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

HARMFUL ALGAL BLOOM ACTION PLAN CONESUS LAKE

www.dec.ny.gov

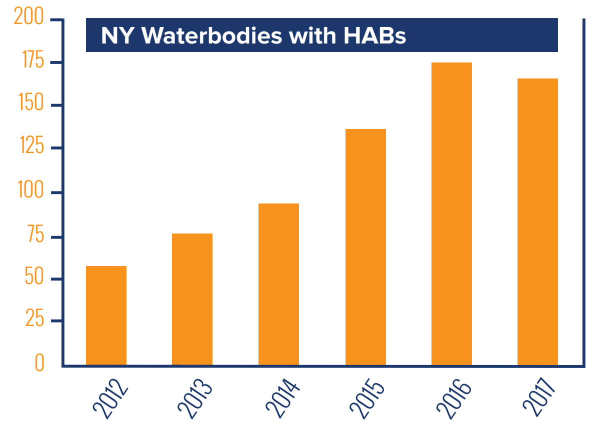
EXECUTIVE SUMMARY

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.

TO LEARN MORE ABOUT HABs, VISIT: on.ny.gov/hab www.health.ny.gov/HarmfulAlgae

CONESUS LAKE

Livingston County

Conesus Lake, a 3,420-acre lake that is the westernmost of the Finger Lakes, is one of the 12 priority lakes impacted by HABs. The lake is used for swimming, fishing and boating. In addition, Conesus Lake is a drinking water source for approximately 20,000 Livingston County residents.

Based on water quality monitoring conducted over the last two decades, Conesus Lake was designated as an “impaired waterbody” due to the excessive nutrients (phosphorus) and harmful algal blooms, which could impact recreational uses in the lake.

The significant sources of phosphorus loading in the lake are:

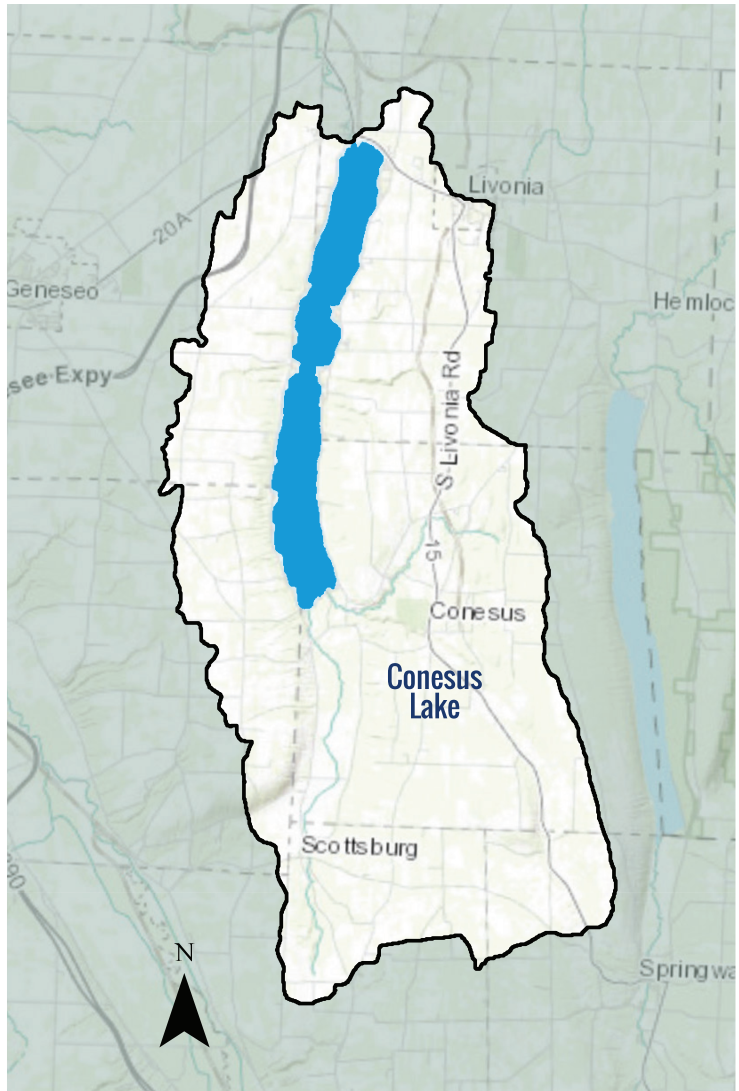
- Internal loading of legacy phosphorus from in-lake sediments;
- Nonpoint sources and nutrient inputs from the contributing watershed; and
- Phosphorus inputs associated with septic system discharges.

There have been 13 observed HABs since 2013, resulting in 46 lost beach days.

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 Conesus Lake, including the following:

- Implement runoff reduction Best Management Practices (BMPs) on croplands to reduce stormwater and nutrient runoff and soil erosion;
- Complete engineering design of a hypolimnetic aeration and oxygenation system, and complete a limnological study of nutrient inactivant application to address legacy phosphorus; and
- Complete a hydrodynamic model and engineering assessment to evaluate altering water circulation, and install water circulation units.



The black outline shows the lake’s watershed area: all the land area where rain, snowmelt, streams or runoff flow into the lake. Land uses and activities on the land in this area have the potential to impact the lake.

CONESUS LAKE 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 Conesus Lake 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 Conesus Lake 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.

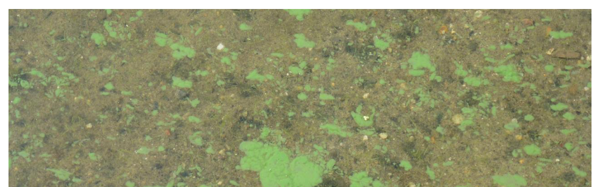
Research, Surveillance, and Monitoring:

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:

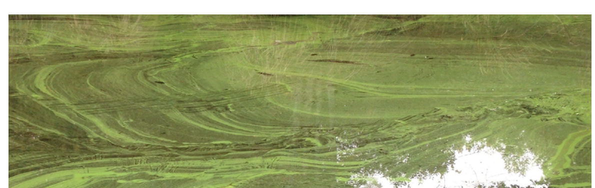
State laws and programs help control pollution and reduce nutrients from entering surface waters. State funding is available for municipalities, soil and water conservation districts, and non-profit organizations to implement projects that reduce nutrient runoff.

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.

Contents

List of Tables

List of Figures

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 a cascade of public health, economic, and ecological benefits including potable drinking water, tourism, water-based recreation, and ecosystem services. Harmful algal blooms (HABs), primarily within ponded waters (i.e., lakes and ponds) of New York State, have become increasingly prevalent in recent years and have impacted the values and services that these resources provide.

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

- Describe existing 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, duration, and intensity 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 in 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. Conesus Lake, with its numerous recreational opportunities, aesthetic beauty, importance as a source of drinking water for local communities, and documented HAB occurrences in recent years, was selected as one of the priority waterbodies, and is the subject of this HABs Action Plan.

Intended audiences for this HABs 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
- Local and regional agencies and organizations involved in the oversight and management of Conesus Lake (e.g., Livingston County Soil & Water Conservation District [SWCD], Departments of Health [DOHs], Conesus Lake Watershed Council [CLWC], Conesus Lake Association [CLA], The Finger Lakes Land Trust [FLLT])
- Lake residents, managers, consultants, and others that are directly involved in the management of HABs in Conesus Lake

Analyses conducted within this Action Plan provide insight into the processes that potentially influence the formation of HABs in Conesus Lake, and their spatial extents, durations, and intensities. Implementation of the mitigation actions recommended in this HABs Action Plan are expected to reduce blooms in Conesus Lake.

