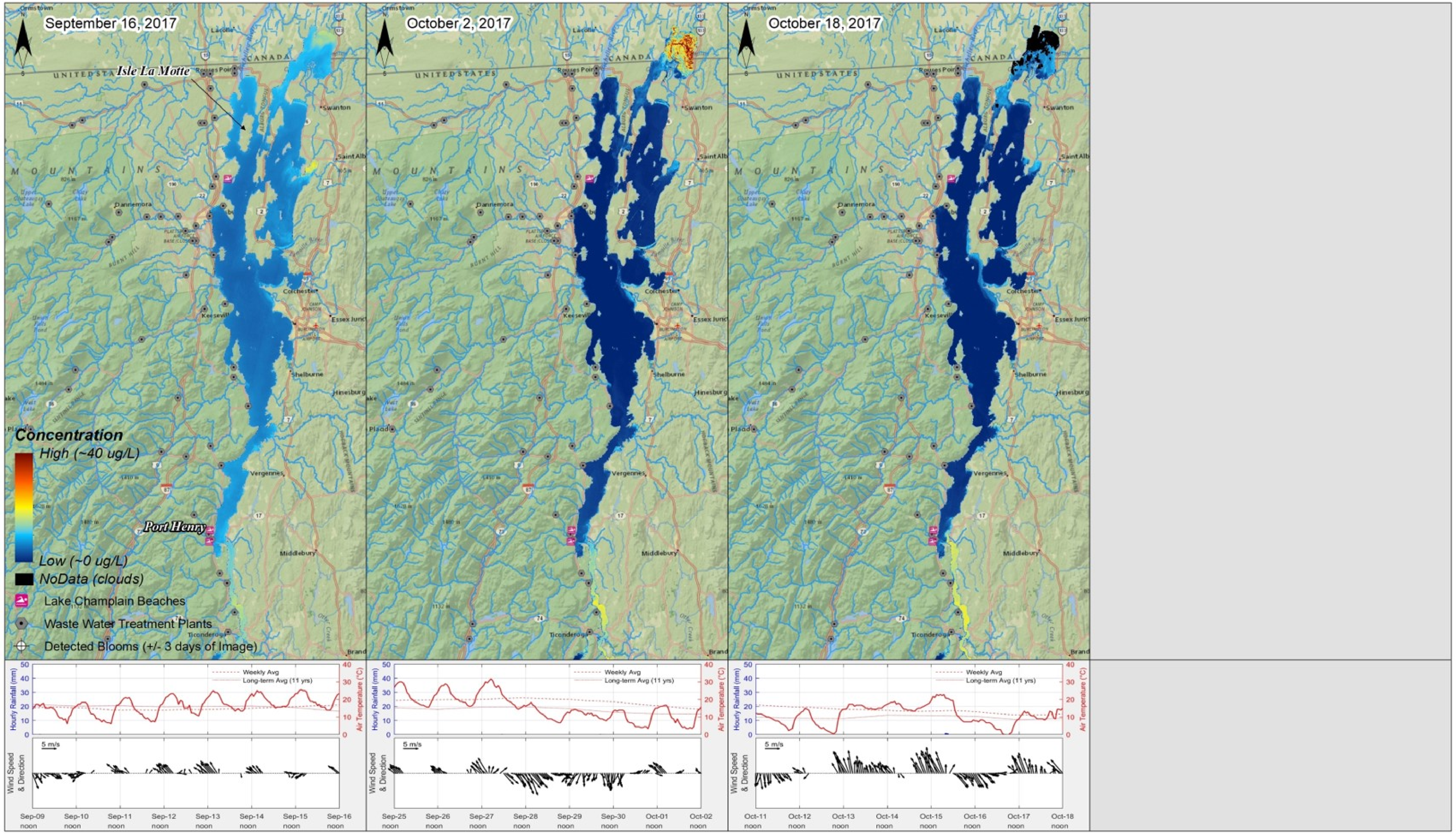

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0 5 10 15 20 Miles

0 5 10 15 20 25 Kilometers

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Basemap: National Geographic World Imagery Layer.
Spatial Reference: WGS 1984 UTM Zone 18N

Appendix D. WI/PWL Summary

Lake Champlain, Main Lake, North (1000-0001) Impaired

Waterbody Location Information

Revised: 05/01/2018

Water Index No:	C (portion 1)	**Water Class:**	A(T)
Hydro Unit Code:	Lake Champlain (0415040816)	**Drainage Basin:**	Lake Champlain
Water Type/Size:	Lake/Reservoir 18334.7 Acres	**Reg/County:**	5/Clinton (10)
Description:	portion of lake, Canadian border to/incl Cumberland Bay		

Water Quality Problem/Issue Information

Uses Evaluated	**Severity**	**Confidence**
Water Supply	Unassessed	-
Public Bathing	Stressed	Suspected
Recreation	Impaired	Known
Aquatic Life	Fully Supported	Known
Fish Consumption	Impaired	Known
Conditions Evaluated		
Habitat/Hydrology	Unknown	
Aesthetics	Unknown	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: MERCURY, NUTRIENTS (PHOSPHORUS), PRIORITY ORGANICS (PCBs), Problem Species

Suspected: ---

Unconfirmed: Pathogens

Source(s) of Pollutant(s)

Known: AGRICULTURE, ATMOSPH. DEPOSITION, TOX/CONTAM. SEDIMENT (see Cumberland Bay), Municipal Discharges, Urban/Storm Runoff

Suspected: ---

Unconfirmed: ---

Management Information

Management Status: Strategy Implementation Scheduled or Underway

Lead Agency/Office: DEC/LCBP

IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, TMDL Completed (IR Category 4a)

Further Details

Overview

This portion of Lake Champlain is assessed as an impaired waterbody due to secondary contact recreation and fish consumption uses that are known to be impaired. Secondary contact recreation uses are impacted by nutrient loadings from point and non-point sources as well as aquatic invasive weed growth. Fish consumption health advisoryies for this segment are due to mercury from atmospheric deposition and PCBs from lake sediments and past industrial discharges.

Use Assessment

This portion of Lake Champlain is predominantly a Class A waterbody (other classification exists within the segment, see ‘Segment Description’ below), required to support and protect the best uses as a water supply source for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing. The waterbody is also designated as a cold water (trout) fishery.

Primary and secondary contact recreation uses are considered to be impaired due to elevated nutrients (phosphorus) and excessive algae. In 2016, the beach in Point Au Roche State Park Beach experienced a total of 7 beach closure days related to harmful algal blooms. The blooms observed that year are best characterized as small localized. Additional bacteriological sampling is needed to more fully evaluate the impact of pathogen levels on public bathing (swimming) use. Non-contact recreation (boating, fishing) is also affected by excessive aquatic vegetation and the presence of invasive plant growth (water chestnut). (DEC/DOW, BWAM/LMAS, March 2018)

Aquatic life support related to the fishing use is considered to be fully supported based on dissolved oxygen sampling that shows criteria are met and fishery surveys that indicate a healthy cold water fishery. (DEC/DOW, LCBP, May 2018)

Fish consumption in this portion of Lake Champlain is impaired by health advisories for the entire lake due to PCB and mercury contamination. The advisory recommends eating no more than one meal per month of larger lake trout (over 25 inches) or walleye (over 19 inches). The Lake Champlain Basin Program and its partners have been working to identify sources of PCBs in the Lake and remedy them. The mercury contamination is widely thought to be a result of atmospheric deposition. The advisories for the lake were first issued prior to 1998–99. (2017 NYS DOH Health Advisories)

Water Quality Information

Water quality sampling of this portion of Lake Champlain has been conducted through the Lake Champlain Basin Program (LCBP) from 1992 through 2017. Results of this sampling indicate the lake is best characterized as mesotrophic, or moderately productive. Chlorophyll/algal levels rarely exceed criteria corresponding to stressed recreational uses, while phosphorus concentrations occasionally exceed the 20 µg/L guidance value. Lake clarity measurements indicate water transparency consistently meets the recommended minimum criteria for swimming beaches. (DEC/DOW, BWAM/LCBP, May 2018)

NYSDEC Rotating Intensive Basin Studies (RIBS) Routine Network monitoring (water chemistry) of the Richelieu River in Rouses Point (mouth of river is north end of lake segment), Clinton County, was conducted annually near the Route 2 bridge. This sampling location was discontinued after the 2016 sampling season. Water column chemistry indicated no contaminants to be present in concentrations that constitute parameters of concern. Total phosphorus concentrations averaged 12 µg/L for 2016. Toxicity testing using water from this location detected no significant mortality or reproductive effects on the test organism. (DEC/DOW, BWAM/RIBS, March 2018)

Exotic and invasive plant and animal species are also an increasing threat to the lake. Zebra mussels are widespread and have impacted water supplies and crowded out native mussels in many areas. Water chestnut and Eurasian milfoil limit various recreational activities and alter riparian cover. Sea lamprey predation of Atlantic salmon and lake trout continues to be an issue in this portion of the lake, however lamprey wounding in survey fish seems to be trending downward. This is a result of lamprey controls efforts in the basin including tributary barriers, trapping, and targeted lampricide applications. (Lake Champlain Basin Program, State of the Lake, 2015)

Source Assessment

The Lake Champlain Phosphorus TMDL refers to this portion of the lake as the ‘Isle LaMotte’ segment. Phosphorus loads in the Isle La Motte segment from NY sources are estimated as 26% from point sources and 74% from non-point sources, with a total load estimate of 28.3 metric tons per year (mt/yr).

Cumberland Bay, at the south end of this segment, was identified as a significant source of PCB to the Lake. In 2000, the NYSDEC completed a three–year, $35 million restoration of Cumberland Bay that removed contaminated sediment and restored affected wetland and shoreline areas. Over 140,000 tons of PCB–contaminated sludge was removed from the bottom of the Bay. (See also Cumberland Bay segment 1001–0001.) Continued monitoring will characterize the site's influence on water quality lakewide. On–going pollution prevention and monitoring efforts are also continuing at Outer Malletts Bay and Inner Burlington Harbor on the Vermont side of the Lake. (DEC/DER and Lake Champlain Basin Program, January 2009)

Mercury sources to the Lake that drive fish consumption advisories are likely due to combustion sources in states to the west that cycle to the lake through atmospheric deposition.

Management Actions

This waterbody segment is considered a highly valued water resource as a a multi–use waterbody for swimming, boating, and fishing. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Lake Champlain was identified for inclusion in this initiative as it is vulnerable to HABs.

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake Champlain and its surrounding watershed. The states of New York and Vermont, the Province of Quebec, the U.S. Environmental Protection Agency, other federal and local government agencies, and many local groups, both public and private, are partners of the LCBP. Created by the Lake Champlain Special Designation Act of 1990, the LCBP's goal is to work cooperatively to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The actions of the LCBP are guided by a pollution prevention, control, and restoration plan entitled "Opportunities for Action – An Evolving Plan for the Future of the Lake Champlain Basin." The Plan was first endorsed in October of 1996 by the governors of New York and Vermont and by the USEPA; it was most recently updated in 2017. The main goals of the Plan include 1) improving water quality throughout the Lake Champlain Basin, 2) protecting the Basin's living natural resources, and 3) preserving and enhancing the region's rich cultural and recreation resources. Considerable information on water quality, natural resources, protection and restoration efforts and other issues in Lake Champlain can be found at the LCBP website (http://www.lcbp.org).