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, including adequate nutrient (e.g., phosphorus) availability, warm temperatures, and calm winds, cyanobacteria may multiply rapidly and form blooms that are visible on the surface of the affected waterbody. Several types of cyanobacteria can 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 documented the occurrence of HABs in Conesus Lake, and has produced this Action Plan to identify the primary factors triggering HAB events, and to facilitate decision-making to minimize the frequency, duration, and intensity of HABs, as well as the effects that HABs can have on both the users of the lake and its resident biological communities.

2. Lake Background

2.1 Geographic Location

Conesus Lake, meaning “berry place”, is the westernmost of the 11 Finger Lakes, and is located approximately 25 miles south of Rochester in Livingston County, western New York. It is the fifth smallest of the Finger Lakes by both water volume and surface area. The largest town adjoining the lake is Geneseo, with a population of approximately 10,500. The majority of the western shoreline of Conesus Lake defines Geneseo’s eastern limits. Livonia, a town of approximately 7,800 residents, is located along the lake’s northeastern section. Lakeville is a hamlet of Livonia, and directly abuts the lake to the north. The Town of Conesus is south of Livonia and borders the lake along its eastern and southern shoreline. Southwest of the lake is the Town of Groveland (**Figure 2**).

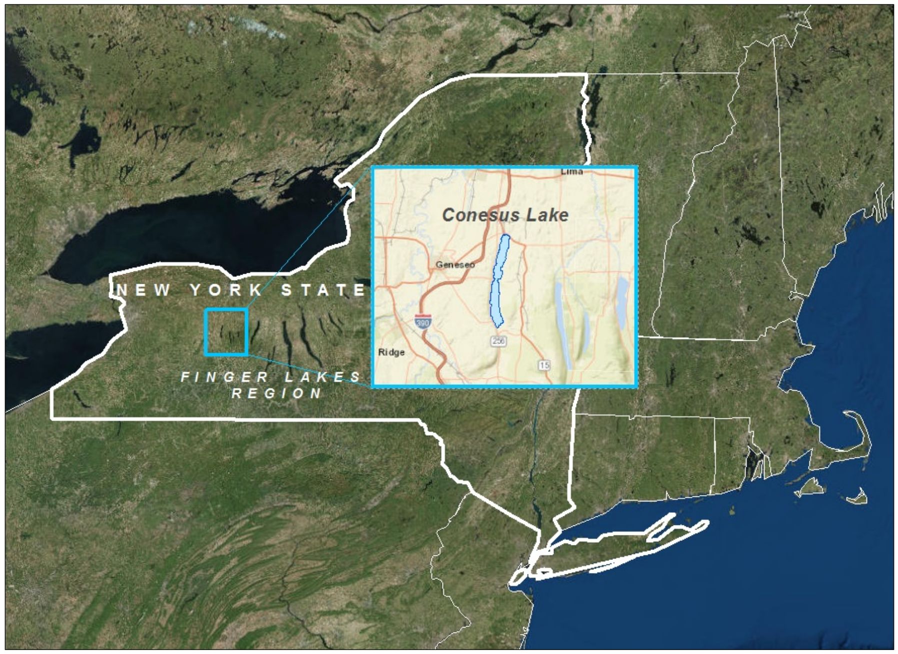


Figure 1. Location of Conesus Lake within New York State.

2.2 Basin Location

Conesus Lake is located within the Genesee River Drainage Basin, specifically the Upper Genesee River Drainage Basin. The Genesee River Watershed comprises 2,373 square miles of land in western New York State, with a small drainage area associated with the upper 15 miles of the Genesee River in Pennsylvania’s Allegheny Plateau. The Genesee River Basin comprises 5,048 miles of rivers and streams and 13,288 acres of ponds, lakes, and reservoirs (NYSDEC 2018a). The Conesus Lake watershed area is approximately 168 square km (64.9 square miles; Halfman 2017) and is contained entirely within Livingston County; there are 18 sub-watersheds based on the major tributaries to the lake. Conesus Lake is in a north-south valley bordered by significant topographic relief along much of its shoreline.

2.3 Morphology

Like the other Finger Lakes, Conesus Lake is elongated in a north-south orientation. Conesus Lake is 12.9 km (8 miles) long and 1.7 km (1 mile) wide at its widest point. The width of the lake is uniform over most of its length (mean = 1.1 km [0.66 miles]), with the exception of a constriction approximately mid-lake, where the lake is only about 0.5 km (0.3 miles) wide. Conesus Lake is topographically elevated at 247.3 meters (811 feet) above mean sea level, has a surface area of 13.8 square km (5.34 square miles), a shoreline perimeter of 29.6 km (18.4 miles), and a volume of 43 billion gallons (CLA 2016a; NYSDEC 2018b). Lakes with large watershed to lake area ratios like Conesus (64.9:5.3, or 12:1), often have shorter water retention times, as well as relatively high sedimentation rates and land-based loading of phosphorus and other nutrients (e.g., nitrogen).

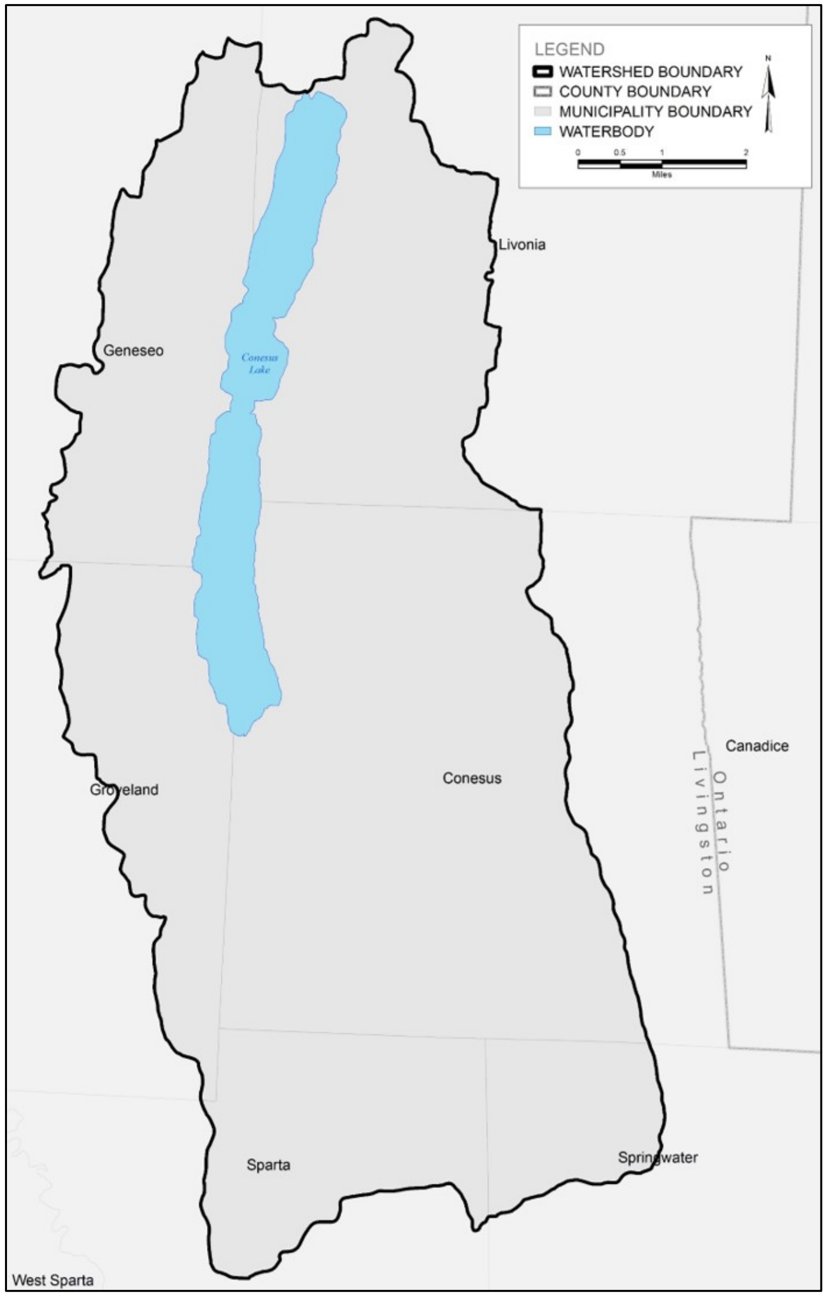


Figure 2. Political boundaries within the Conesus Lake watershed.