The New York TMDL to address phosphorus loadings to the Lake was established in 2002. The TMDL outlines a strategy of both point and nonpoint source reductions in the tributary watersheds of the Lake. (DEC/DOW, BWAM, March 2018)

Section 303(d) Listing

This portion of Lake Champlain is included on the NYS 2016 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water due to PCB contamination. This waterbody was first listed on the 1998 Section 303(d) List. Lake Champlain was also previously listed due to mercury contamination, but was delisted in 2008 due to the completion of the Northeast Regional Mercury TMDL which was approved in 2007 and provides coverage for this specific waterbody. A previous listing for Lake Champlain for phosphorus was delisted in 2004 due to completion of the Lake Champlain Phosphorus TMDL. (DEC/DOW, BWAM, March 2018)

Segment Description

This segment includes the waters of the Lake (within NYS) between the Canadian border and an east–west line at Cumberland Head. The shoreline waters of Lake Champlain, extending one–quarter mile and to a depth of 30 feet, are designated Class A(T); except for Deep Bay which is Class C. The deeper, open reaches of the lake (beyond the shoreline waters) are Class AA(T).

Cumberland Bay (1001-0001) Impaired

Waterbody Location Information

Revised: 05/01/2018

Water Index No: C (portion 2a)
Water Class: B
Hydro Unit Code: Lake Champlain (0415040816)
Drainage Basin: Lake Champlain
Water Type/Size: Lake/Reservoir 2658.4 Acres
Reg/County: 5/Clinton (10)
Description: entire bay, as described below

Water Quality Problem/Issue Information

Uses Evaluated	Severity	Confidence
Water Supply	N/A	-
Public Bathing	Threatened	Unconfirmed
Recreation	Stressed	Known
Aquatic Life	Unassessed	-
Fish Consumption	Impaired	Known
Conditions Evaluated		
Habitat/Hydrology	Unknown	
Aesthetics	Unknown	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: MERCURY, PRIORITY ORGANICS (PCBs), Problem Species, Nutrients (Phosphorus)
Suspected: Low D.O./Oxygen Demand, Pathogens
Unconfirmed: ---

Source(s) of Pollutant(s)

Known: Municipal Discharges, TOX/CONTAM. SEDIMENT, Atmosph. Deposition, INDUSTRIAL DISCHARGES (historic/legacy)
Suspected: Agriculture, Urban/Storm Runoff
Unconfirmed: Unknown Source

Management Information

Management Status: Strategy Implementation Scheduled or Underway
Lead Agency/Office: DEC/Reg5
IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, TMDL Completed (IR Category 4a)

Further Details

Overview

The Cumberland Bay portion of Lake Champlain is assessed as an impaired waterbody due fish consumption use that is known to be impaired. Fish consumption health advisories for this segment are due to mercury from atmospheric deposition and PCBs from lake sediments and past industrial discharges. Primary and secondary contact recreation uses in the Bay are also known to be threatened or stressed by elevated nutrient (phosphorus) levels and invasive aquatic species.

Use Assessment

The Cumberland Bay portion of Lake Champlain is a Class B waterbody required to support and protect the best uses of primary and secondary contact recreation, and fishing.

Primary contact recreational uses in Cumberland Bay may be threatened due to occasional elevated nutrients (phosphorus) excessive algae, and water clarity. Fish consumption use in Cumberland Bay is impaired by health advisories for the entire lake due to PCBs and mercury contamination. The advisory recommends eating no more than one meal per month of American eel (any length), larger lake trout (over 25 inches) or walleye (over 19 inches). The Lake Champlain Basin Program and its partners have been working to identify sources of PCBs in the lake and remedy them. The mercury contamination is widely thought to be a result of atmospheric deposition. The advisories for the lake were first issued prior to 1998–99. (2017 NYS DOH Health Advisories)

Water Quality Information

Water quality sampling in the Cumberland Bay portion of Lake Champlain has been conducted through the Lake Champlain Basin Program (LCBP) from 1992 through 2017. Results of this sampling indicate the lake is best characterized as mesotrophic, or moderately productive. Chlorophyll/algal levels rarely exceed criteria corresponding to stressed recreational uses while phosphorus concentrations rarely exceed the 20 µg/L guidance value. Lake clarity measurements indicate water transparency consistently meet the recommended minimum criteria for swimming beaches. (DEC/DOW, BWAM/LCBP, May 2018)

Source Assessment

The Lake Champlain Phosphorus TMDL designates Cumberland Bay as a management segment. Phosphorus loads in Cumberland Bay are estimated as 77% from point sources and 23% from non-point sources, with a total load estimate of 38.0 metric tons per year (mt/yr).

Cumberland Bay was identified as a significant source of PCBs to the lake. In 2000, the NYSDEC completed a three–year, $35 million restoration of Cumberland Bay that removed contaminated sediment and restored affected wetland and shoreline areas. Over 140,000 tons of PCB–contaminated sludge was removed from the bottom of the Bay. Continued monitoring will characterize the site's influence on water quality lakewide. On–going pollution prevention and monitoring efforts are also continuing at Outer Malletts Bay and Inner Burlington Harbor on the Vermont side of the Lake. (DEC/DER and Lake Champlain Basin Program, January 2009)

Mercury sources to the Lake that drive fish consumption advisories are likely due to combustion sources in states to the west that cycle to the lake through atmospheric deposition.

Management Actions

This waterbody segment is considered a highly valued water resource as a a multi–use waterbody for swimming, boating, and fishing. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Lake Champlain was identified for inclusion in this initiative as it is vulnerable to HABs.

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake Champlain, Willsboro Bay, and its surrounding watershed. The states of New York and Vermont, the Province of Quebec, the U.S. Environmental Protection Agency, other federal and local government agencies, and many local groups, both public and private, are partners of the LCBP. Created by the Lake Champlain Special Designation Act of 1990, the LCBP's goal is to work cooperatively to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The actions of the LCBP are guided by a pollution prevention, control, and restoration plan entitled "Opportunities for Action – An Evolving Plan for the Future of the Lake Champlain Basin." The Plan was first endorsed in October of 1996 by the governors of New York and Vermont and by the USEPA; it was most recently updated in 2017. The main goals of the Plan include 1) improving water quality throughout the Lake Champlain Basin, 2) protecting the Basin's living natural resources, and 3) preserving and enhancing the region's rich cultural and recreation resources. Considerable information on water quality, natural resources, protection and restoration efforts and other issues in Lake Champlain can be found at the LCBP website (http://www.lcbp.org).

The New York TMDL to address phosphorus loadings to the Lake was established in 2002. The TMDL outlines a strategy of both point and nonpoint source reductions in the tributary watersheds of the Lake. (DEC/DOW, BWAM, March 2018)

Section 303(d) Listing

Cumberland Bay is included on the NYS 2016 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water due to PCB contamination. This waterbody was first listed on the 1998 Section 303(d) List. Willsboro Bay was also previously listed due to mercury contamination, but was delisted in 2008 due to the completion of the Northeast Regional Mercury TMDL which was approved in 2007 and provides coverage for this specific waterbody. (DEC/DOW, BWAM, March 2018)

Segment Description

This segment includes the bay waters west of line from point along western shore of Cumberland Head near Champlain Park to the shore as the southern boundary of City of Plattsburgh. These waters are also included in the Lake Champlain, Main Lake, Middle segment.

Lake Champlain, Main, Middle, Willsboro Bay (1000-0002) Impaired

Waterbody Location Information

Revised: 05/01/2018

Water Index No: C (portion 2) **Water Class:** A(T)
Hydro Unit Code: Lake Champlain (0415040816) **Drainage Basin:** Lake Champlain
Water Type/Size: Lake/Reservoir 57348.3 Acres **Reg/County:** 5/Clinton (10) **Description:** portion of lake, from Cumberland Bay to Split Rock Pt., including Willsboro Bay

Water Quality Problem/Issue Information

Uses Evaluated	**Severity**	**Confidence**
Water Supply	Unassessed	-
Public Bathing	Stressed	Suspected
Recreation	Impaired	Known
Aquatic Life	Fully Supported	Known
Fish Consumption	Impaired	Known
Conditions Evaluated		
Habitat/Hydrology	Unknown	
Aesthetics	Unknown	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: MERCURY, NUTRIENTS (PHOSPHORUS), PRIORITY ORGANICS (PCBs), Problem Species
Suspected: ---
Unconfirmed: Pathogens

Source(s) of Pollutant(s)

Known: Agriculture, Atmosph. Deposition, Municipal Discharges, TOX/CONTAM. SEDIMENT (see Cumberland Bay), Urban/Storm Runoff
Suspected: ---
Unconfirmed: ---

Management Information

Management Status: Strategy Implementation Scheduled or Underway
Lead Agency/Office: DEC/LCBP
IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, TMDL Completed (IR Category 4a)

Further Details

Overview
This portion of Lake Champlain including Willsboro Bay are assessed as impaired waterbodies due to secondary contract recreation and fish consumption uses that are known to be impaired. Secondary contact recreation uses are impacted by nutrients (phosphorus) and excessive algae. Fish consumption health advisories for this segment are due to

mercury from atmospheric deposition and PCBs from lake sediments and past industrial discharges.

Use Assessment
This segment of Lake Champlain is predominantly a Class A(T) waterbody (other classification exists within the segment, see 'Segment Description' below), required to support and protect the best uses as a water supply source for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing. The waterbody is also designated as a cold water (trout) fishery.

Secondary contact recreation use is impaired due to elevated nutrients (phosphorus), excessive algae, and poor water clarity. Primary contact recreation use is stressed due to similar pollutants. In 2016, the beach in Port Douglas experienced a total of 3 beach closure days related to harmful algal blooms. The blooms observed that year are best characterized as small localized. (DEC/DOW, BWAM/LMAS, May 2018)

Fishing use is fully supported based on dissolved oxygen sampling that shows criteria are met and fishery surveys that indicate a healthy cold water fishery. (DEC/DOW, LCBP, May 2018)

Fish consumption in this portion of Lake Champlain is impaired by health advisories for the entire lake due to PCB and mercury contamination. The advisory recommends eating no more than one meal per month of larger lake trout (over 25 inches) or walleye (over 19 inches). The Lake Champlain Basin Program and its partners have been working to identify sources of PCBs in the Lake and remedy them. The mercury contamination is widely thought to be a result of atmospheric deposition. The advisories for the lake were first issued prior to 1998–99. (2017 NYS DOH Health Advisories)

Water Quality Information
Water quality sampling of this portion of Lake Champlain has been conducted through the Lake Champlain Basin Program (LCBP) from 1992 through 2017. Results of this sampling indicate the lake is best characterized as mesotrophic, or moderately productive. Chlorophyll/algal levels occasionally exceed criteria corresponding to stressed recreational uses, while phosphorus concentrations rarely exceed the 20 µg/L guidance value. Lake clarity measurements indicate water transparency consistently meets the recommended minimum criteria for swimming beaches. (DEC/DOW, BWAM/LCBP, May 2018)

Exotic and invasive plant and animal species are also an increasing threat to the lake. Zebra mussels are widespread and have impacted water supplies and crowded out native mussels in many areas. Water chestnut and Eurasian milfoil limit various recreational activities and alter riparian cover. Sea lamprey predation of Atlantic salmon and lake trout continues to be an issue in this portion of the lake, however lamprey wounding in survey fish seems to be trending downward. This is a result of lamprey controls efforts in the basin including tributary barriers, trapping, and targeted lampricide applications. Alewife and spiny water flea are newly found invasives in the lake and continue to be studied. The ability to control many of these exotics is limited, and expensive and long–term impact is relatively uncertain. (Lake Champlain Basin Program, State of the Lake, 2015)

Source Assessment
The Lake Champlain Phosphorus TMDL refers to this portion of the lake as the 'Main Lake' segment. Phosphorus loads in the Main Lake segment from NY sources are estimated as 18% from point sources and 82% from non-point sources, with a total load estimate of 38.9 metric tons per year (mt/yr).