Conesus Lake is relatively deep compared to most lakes in New York State, with a maximum depth of 20.1 meters (66 feet) and a mean depth of 11.6 meters (38 feet) (NYSDEC 2018b; Livingston County 2018a) (**Figure 3**), but is shallow compared to the other Finger Lakes, having the second shallowest maximum depth behind only Honeoye Lake. Approximately 39% of the lake bottom is within 4.9 meters (16 feet) of the lake surface (Forest et al. 1978). Along with Honeoye and Chautauqua, Conesus Lake falls into a group of large lakes with relatively shallow water. The morphology of these lakes is such that the hypolimnion is relatively thin and prone to rapid depletion of dissolved oxygen. Phosphorus is released from anoxic sediments and transported to the photic zone during wind-driven mixing events and fall turnover.

According to wind data from the Dansville Municipal Airport during 2004-2017, prevailing winds over Conesus Lake during the June to November interval were generally out of the northwest and southeast (**Appendix A)**. These wind patterns likely result in a large fetch over which wind and wave action can mix the water and drive water-borne nutrients and buoyant cyanobacteria towards the southeastern and northwestern portions of Conesus Lake. When HABs occur in the lake, buoyant cyanobacteria may concentrate in these northern or southern portions, thus impacting bathing beaches and access locations.

2.4 Hydrology

Conesus Lake has a hydraulic retention time, or the average amount of time it takes water to pass through the lake, of 1.5-3 years. This is the second shortest retention time of the 11 Finger Lakes (CLA 2016a), but is significantly longer than most New York State lakes. Outflow from Conesus Lake is conveyed to Conesus Creek (also called Conesus Outlet), located at the lake's north end, which then flows to the Genesee River south of Avon, NY.

The deepest waters in Conesus Lake are located approximately 122 meters (400 feet) off of the eastern shoreline in the southern quarter of the lake (**Figure 3**). The configuration of Conesus Lake and its basin contributes to sharply sloping shorelines and the absence of a littoral zone (nearshore zone of full sunlight penetration) along much of the lake's perimeter, with the exception of the shallow (< 6 meters (20 feet)), often heavily vegetated, northern and far southern ends of the lake. Sediment accretion has occurred in nearshore areas receiving suspended solids from stormwater inflows and tributaries (Livingston County 2018a).

A total of 18 tributaries and several smaller perennial and intermittent streams, many of them less than one mile in length, flow into either Conesus Lake or its tributaries (LCPD and EcoLogic 2002). As discussed in **Section 2.2**, these watercourses collectively drain a watershed of approximately 65 square miles. The primary tributary to Conesus Lake is the Conesus Inlet that discharges surface water to the lake from the south. This watercourse flows within and along an 1,120-acre flat valley wetland-floodplain 2018c). The Conesus Inlet also serves as a flood storage area during high intensity rainfall events. The Conesus Inlet drains 29.9% (17.3 square miles) of the lake watershed (not including lake surface area) and contributes approximately 12% of the surface water discharge to the lake (LCPD and EcoLogic 2002).

Other tributaries of the watershed include North McMillan Creek, located approximately 0.6 km (0.4 miles) northeast of the Conesus Inlet, which discharges directly to Conesus Lake, and South McMillan Creek, which discharges to Conesus Inlet approximately 1 km (0.6 miles) upstream of the Inlet's entry to the lake. complex, which is a state-designated Wildlife Management Area (WMA) and is managed for wildlife, wildlife habitat, and wildlife-dependent recreation (NYSDEC

These two watercourses collectively drain 28.3% of the watershed area and contribute 44.3% of the surface water discharges to the lake (LCPD and EcoLogic 2002). The discrepancy between drainage area and surface water discharge in these tributaries can be attributed to differences in geology, slope, soil types, and vegetative cover (LCPD and EcoLogic 2002). Areas such as the Conesus Inlet tend to have a lower water yield per unit area due to the extensive areas of vegetation where water can evapotranspire and/or seep into the groundwater before reaching the lake, whereas areas with more impervious cover will tend to have higher water yields per unit area. Other tributaries include the following:

- North Gully – 4.4% of drainage area, 4.2% of surface water discharge
- Hanna's Creek – 4.3% of drainage area, 7.8% of surface water discharge
- Wilkins Creek – 4.1% of drainage area, 3.2% of surface water discharge
- Densmore – 3.9% of drainage area, 3.0% of surface water discharge
- Long Point – 3.7% of drainage area, 3.1% of surface water discharge

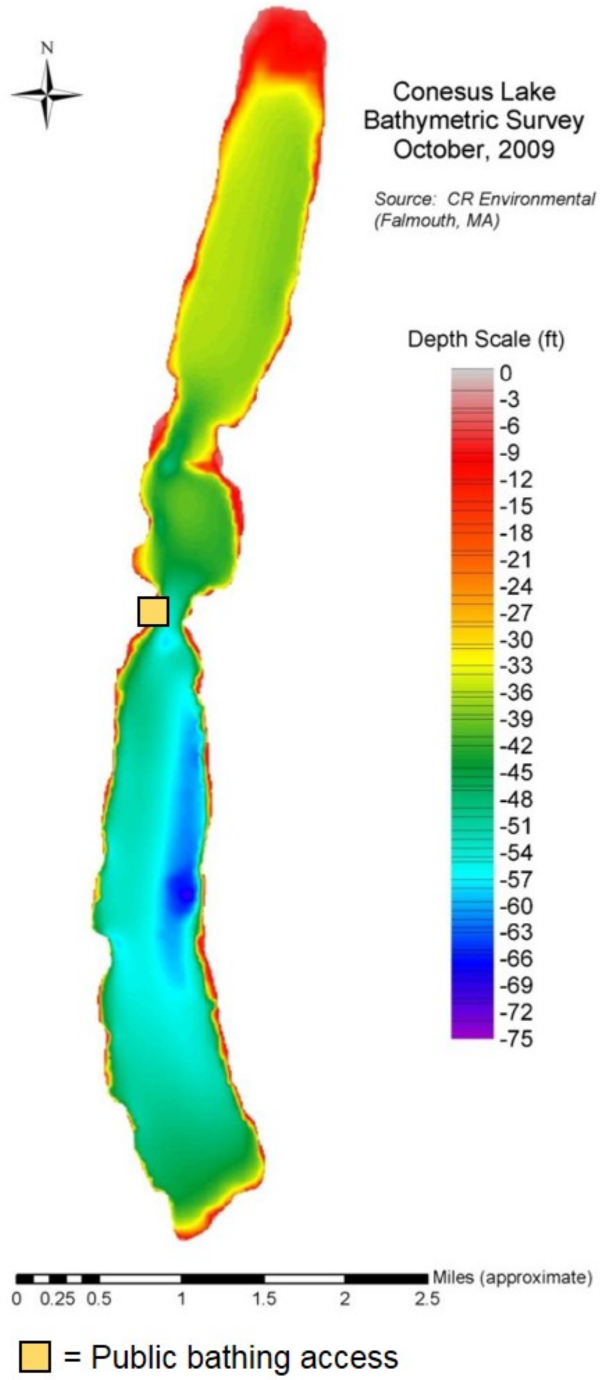


Figure 3. Bathymetry of Conesus Lake. Public bathing access location is depicted.

Watershed area percentages and hydrologic contributions are based on data available in the State of Conesus Lake Characterization Report (LCPD and EcoLogic 2002).