Cumberland Bay, adjacent to this segment, was identified as a significant source of PCB to the Lake. In 2000, the NYSDEC completed a three–year, $35 million restoration of Cumberland Bay that removed contaminated sediment and restored affected wetland and shoreline areas. Over 140,000 tons of PCB–contaminated sludge was removed from the bottom of the Bay. (See also Cumberland Bay segment 1001–0001.) Continued monitoring will characterize the site's influence on water quality lakewide. On–going pollution prevention and monitoring efforts are also continuing at Outer Malletts Bay and Inner Burlington Harbor on the Vermont side of the Lake. (DEC/DER and Lake Champlain

Basin Program, January 2009)

Mercury sources to the Lake that drive fish consumption advisories are likely due to combustion sources in states to the west that cycle to the lake through atmospheric deposition.

Management Actions

This waterbody segment is considered a highly valued water resource as a a multi–use waterbody for swimming, boating, and fishing. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Lake Champlain was identified for inclusion in this initiative as it is vulnerable to HABs.

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake Champlain and its surrounding watershed. The states of New York and Vermont, the Province of Quebec, the U.S. Environmental Protection Agency, other federal and local government agencies, and many local groups, both public and private, are partners of the LCBP. Created by the Lake Champlain Special Designation Act of 1990, the LCBP's goal is to work cooperatively to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The actions of the LCBP are guided by a pollution prevention, control, and restoration plan entitled "Opportunities for Action – An Evolving Plan for the Future of the Lake Champlain Basin." The Plan was first endorsed in October of 1996 by the governors of New York and Vermont and by the USEPA; it was most recently updated in 2017. The main goals of the Plan include 1) improving water quality throughout the Lake Champlain Basin, 2) protecting the Basin's living natural resources, and 3) preserving and enhancing the region's rich cultural and recreation resources. Considerable information on water quality, natural resources, protection and restoration efforts and other issues in Lake Champlain can be found at the LCBP website (http://www.lcbp.org).

The New York TMDL to address phosphorus loadings to the Lake was established in 2002. The TMDL outlines a strategy of both point and nonpoint source reductions in the tributary watersheds of the Lake. (DEC/DOW, BWAM, March 2018)

Section 303(d) Listing

This portion of Lake Champlain is included on the NYS 2016 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water due to PCB contamination. This waterbody was first listed on the 1998 Section 303(d) List. Lake Champlain was also previously listed due to mercury contamination, but was delisted in 2008 due to the completion of the Northeast Regional Mercury TMDL which was approved in 2007 and provides coverage for this specific waterbody. A previous listing for Lake Champlain for phosphorus was delisted in 2004 due to completion of the Lake Champlain Phosphorus TMDL. (DEC/DOW, BWAM, March 2018)

Segment Description

This segment includes the waters of the Lake (within NYS) between an east–west line at Cumberland Head and an east–west line at Split Rock Point, except for Cumberland Bay which is listed separately. This segment does include Willsboro Bay. The shoreline waters of Lake Champlain, extending one–quarter mile and to a depth of 30 feet, are designated Class A(T); except for a few specific bays which are classified separately. The deeper, open reaches of the lake (beyond the shoreline waters) are Class AA(T).

Lake Champlain, Main Lake, South (1000-0003) — Impaired

Waterbody Location Information

Revised: 5/01/2018

Water Index No:	C (portion 3)	**Water Class:**	A(T)
Hydro Unit Code:	Northwest Bay-Lake Champlain (0415040806)	**Drainage Basin:**	Lake Champlain
Water Type/Size:	Lake/Reservoir 10454.9 Acres	**Reg/County:**	5/Essex (16)
Description:	portion of lake, from Split Rock Pt to Crown Point Br		

Water Quality Problem/Issue Information

Uses Evaluated	**Severity**	**Confidence**
Water Supply	Unassessed	-
Public Bathing	Impaired	Suspected
Recreation	Stressed	Known
Aquatic Life	Fully Supported	Known
Fish Consumption	Impaired	Known
Conditions Evaluated		
Habitat/Hydrology	Unknown	
Aesthetics	Unknown	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: MERCURY, NUTRIENTS (PHOSPHORUS), PRIORITY ORGANICS (PCBs), Problem Species

Suspected:

Unconfirmed: Pathogens

Source(s) of Pollutant(s)

Known: AGRICULTURE, ATMOSPH. DEPOSITION, Municipal Discharges, TOX/CONTAM. SEDIMENT, Urban/Storm Runoff

Suspected: ---

Unconfirmed: ---

Management Information

Management Status: Strategy Implementation Scheduled or Underway

Lead Agency/Office: DEC/LCBP

IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, TMDL Completed (IR Category 4a)

Further Details

Overview

This portion of Lake Champlain is assessed as an impaired waterbody due to fish consumption use that is known to be impaired. Fish consumption use is impaired due to mercury from atmospheric desposition, and PCBs from lake sediments and past industrial discharges.

Use Assessment

This portion of Lake Champlain a Class A(T) waterbody (other classification exists within the segment, see 'Segment Description' below), required to support and protect the best uses as a water supply source for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing. This portion of the lake is also designated as a cold water (trout) fishery.

Primary contact recreation use may be impaired due to the closure of two beaches in this portion of the lake related to HABs in 2017. The blooms observed were best characterized as small localized and suspicious algal blooms. Additional bacteriological sampling is needed to more fully evaluate the impact of pathogen levels on public bathing (swimming) use. Non-contact recreation (boating, fishing) is also affected by excessive aquatic vegetation and the presence of invasive plant growth (water chestnut). (DEC/DOW, BWAM/LMAS, March 2018)

Fishing use is considered to be fully supported based on dissolved oxygen sampling that shows criteria are met and fishery surveys that indicate a healthy cold water fishery. (DEC/DOW, LCBP, May 2018)

Fish consumption in this portion of Lake Champlain is impaired by health advisories for the entire lake due to PCB and mercury contamination. The advisory recommends eating no more than one meal per month of larger lake trout (over 25 inches) or walleye (over 19 inches). The Lake Champlain Basin Program and its partners have been working to identify sources of PCBs in the Lake and remedy them. The mercury contamination is widely thought to be a result of atmospheric deposition. The advisories for the lake were first issued prior to 1998–99. (2017 NYS DOH Health Advisories)

Water Quality Information

Water quality sampling of this portion of Lake Champlain has been conducted through the Lake Champlain Basin Program (LCBP) from 1992 through 2017. Results of this sampling indicate the lake is best characterized mesotrophic, or moderately productive. Chlorophyll/algal levels occasionally exceed criteria corresponding to stressed recreational uses while phosphorus concentrations occasionally exceed the 20 µg/L guidance value. Lake clarity measurements indicate water transparency consistently meets the recommended minimum criteria for swimming beaches, with infrequent excursions below. (DEC/DOW, BWAM/LCBP, May 2018)

Zebra mussels are widespread and have impacted water supplies and crowded out native mussels in many areas. Water chestnut and Eurasian milfoil limit various recreational activities and alter riparian cover. Sea lamprey predation of Atlantic salmon and lake trout continues to be an issue in this portion of the lake, however lamprey wounding in survey fish seems to be trending downward. This is a result of lamprey controls efforts in the basin including tributary barriers, trapping, and targeted lampricide applications. (Lake Champlain Basin Program, State of the Lake, 2015)

Source Assessment

The Lake Champlain Phosphorus TMDL divides this segment into two management segments, Port Henry and Otter Creek. Phosphorus loads in Port Henry segment from NY sources are estimated as 41% from point sources and 59% from non-point sources, with a total load estimate of 4.4 metric tons per year (mt/yr). Phosphorus loads in the Otter Creek segment from NY sources are estimated as all from non-point sources, with a total load estimate of 0.1 mt/yr.

PCB sources to the lake that drive fish consumption advisories are likely due to legacy industrial and sediment contamination.

Mercury sources to the Lake that drive fish consumption advisories are likely due to combustion sources in states to the west that cycle to the lake through atmospheric deposition.

Management Actions

This waterbody segment is considered a highly valued water resource as a a multi–use waterbody for swimming, boating, and fishing. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Lake Champlain was identified for inclusion in this initiative as it is vulnerable to HABs.

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake

Champlain and its surrounding watershed. The states of New York and Vermont, the Province of Quebec, the U.S. Environmental Protection Agency, other federal and local government agencies, and many local groups, both public and private, are partners of the LCBP. Created by the Lake Champlain Special Designation Act of 1990, the LCBP's goal is to work cooperatively to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The actions of the LCBP are guided by a pollution prevention, control, and restoration plan entitled "Opportunities for Action – An Evolving Plan for the Future of the Lake Champlain Basin." The Plan was first endorsed in October of 1996 by the governors of New York and Vermont and by the USEPA; it was most recently updated in 2017. The main goals of the Plan include 1) improving water quality throughout the Lake Champlain Basin, 2) protecting the Basin's living natural resources, and 3) preserving and enhancing the region's rich cultural and recreation resources. Considerable information on water quality, natural resources, protection and restoration efforts and other issues in Lake Champlain can be found at the LCBP website (http://www.lcbp.org).

The New York TMDL to address phosphorus loadings to the Lake was established in 2002. The TMDL outlines a strategy of both point and nonpoint source reductions in the tributary watersheds of the Lake. (DEC/DOW, BWAM, March 2018)

Section 303(d) Listing
This portion of Lake Champlain is included on the NYS 2016 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water due to PCB contamination. This waterbody was first listed on the 1998 Section 303(d) List. Lake Champlain was also previously listed due to mercury contamination, but was delisted in 2008 due to the completion of the Northeast Regional Mercury TMDL which was approved in 2007 and provides coverage for this specific waterbody. A previous listing for Lake Champlain for phosphorus was delisted in 2004 due to completion of the Lake Champlain Phosphorus TMDL. (DEC/DOW, BWAM, March 2018)

Segment Description
This segment includes the waters of the Lake (within NYS) between an east–west line at Split Rock Point and the Crown Point Bridge. The shoreline waters of Lake Champlain, extending one–quarter mile and to a depth of 30 feet, are designated Class A(T); except for Bullwagaa Bay which is Class B. The deeper, open reaches of the lake (beyond the shoreline waters) are Class AA(T).