2.5 Lake Origin

The Finger Lakes, including Conesus Lake, were formed more than 2 million years ago during the Pleistocene Epoch. Glacial scouring carved deep slices into the land through the area, moving land and rocks southward. As the ice gradually melted and the glaciers receded, valleys of water dammed by unconsolidated glacial debris were left, and are now the Finger Lakes (Murdock 2010).

3. Designated Uses

3.1 Water Quality Classification – Lake and Major Tributaries

Conesus Lake is a Class AA waterbody according to the New York Codes, Rules, and Regulations (NYCRR). Class AA waterbodies are best utilized for drinking water, culinary or food processing purposes, primary and secondary contact recreation, and fishing. Class AA waters may, if subjected to approved disinfection treatment, with additional treatment if necessary, meet New York State Department of Health (NYSDOH) drinking water standards (6 NYCRR 701.5).

Conesus Inlet and all other tributaries to this lake are Class C watercourses. This classification indicates these tributaries are best used for fishing, fish propagation and survival, and primary and secondary contact recreation, although other factors may limit their use for these purposes. These waterbodies are not suitable as water supplies or for public bathing uses.

More information about the New York State classification system is provided in **Appendix B**.

3.2 Potable Water Uses

The total permitted surface water withdrawal for the Finger Lakes is approximately 190 million gallons per day (MGD). Of the 10 Finger Lakes that are permitted for water withdrawal, Conesus Lake has the second lowest permitted withdrawal (6.9 MGD) (Halfman 2017). Approximately 20,000 residents in the Towns of Geneseo, Avon, York, and portions of Groveland and Leicester, collectively 22% of Livingston County's population, obtain their drinking water from Conesus Lake (CLA 2016a). 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 of 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 cyanobacteria 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 United States 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 USEPA 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). Health advisories are not legally enforceable federal standards and are subject to change as new information becomes available.”

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 (μg/L) for infants and children under the age of 6, and 1.6 μg/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 1,000-fold lower than levels that caused health effects in laboratory animals. The USEPA's lower 10-day health advisory of 0.3 μg/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 μg/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 detected HAB toxin.

The Village of Geneseo draws water from Conesus Lake through an intake line and is then conveyed to a water treatment plant in the Town of Geneseo. After pre-chlorination, filtration, disinfection, fluoridation, and corrosion control treatment, water is pumped to the village distribution system. This system serves the Village of Geneseo and the Towns of Geneseo, Groveland, and York. The Village of Avon system serves a portion of the Town of Geneseo and the Village and Town of Avon. In 2016, the Geneseo and Avon systems withdrew 1.03 MGD and 0.87 MGD from the lake, respectively (CLWC 2016). The Geneseo and Avon raw water supply intakes are located 13.7 and 5.4 meters (45 and 18 feet) below the lake surface, respectively (LCPD and EcoLogic 2002).

The formation of HABs and associated cyanotoxins in Conesus Lake in recent years represents a potential threat to potable water purveyors and users of lake-derived drinking water such as the communities described above. Additional discussion of potential HABs-associated impacts to potable water use is provided in **Section 7.2**.

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 the 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 the 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 USEPA 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

Only one public bathing beach is present on Conesus Lake, at Long Point Park along the lake's western shoreline in Geneseo. This community park contains a small beach area that is tended by lifeguards during the swimming season. Other beach/lakefront areas where swimming is known to occur in Conesus Lake include those at Camp Stella Maris on the northeast shore of the lake and at Southern Shores Beach, located along the lake's southeast shoreline. These three beach areas are routinely monitored for fecal coliform throughout the recreation season by the Livingston County Department of Health (LCDOH) (CLWC 2016). Swimming is also permitted at Conesus Lake Campgrounds, located a short distance north of Southern Shores Campground; however, lifeguard supervision is not available at the campground bathing beach. In addition to Long Point Park, private swimming areas are also regulated by the NYSDOH, and therefore may be subject to beach closures due to HABs.

3.4 Recreation Uses

The surrounding land in the watershed provides opportunities for camping, sight-seeing, birdwatching, hiking, bicycling, and other recreational uses through public and private access. Cold weather activities include ice fishing, snowmobiling, and ice skating. The lake is surrounded by numerous lakeshore cottages, some inhabited year-round by its owners and some by part-time vacationers. A golf course is present south of the lake in the Town of Conesus.

Vitale Park on the north shore of the lake near its outlet to Conesus Creek provides opportunities for picnicking and playground recreation, and contains pavilions, a dockside fishing area, walking trails, and a hand boat launch, and also hosts a summer concert series, (LCPD and EcoLogic 2002; NYFalls.com 2013). This community park, also known as Sand Point, is hosted by the Town of Livonia. Long Point Park, hosted by the Town of Geneseo, provides the lake's only official public bathing beach and offers picnic tables, pavilion, and playground area.

Conesus Lake has four public boat launch sites and two private marinas. Conesus Lake Boat Launch, located on the eastern shoreline near the Village of Livonia, is the only public boat launch equipped with a concrete ramp for trailer launching. The launch facility also includes picnic tables and a fishing area (NYFalls.com 2013).

The Conesus Inlet WMA, located at the south end of the lake, spans wetlands and uplands and provides opportunities for hiking, fishing, birdwatching, hunting/trapping, wildlife viewing, and photography. Two scenic overlooks, several parking areas, and boat launch access are available for recreators of the area. NYSDEC has constructed wetlands and ponds in the WMA to enhance natural areas lost from development (NYSDEC 2018c).

3.5 Fish Consumption/Fishing Uses

Conesus Lake supports an assemblage of warmwater fish species. More than 39 species have been reported as inhabiting Conesus Lake and Conesus Inlet (LCPD and EcoLogic 2002), several of which are important recreationally and may be taken for consumption. Sought after species include, but are not limited to:

- Largemouth bass (*Micropterus salmoides*)
- Smallmouth bass (*Micropterus dolomieu*)
- Walleye (*Sander vitreus*)
- Northern pike (*Esox lucius*)
- Tiger muskellunge (*Esox masquinongy x E. lucius*)
- Yellow perch (*Perca flavescens*)
- Brown bullhead (*Ameiurus nebulosus*)

- Panfish, including bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), rock bass (*Ambloplites rupestris*), and black crappie (*Pomoxis nigromaculatus*)

Notable events and actions pertaining to sport fish management in Conesus Lake include the following:

- In the late 1960s and early 1970s, trout were stocked in the lake, but these efforts were met with limited success, and stocking was subsequently discontinued after 1975.
- In 1979, 83 acres were purchased and added to the Conesus Inlet WMA to provide access to Conesus Lake and to preserve critical northern pike spawning habitat.
- In the 1980s, the lake's yellow perch population declined, presumably attributable to the incidental introduction and population explosion of unwanted alewives (*Alosa pseudoharengus*).
- In 1991, NYSDEC began stocking tiger muskellunge, a sterile hybrid, to enhance the lake's sport fishery (NYSDEC 2018c).
- In 2015, 9,500 tiger muskellunge and 357,500 walleye were stocked in the lake (NYSDEC 2015a).

Recent management efforts have focused on both the walleye and yellow perch fisheries in an effort to reduce the alewife population. Alewife, introduced in the late 1970s, are known to have a significant impact on the size distribution and community structure of zooplankton (see **Section 6.3**), which in turn can increase the prevalence of cyanobacteria. Since 2000, the walleye population has been in decline, with population levels down to approximately 12% of historic levels (LCPD and EcoLogic 2013; NYSDEC 2014).

New York State fishing regulations are applicable to Conesus Lake, with special minimum size and take provisions for largemouth bass, smallmouth bass, and trout (eRegulations 2017). No fish consumption advisories specific to Conesus Lake have been issued by the NYSDOH. In the absence of a specific advisory, the NYSDOH recommends limiting fish consumption to four, half-pound meals per month (NYSDOH 2018a). The fish consumption use was considered "fully supported" in the 2015 update to the Conesus Creek WI/PWL fact sheets (NYSDEC 2015b).