Lake Champlain, South Lake (1000-0004) Impaired

Waterbody Location Information

Revised: 5/01/2018

Water Index No:	C (portion 4)	**Water Class:**	B
Hydro Unit Code:	Putnam Creek-Lake Champlain (0415040803)	**Drainage Basin:**	Lake Champlain
Water Type/Size:	Lake/Reservoir 5754 Acres	**Reg/County:**	5/Essex (16)
Description:	portion of lake, from Crown Point Br to Champlain Canal		

Water Quality Problem/Issue Information

Uses Evaluated	Severity	Confidence
Water Supply	N/A	-
Public Bathing	Impaired	Suspected
Recreation	Impaired	Known
Aquatic Life	Stressed	Suspected
Fish Consumption	Impaired	Known
Conditions Evaluated		
Habitat/Hydrology	Fair	
Aesthetics	Poor	

Type of Pollutant(s) (CAPS indicate Major Pollutants/Sources that contribute to an Impaired/Precluded Uses)

Known: PRIORITY ORGANICS (PCBs), MERCURY, NUTRIENTS (PHOSPHORUS), Algal/Plant Growth, Problem Species

Suspected: Low D.O./Oxygen Demand

Unconfirmed: Pathogens

Source(s) of Pollutant(s)

Known: AGRICULTURE, ATMOSPH. DEPOSITION, Habitat Alteration, Municipal Discharges, TOX/CONTAM.SEDIMENT, Urban/Storm Runoff

Suspected: ---

Unconfirmed: ---

Management Information

Management Status: Strategy Implementation Scheduled or Underway

Lead Agency/Office: DEC/LCBP

IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, TMDL Completed (IR Category 4a)

Further Details

Overview

This portion of Lake Champlain is assessed as an impaired waterbody due to secondary contact recreation and fish consumption uses that are known to be impaired. Secondary contact recreation uses are impaired by nutrient loadings from point and non-point sources as well as aquatic invasive weed growth. Fish consumption health advisoryies for this segment are due to mercury from atmospheric deposition and PCBs from lake sediments and past industrial discharges.

Use Assessment

This segement is a Class B waterbody, required to support and protect the best use of primary and secondary contact recreation, and fishing, but not as a source of water supply for drinking.

Primary and secondary contact recreation are impaired due to elevated nutrients (phosphorus), excessive plant and algal growth, and poor water clarity. Additional bacteriological sampling is needed to more fully evaluate the impact of pathogen levels on primary contact recreational uses. Secondary contact recreation (boating, fishing) is also affected by excessive aquatic vegetation and the presence of invasive plant growth (water chestnut). (DEC/DOW, BWAM/LMAS, March 2018)

Aquatic life is evaluated as supported but stressed based on sampling data showing periodic low dissolved oxygen at lower depths of this section of the lake. (DEC, DOW, BWAM, May 2018)

Fish consumption in this portion of Lake Champlain is impaired by health advisories for the entire lake due to PCB and mercury contamination. The advisory recommends eating no more than one meal per month of larger lake trout (over 25 inches) or walleye (over 19 inches). The Lake Champlain Basin Program and its partners have been working to identify sources of PCBs in the Lake and remedy them. The mercury contamination is widely thought to be a result of atmospheric deposition. The advisories for the lake were first issued prior to 1998–99. (2017 NYS DOH Health Advisories)

Water Quality Information

Water quality sampling of this portion of Lake Champlain has been conducted through the Lake Champlain Basin Program (LCBP) from 1992 through 2017. Results of this sampling indicate this portion of the lake is best characterized as eutrophic, or highly productive. Chlorophyll/algal levels typically exceed criteria corresponding to impaired recreational uses while phosphorus concentrations exceed the NYS guidance value of 20 µg/L most of the time. Lake clarity measurements indicate water transparency typically fails to meet the recommended minimum criteria for swimming beaches. (DEC/DOW, BWAM/LCBP, May 2018)

Exotic and invasive plant and animal species are also an increasing threat to the lake. Water chestnut, in particular, is an issue in this portion of the lake. Water chestnut is a plant that forms dense surface mats, crowding out other plant species, disrupting habitat, and severely limiting recreational enjoyment and commercial use of the Lake in some areas. Its spread throughout the southern end of the Lake includes this entire segment, but effective management actions have reduced its impact in recent years. In 1999, the entire segment was rated as 'poor' with regard water chestnut coverage, but the most recent survey (2017) shows that most of the segment is now rated as 'fair' with only the southern most portion, from near Dresden to Whitehall, continues to be rated as 'poor' coverage.Eurasian milfoil also impacts uses in some Lake bays. Zebra mussels are widespread and have impacted water supplies and crowded out native mussels in many areas. Sea lamprey predation of Atlantic salmon and lake trout continues to be an issue in this portion of the lake, however lamprey wounding in survey fish seems to be trending downward. This is a result of lamprey controls efforts in the basin including tributary barriers, trapping, and targeted lampricide applications. (Lake Champlain Basin Program, State of the Lake, 2015)

Source Assessment

The Lake Champlain Phosphorus TMDL divides this segment into two management segments, South Lake A and South Lake B. Phosphorus loads in South Lake A from NY sources are estimated as 73% from point sources and 27% from non-point sources, with a total load estimate of 13.1 metric tons per year (mt/yr). Phosphorus loads in South Lake B from NY sources are estimated as 14% from point sources and 86% from non-point sources, with a total load estimate of 28.2 mt/yr.

PCB sources to the lake that drive fish consumption advisories are likely due to legacy industrial and sediment contamination.

Mercury sources to the Lake that drive fish consumption advisories are likely due to combustion sources in states to the west that cycle to the lake through atmospheric deposition.

Management Actions
This waterbody segment is considered a highly valued water resource as a a multi–use waterbody for swimming, boating, and fishing. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Lake Champlain was identified for inclusion in this initiative as it is vulnerable to HABs.

The Lake Champlain Basin Program (LCBP) is a federal, state and local initiative to restore and protect Lake Champlain and its surrounding watershed. The states of New York and Vermont, the Province of Quebec, the U.S. Environmental Protection Agency, other federal and local government agencies, and many local groups, both public and private, are partners of the LCBP. Created by the Lake Champlain Special Designation Act of 1990, the LCBP's goal is to work cooperatively to protect and enhance the environmental integrity and the social and economic benefits of the Lake Champlain Basin. The actions of the LCBP are guided by a pollution prevention, control, and restoration plan entitled "Opportunities for Action – An Evolving Plan for the Future of the Lake Champlain Basin." The Plan was first endorsed in October of 1996 by the governors of New York and Vermont and by the USEPA; it was subsequently updated in 2003 and 2010 and was most recently updated in 2017. The main goals of the Plan include 1) improving water quality throughout the Lake Champlain Basin, 2) protecting the Basin's living natural resources, and 3) preserving and enhancing the region's rich cultural and recreation resources. Considerable information on water quality, natural resources, protection and restoration efforts and other issues in Lake Champlain can be found at the LCBP website (http://www.lcbp.org).

The New York TMDL to address phosphorus loadings to the Lake was established in 2002. The TMDL outlines a strategy of both point and nonpoint source reductions in the tributary watersheds of the Lake. (DEC/DOW, BWAM, March 2018)

Section 303(d) Listing
This portion of Lake Champlain is included on the NYS 2016 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water due to PCB contamination. This waterbody was first listed on the 1998 Section 303(d) List. Lake Champlain was also previously listed due to mercury contamination, but was delisted in 2008 due to the completion of the Northeast Regional Mercury TMDL which was approved in 2007 and provides coverage for this specific waterbody. A previous listing for Lake Champlain for phosphorus was delisted in 2004 due to completion of the Lake Champlain Phosphorus TMDL. The lake is also included in IR Category 4c (TMDL is not appropriate because the sole impairment is the result of pollution, rather than a pollutant) for problem species and algal/weed growth. (DEC/DOW, BWAM, March 2018)

Segment Description
This segment includes the waters of the Lake (within NYS) between the Crown Point Bridge and the Champlain Canal. The waters of this portion of Lake Champlain are Class B.

Appendix E. NYSDEC Water Quality Monitoring Programs

Additional information can be found at: http://www.dec.ny.gov/chemical/81576.html

Appendix F. Road Ditches

In New York State, ditches parallel nearly every mile of our roadways and in some watersheds, the length of these conduits is greater than the natural watercourses themselves. Although roadside ditches have long been used to enhance road drainage and safety, traditional management practices have been a significant, but unrecognized contributor to flooding and water pollution, with ditch management practices that often enhance rather than mitigate these problems. The primary objective has been to move water away from local road surfaces as quickly as possible, without evaluating local and downstream impacts. As a result, elevated discharges increase peak stream flows and exacerbate downstream flooding. The rapid, high volumes of flow also carry nutrient-laden sediment, salt and other road contaminants, and even elevated bacteria counts, thus contributing significantly to regional water quantity and quality concerns that can impact biological communities. All of these impacts will be exacerbated by the increased frequency of high intensity storms associated with climate change. Continued widespread use of outdated road maintenance practices reflects a break-down in communications among scientists, highway managers, and other relevant stakeholders, as well as tightening budgets and local pressures to maintain traditional road management services. Although road ditches can have a significant impact on water quality, discharges of nutrients and sediment from roadways can be mitigated with sound management practices.

Road Ditch Impacts

Roadside ditch management represents a critical, but overlooked opportunity to help meet watershed and clean water goals in the Lake Champlain watershed by properly addressing the nonpoint sources of nutrients and sediment entering the New York waters from roadside ditches. The three main impacts of roadside ditch networks are: (1) hydrological modification, (2) water quality degradation, and (3) biological impairment.

Mitigation Strategies to Reduce Impacts

Traditional stormwater management focused on scraping or armoring ditches to collect and rapidly transport water downstream. The recommended mitigation strategies described below focus on diffusing runoff to enhance sheet flow, slowing velocities, and increasing infiltration and groundwater recharge. This approach reduces the rapid transfer of rainwater out of catchments and helps to restore natural hydrologic conditions and to reduce pollution while accommodating road safety concerns.

These strategies can be divided into three broad, but overlapping categories:

1. **Practices designed to hold or redirect stormwater runoff to minimize downstream flooding.**
    - Redirect the discharges to infiltration or detention ponds.
    - Restore or establish an intervening wetland between the ditch and the stream.

- Divert concentrated flow into manmade depressions oriented perpendicular to flow using level lip spreader systems.
- Modify the road design to distribute runoff along a ditch, rather than a concentrated direct outflow.

2. **Practices designed to slow down outflow and filter out contaminants.**
    - Reshape ditches to shallow, trapezoidal, or rounded profiles to reduce concentrated, incisive flow and the potential for erosion.
    - Optimize vegetative cover, including hydroseeding and a regular mowing program, instead of mechanical scraping. Where scraping is necessary, managers should schedule roadside ditch maintenance during late spring or early summer when hydroseeding will be more successful.
    - Build check dams, or a series of riprap bars oriented across the channel perpendicular to flow, to reduce channel flow rates and induce sediment deposition while enhancing ground water recharge.
    - Reestablish natural filters, such as bio-swales, compound or “two-stage” channels, and level lip spreaders.
3. **Practices to improve habitat.**
    - Construct wetlands for the greatest potential to expand habitat.
    - Reduce runoff volumes to promote stable aquatic habitat.

The Upper Susquehanna Coalition (USC) is developing a technical guidance document in the form of a Ditch Maintenance Program Guide that can be used by any local highway department. The guide will include an assessment program to determine if the ditch needs maintenance and what is necessary to stabilize the ditch. It will also contain a group of acceptable and proven management guidelines and practices for ditch stabilization. In addition, the USC is developing a broad-based education and outreach program to increase awareness and provide guidance to stakeholder groups. This program will take advantage of existing education programs, such as the NY’s Emergency Stream Intervention (ESI) Training program, USC, Cornell University and the Cornell Local Roads program. This new program will be adaptable in all watersheds.