3.6 Aquatic Life Uses

Conesus Lake is designated as a Class AA water, suitable for fish propagation and survival. Water quality monitoring conducted by the NYSDEC focuses primarily on support of aquatic life and general recreation. Aquatic life uses in the lake were identified as "stressed" in the updated WI/PWL based on periodic oxygen depletion in the lake's hypolimnion during the summer months (NYSDEC 2015b). Low dissolved oxygen concentrations are attributable to the lake's small hypolimnetic volume and mesotrophic (and sometime eutrophic [nutrient-enriched]) state. The eutrophic conditions present during certain periods limits the attainment of the best use of the lake as a Class AA waterbody. Despite these periodic deleterious conditions, the decline in the yellow perch and walleye fisheries decades ago (see **Section 3.5**), and the introduction of invasive zebra mussels, Conesus Lake provides adequate conditions to support a diverse and productive warmwater fishery (NYSDEC 2015b).

Careful management of the sport fishery in Conesus Lake, coupled with the absence of observable impairment to the aquatic life use in the lake, 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 Conesus Lake. However, the presence of alewife, an invasive alosine fish species 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. The alewife introduction may have adversely affected water quality conditions since the 1970s and may continue to affect food web interactions, including phytoplankton community composition. This trophic interaction is discussed further in **Section 6.3**.

3.7 Other Uses

Many taxa of birds and mammals rely on Conesus Lake and its shoreline as high quality foraging, roosting, and nesting habitat. While resident birds stay in the area year-round, the majority are found seasonally during breeding and migration seasons. NYSDEC has published a statewide WMA checklist for birds that includes many species of waterfowl, game birds, marsh and shore birds, raptors, woodpeckers, and songbirds that are expected to utilize the Conesus Inlet WMA and associated lake habitat. The diverse bird community is reflective of the mosaic of habitats and richness of transition zones between wetlands, woodlands, and open fields. Mammals that depend on the lake for foraging and den habitat include muskrat, mink, beaver, and river otter. The NYSDEC WMA mammal checklist includes the species listed above and other small mammals such as American marten, fisher, long-tailed weasel, and striped skunk, and large mammals, including black bear, bobcat, coyote, red fox, gray fox, and white-tailed deer (NYSDEC 2018c). Aerial mammals, such as little brown bat, may also be observed in the Conesus Inlet WMA and along the lakeshore.

Public hunting opportunities for ring-necked pheasants, ruffed grouse, woodcock, deer, fox, squirrels, and cottontail rabbits are available at the Conesus Inlet WMA. Additionally, trapping for raccoon, mink, muskrat, gray fox, and red fox is a common activity in this area (LCPD and EcoLogic 2002).

4. User and Stakeholder Groups

Conesus Lake is used by all age groups, including fulltime and seasonal homeowners of more than 1,100 lakeside properties, homeowner guests, day or extended stay recreators, private club members, 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 select access points such as Vitale Park and Long Point Park that include marinas and public boat launches. Shoreline residents and their guests may also access the lake directly via private docks, piers, and boat launches.

The Conesus Lake Association (CLA) was established in 1932 and is a not-for-profit homeowners' association whose mission is to "…promote the health, safety, and welfare of the residents, both permanent and temporary…" of the Conesus Lake watershed (CLA 2016b). The CLA works closely with lakeshore towns on several important watershed items, including passing town dock laws in the lakeshore towns, installing utility lines, building flood control structures at the lake's northern outlet, establishing boating speed limits, holding periodic workshops to raise resident awareness of environmental issues plaguing the lake, adopting the *Conesus Lake Watershed Management Plan* (CLWMP) (LCPD and EcoLogic 2003), and numerous other activities. Development of the CLWMP was facilitated through the shared engagement of the agricultural community and shoreline resident community in a science-based assessment of the interrelationship of the lake's water resources and adjacent land use (Moran and Woods 2009). The CLA also promotes a watershed stewardship initiative consisting of a cohesive set of actions, including funding and supporting watershed programs, engaging in community outreach, and educating and implementing best management practice techniques to educate watershed residents and promote practices favorable to the lake's water quality (CLA 2016c).

The Conesus Lake Watershed Council (CLWC) was established in 2003 and consists of an inter-municipal watershed advisory body responsible for governing the implementation of the lake's Watershed Management Plan. The CLWC comprises numerous entities, including the towns and villages (Conesus, Geneseo, Groveland, Livonia, Sparta), county (Livingston), and water purveyors (Geneseo, Avon) within the watershed boundaries. Three committees (agricultural, technical, and public education and outreach) have been established within the CLWC to address various watershed issues. The CLWC publishes an Annual Report Card updating the prior year's implementation activities and water quality monitoring results conducted under the Watershed Management Plan (Livingston County 2018b). The CLWC also approved and implemented the *Conesus Lake Blue-Green Algae Early Detection and Rapid Response Plan*, which was developed to identify a coordinated set of actions essential to identifying a HAB, evaluate its spatial extent in the lake, and assess its potential for exerting harmful effects on public health (Livingston County 2018c).

The Finger Lakes Land Trust (FLLT) is a small non-profit organization founded in 1989, and comprising members, landowners, and volunteers whose mission is to "*...to conserve forever the lands and waters of the Finger Lakes region, ensuring scenic vistas, clean water, local foods, and wild places for everyone*" (FLLT 2018). Although no FLLT preserves or conservation areas have been purchased in the Conesus Lake watershed, the FLLT partners with the CLWC to support maintenance of the highest quality of land and water resources within the watershed.

5. Monitoring Efforts

5.1 Lake Monitoring Activities

Monitoring efforts on Conesus Lake have been conducted as part of the Citizen's Statewide Lake Assessment Program (CSLAP) from 1986-1991 and then again in 2017. Water quality parameters monitored as part of CSLAP generally include:

- Water temperature
- Water clarity (Secchi depth)
- Total phosphorus (TP)
- Total nitrogen (TN)
- Chlorophyll-a
- pH
- Specific conductivity
- Color

Monitoring efforts under CSLAP were conducted at one location near the center of the Southern basin of Conesus Lake during the 1986-1991 sampling period. In 2017, sampling was conducted at two locations in the Northern and Southern basins of the lake (**Figure 4**). Water quality summary reports are being developed for each Finger Lake and for the entire Finger Lakes region, including comparisons to historical NYSDEC data, using CSLAP data as part of the evaluation. SUNY Geneseo and SUNY Brockport have also collected water quality data on the lake in collaboration with Livingston County.

Other monitoring efforts conducted in Conesus Lake include the NYSDEC Disinfection by-products (DBPs) Study (Callinan et al. 2013) in 2004, NYSDEC Lake Classification and Inventory (LCI) Monitoring Program in 2002 and 2005, and the Finger Lakes Synoptic Water Quality Investigation (FL/SWQI) from 1996 to 2000. In addition to these monitoring efforts, individual researchers have studied Conesus Lake's water quality since the early 20th century. Earlier studies related to nutrient loadings, water clarity, sedimentation, and biological surveys are detailed in the Conesus Lake Watershed Characterization Report Update (LCPD and EcoLogic 2013).

The DBPs study was conducted in 2004 in response to the USEPA initiation of a National Nutrient Strategy (USEPA 1998) that called on states to establish a numeric nutrient criteria (NNC). A total of 21 lakes, including Conesus Lake, were included in the NYSDEC DBPs study, which focused on lakes designated as potable water supplies. Nutrient enrichment in lakes used as potable water supplies are associated with increases in human health-risk factors such as increased generation of DBPs and production of cyanotoxins by certain species of cyanobacteria (Callinan et al. 2013). Sampling efforts focused on total phosphorus, chlorophyll-a, dissolved organic carbon

(DOC), and the total trihalomethanes formation potential (THMFP - a measure of DBPs).

NYSDEC collects data as part of the LCI program to support water quality assessments and management activities, including identifying and responding to HABs. The LCI data set for Conesus Lake comprises monthly samples collected in 2002 and 2005 from May to September. Data collected during the LCI for Conesus Lake included monthly profiles of water quality parameters from just below the water surface to the lake bottom. The LCI sampling efforts were conducted in the Southern basin of the lake (e.g., NYSDEC Historic location in **Figure 4**).

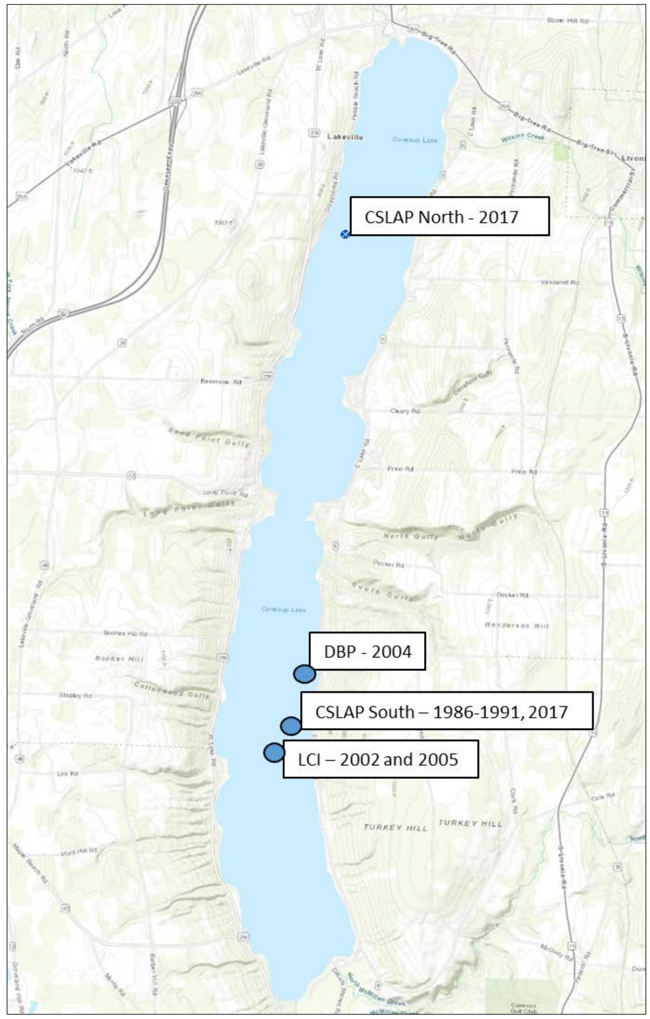


Figure 4. Map of Conesus Lake with current and historic water quality sampling locations.

The NYSDEC Finger Lakes study in the late 1990s was an attempt to replicate comparative investigations of the Finger Lakes not conducted systematically on all eleven Finger Lakes since at least the 1970. This study included sediment coring and monthly water quality monitoring from 1996 to 1999 on at least one sample site per lake, as well as comparisons of water quality data to historical NYS sampling results. Conesus Lake was included in this evaluation.

5.2 Tributary Monitoring Activities

Four of the tributaries to Conesus Lake have been monitored as part of the NYSDEC Rotating Intensive Basin Studies (RIBS) program. The objectives of the RIBS program are to monitor water quality conditions throughout New York State to identify water quality problems, long-term water quality trends, and characterize naturally occurring or background conditions to be used to measure the effectiveness of site-specific restoration and protection activities. Water quality assessments are based on macroinvertebrate community analysis, measures of acute toxicity in the water, physical habitat evaluation and water chemistry. Results of the RIBS assessment conducted on tributaries to Conesus Lake are summarized in **Section 6.4**.

From 2002 to 2007, weekly sampling was conducted during the Conesus Lake U.S. Department of Agriculture (USDA) project at the mouths of six small sub-watersheds under the direction of Dr. Joseph Makarewicz at SUNY Brockport. This sampling was conducted to assess the effectiveness of agricultural Best Management Practices (BMPs). Five of the sub-watersheds were located on the west side of Conesus Lake while one (North McMillan Creek) was located on the south end of the lake and used as a reference (i.e., no BMPs implemented [Makarewicz et al. 2009a]). Within each sub-watershed, farmers were voluntarily enlisted to implement a variety of BMPs tailored to existing farming practices and soil conditions. Experimental sub-watersheds included in the project are:

- Cottonwood Gully
- Graywood Gully
- Sand Point Gully
- Long Point Gully
- Sutton Point Gully

Research conducted by SUNY Brockport monitored the impacts of the BMPs in the export of nutrients, sediments, and other materials to Conesus Lake. The 2002-2007 intensive monitoring data set was used by SUNY Brockport to develop Stream Water Quality Indices for the experimental USDA sub-watersheds. Indices were developed for total suspended solids, total phosphorus, soluble reactive phosphorus, nitrate, total Kjeldahl nitrogen and sodium. Indices were used to assess the long-term impacts of BMPs during the 2011 and 2012 spring sampling. Results of these monitoring efforts are summarized in **Section 6.4**. Refer to Makarewicz et al. (2011, 2012) and the Conesus Lake Watershed Characterization Report Update (2013) for more details on the development of the Stream Water Quality Indices.

6. Water Quality Conditions

General long-term trends in water quality conditions were assessed using available data collected from the southern portion of Conesus Lake through CSLAP (1986-1991 and 2017), LCI (2002 and 2005), DBPs (2004) and SWQI (1996 to 2000) programs (**Figure 4**). Data from the Northern and Southern sampling locations in 2017 were kept separate due to the distinction between the two basins. Trends were evaluated using a nonparametric correlations coefficient (Kendall's tau, τ) to determine if time trends were significant (assumed for p-values less than 0.05). In general, water quality data used in this analysis were limited to those that were collected under a State-approved Quality Assurance Project Plan (QAPP) and analyzed at an Environmental Laboratory Accredited Program (ELAP) certified laboratory. Note that long-term trends presented below are intended to provide an overview of water quality conditions, and that continued sampling will better inform trend analyses over time. As discussed in **Section 5.1**, Livingston County has long contracted SUNY Geneseo and SUNY Brockport for summertime water quality monitoring in Conesus Lake. While it is acknowledged that the data collected from these water monitoring activities would fill temporal data gaps in water quality and represent a potentially important source of information to the understanding of HABs in the lake, they were not incorporated into this Action Plan given that such an evaluation would require a time-consuming effort that would span beyond the time constraint for this Action Plan. NYSDEC continues to review this data.

In freshwater lakes, phosphorus is typically the nutrient that limits plant growth; therefore, when excess phosphorus becomes available from point sources or nonpoint sources, excessive aquatic macrophyte and algae (including cyanobacteria) growth often can occur. Under certain circumstances described in **Section 9**, excessive phosphorus loading can lead to algal blooms. Note that phosphorus form is an important consideration when evaluating management alternatives (**Section 13**).

The data provided in **Table 1** indicate that the current TP concentration in the north and south basins of Conesus Lake, based on average 2017 samples, was higher compared to other Finger Lakes, though TP concentrations are lower compared to other smaller lakes in the region. Additionally, the average 2017 TP concentration for the North basin Conesus Lake was equal to the New York State recreational water quality guidance value of 0.02 mg/L of TP, while the South basin was lower than the guidance value. Given that HABs have been recorded in Conesus Lake, targeted TP concentrations lower than the Statewide guidance value are appropriate when the waterbody is a potable water source (Class A and above), as well as when considering future management actions to limit the frequency and duration of HABs.

Table 1. Regional summary of surface total phosphorus (TP) concentrations (mg/L, ± standard error) for New York State lakes, 2012-2017 (CSLAP and LCI), and the average TP concentration (± standard error) in Conesus Lake from the two sampling locations in 2017.

Region	Number of Lakes	Average TP (mg/L)	Average TP Conesus Lake (mg/L) North 2017	Average TP Conesus Lake (mg/L) South 2017
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)	-	-
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)	0.020 (± 0.001)	0.016 (± 0.001)
Western NY	47	0.045 (± 0.008)	-	

Conesus Lake is typically considered mesotrophic, but with periodic conditions of eutrophy (high productivity), and has a high susceptibility to HABs. A summary of HABs in the lake is provided in **Section 7**. The presence of HABs in the lake over the past decade have raised major concerns about long-term water quality and public health. Lake 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 – in 2017, these indicators reflected mesotrophic, or moderately productive, conditions in both lake basins (**Table 2**).

Table 2. New York State criteria for trophic classifications (NYSFOLA 2009) compared to average (± standard error) Conesus Lake values in 2017 (CSLAP).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Conesus Lake North 2017	Conesus Lake South 2017
Transparency (m)	>5	2-5	<2	3.1 (± 0.24)	3.2 (± 0.37)
TP (mg/L)	<0.010	0.010-0.020	>0.020	0.020 (± 0.001)	0.016 (± 0.001)
Chlorophyll a (µg/L)	<2	2-8	>8	5.4 (± 0.97)	6.3 (± 0.73)

6.1 Physical Conditions

Water clarity data, as represented by Secchi depth, collected in Conesus Lake between 1986 and 2017 (**Figure 5a**) were typically greater than 2 meters and were indicative of mesotrophic conditions. Water clarity can be related to the amount of suspended material in the water column including suspended sediment, phytoplankton, and cyanobacteria. Seasonal trends in water clarity suggest a decrease from May to early July before increasing again in late August and September. Annual minimum water clarity, which occurred around mid-July to early August, was typically less than 2 m, likely due to high algal biomass. Maximum annual water clarity occurred in late August to early September. Long-term trends in water clarity from the South sampling location indicate no change over time ($p > 0.05$, $\tau = 0.0$).

In 2017 (**Figure 5b**), seasonal trends were typical for Conesus Lake in both the North and South basins. Secchi disk transparency readings exceeded the New York State Sanitary Code requirements for siting new bathing beaches (1.2-meter, or 4 ft., minimum, NYSDOH 2018b). However, such trophic indicators should continue to be monitored for any changes.

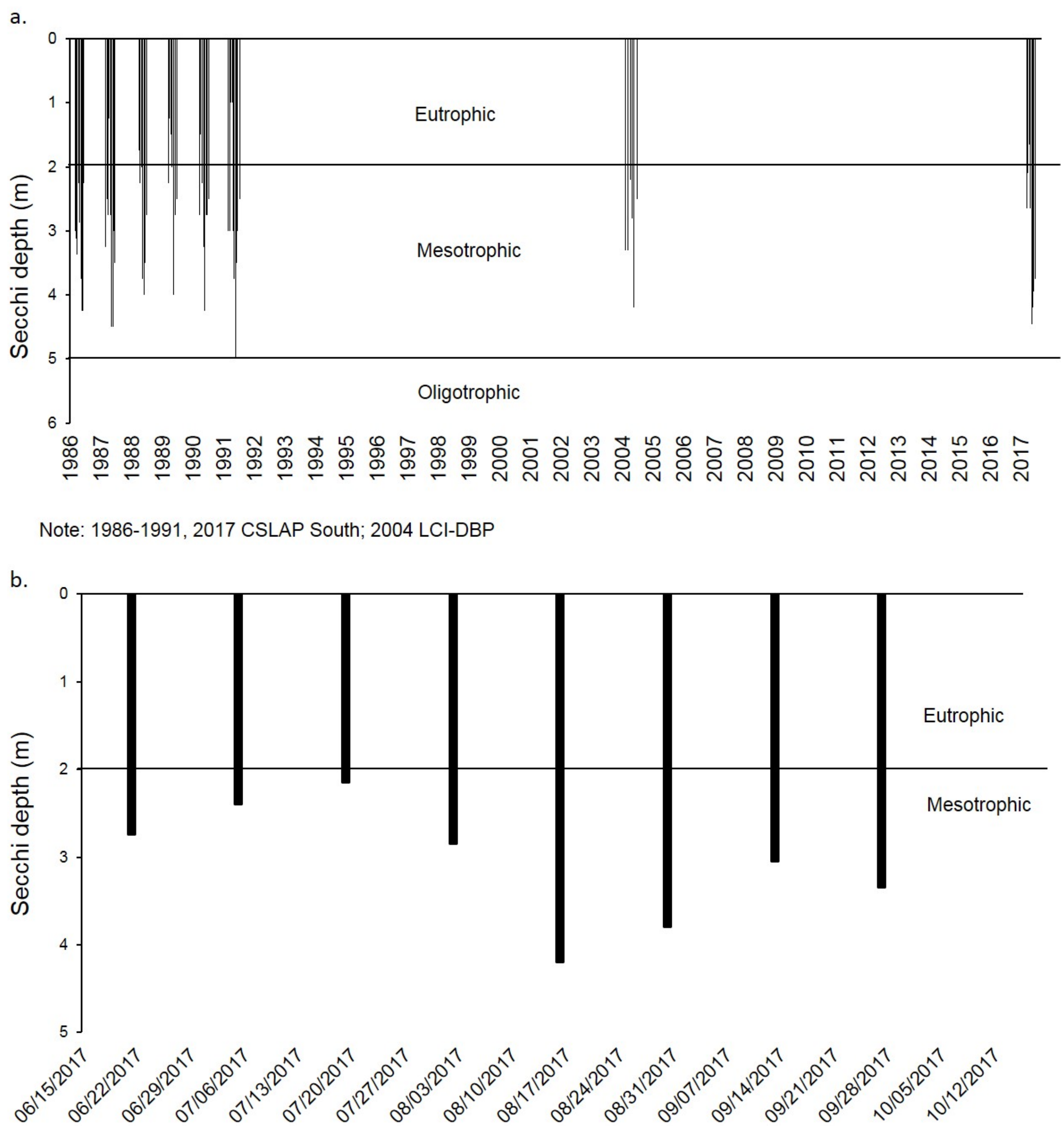
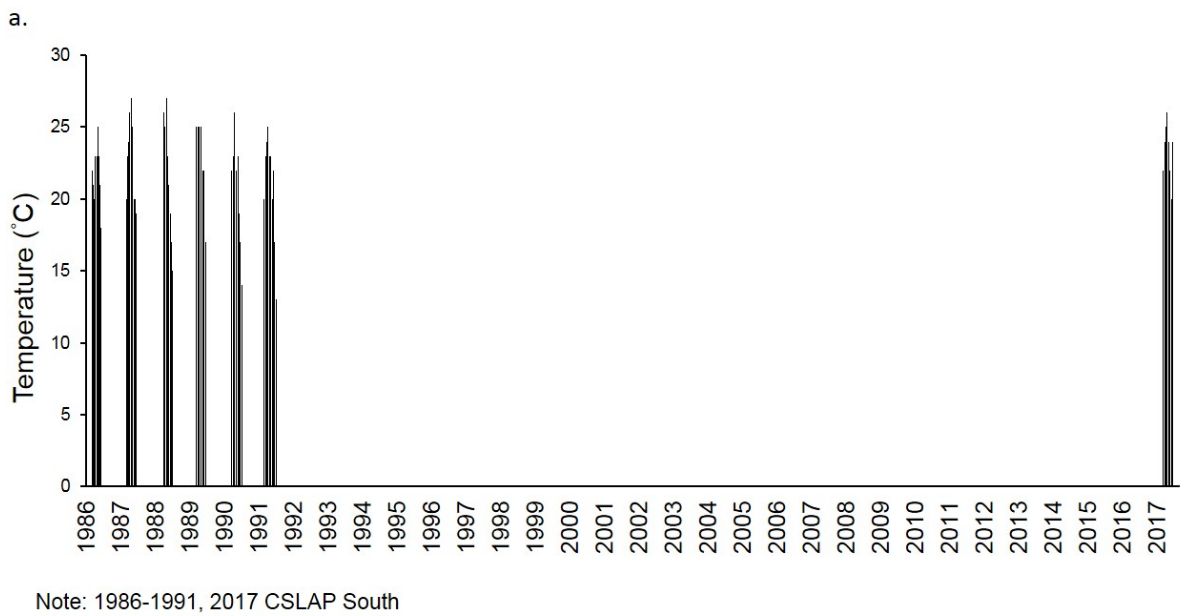


Figure 5. (a) Long-term (1986-2017) water clarity, measured as Secchi depth (m), data from the South sampling location. (b) Water clarity data from the North station in 2017 (CSLAP).

Understanding temperature changes within a waterbody seasonally, as well as annually, is important in understanding HABs. Most cyanobacteria taxa grow better at higher temperatures (typically above 25°C) than other phytoplankton which give them a competitive advantage under these conditions (Paerl and Huisman 2008). Maximum summer water temperatures (**Figure 6a**) ranged between 24.0 °C (75.2°F, 1986,1989 and 1991) and 27.0 °C (80.6°F, 1987 and 1988). No long-term trend was observed in average annual (p = 0.652, τ = 0.143) and maximum water temperatures (p = 0.748, τ = -0.109) from 1986 to 2017 at the South sampling location. Typical seasonal trends in water temperature were observed, with temperatures increasing in the spring and early summer before decreasing in late summer and early fall. In 2017 (**Figure 6b**), warmer air temperatures in late September resulted in increased lake surface water temperatures. Water temperature in the Northern basin was slightly lower than the Southern basin in 2017. Maximum water temperature was 26.0 °C (78.8°F) in the Southern basin and 25.0 °C (77.0°F) in the Northern basin.



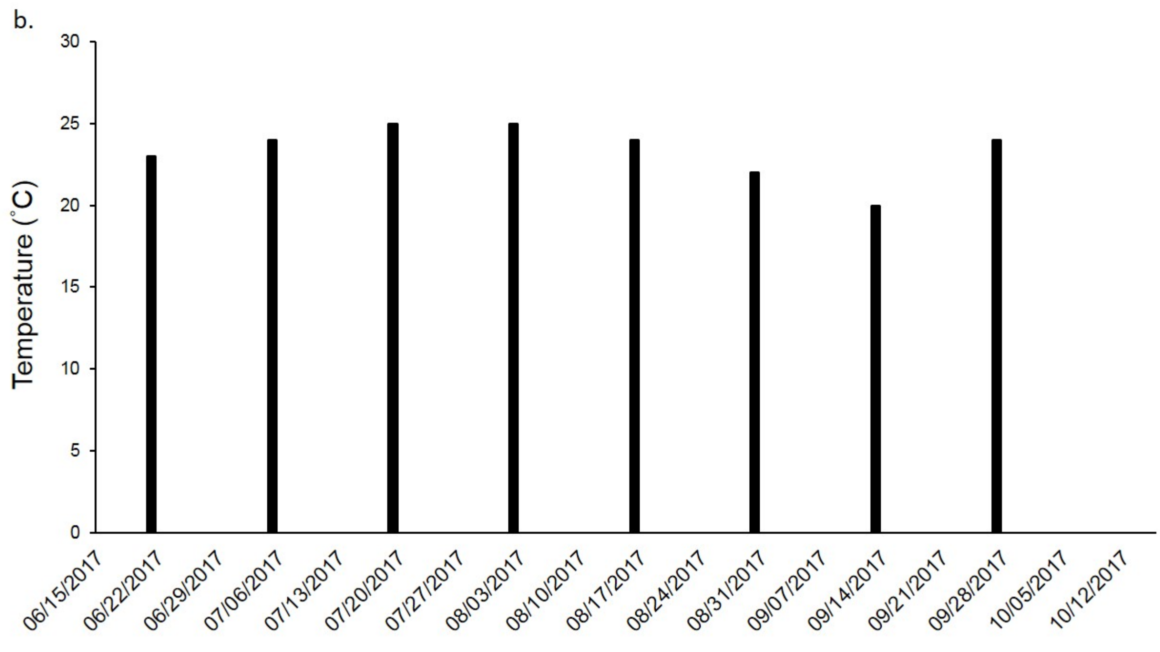


Figure 6. (a) Long-term (1986-2017) water surface water temperature (°C) data from the Southern sampling location. (b) Surface water temperature data from the Northern station in 2017 (CSLAP).

6.2 Chemical Conditions

Surface water TP concentrations in Conesus Lake from 1986 to 2017 at the South location (**Figure 7a**) were on average indicative of mesotrophic (moderate productivity) conditions, although many individual readings exceeded 0.02 mg/l. There was not a significant long-term trend in average (p = 0.211, τ = 0.359) or maximum (p > 0.05, τ = -0.051) TP concentrations from 1986 to 2017 in the South basin. Seasonal trends suggest decreasing TP concentrations from May to early July before increasing again in late August and September (**Figure 7a**). Annual minimum concentrations of TP were typically observed after minimum water clarity depths, indicating that decreases in TP concentrations are likely due to algal growth. In 2017 (**Figure 7b**), seasonal trends were typical for Conesus Lake in both the North and South basins.

Bottom (North basin 9 m and South basin 12 m deep) TP concentrations in August increased to over 0.10 mg/L in the North basin and to approximately 0.04 mg/L in the South basin (**Figure 8a**). In the North basin, concentrations continued to be elevated through September. Increased TP concentrations at depth are likely a result of internal phosphorus loading caused by anoxic conditions present in the hypolimnion (bottom layer) of Conesus Lake. A dissolved oxygen profile conducted during the 1996 SWQI sampling indicated anoxia in the hypolimnion in mid-September; more recently Livingston County and EcoLogic (2013) also documented the development of anoxic conditions in the hypolimnion of this lake. It should be noted that North basin TP bottom concentrations in August and September being elevated relative to South basin bottom concentrations may be an artifact of the CSLAP sample design, potentially confounding the interpretation of relative internal phosphorus loading. North basin measurements are taken 1-2 m off the lake bottom, while South basin measurements are taken 5-6 m off the bottom. Studies by J. Makarewicz at SUNY-Brockport have shown that dissolved phosphorus levels increase significantly from the top of the hypolimnion to the bottom during stratified conditions, and that internal loading is greater in the South basin than in the North basin. Extended periods of hypolimnetic dissolved oxygen depletion facilitates substantial phosphorus release (internal loading) from benthic sediments. The release of phosphorus under these conditions is biochemically mediated and is the result of reduction/oxidation (redox) processes occurring at the sediment-water interface. In addition, this phosphorus is more likely to be found in a (biologically available) form that can rapidly contribute to phytoplankton growth.

The pattern of generally higher TP concentrations in an anoxic hypolimnion in the later part of summer is consistent with this class of lakes (shallow Finger Lakes) that have a relatively thin hypolimnion which results in rapid depletion of dissolved oxygen (compared to the class of much deeper Finger Lakes). Partial mixing between the hypolimnion and epilimnion will result from internal waves during wind events in late summer when TP concentrations are highest in the hypolimnion. Fall turnover results in complete vertical mixing of the water column, completing the migration of nutrients from bottom to surface waters. These late summer to fall migrations of nutrients from bottom to top waters may also contribute to late season blooms in these lakes.

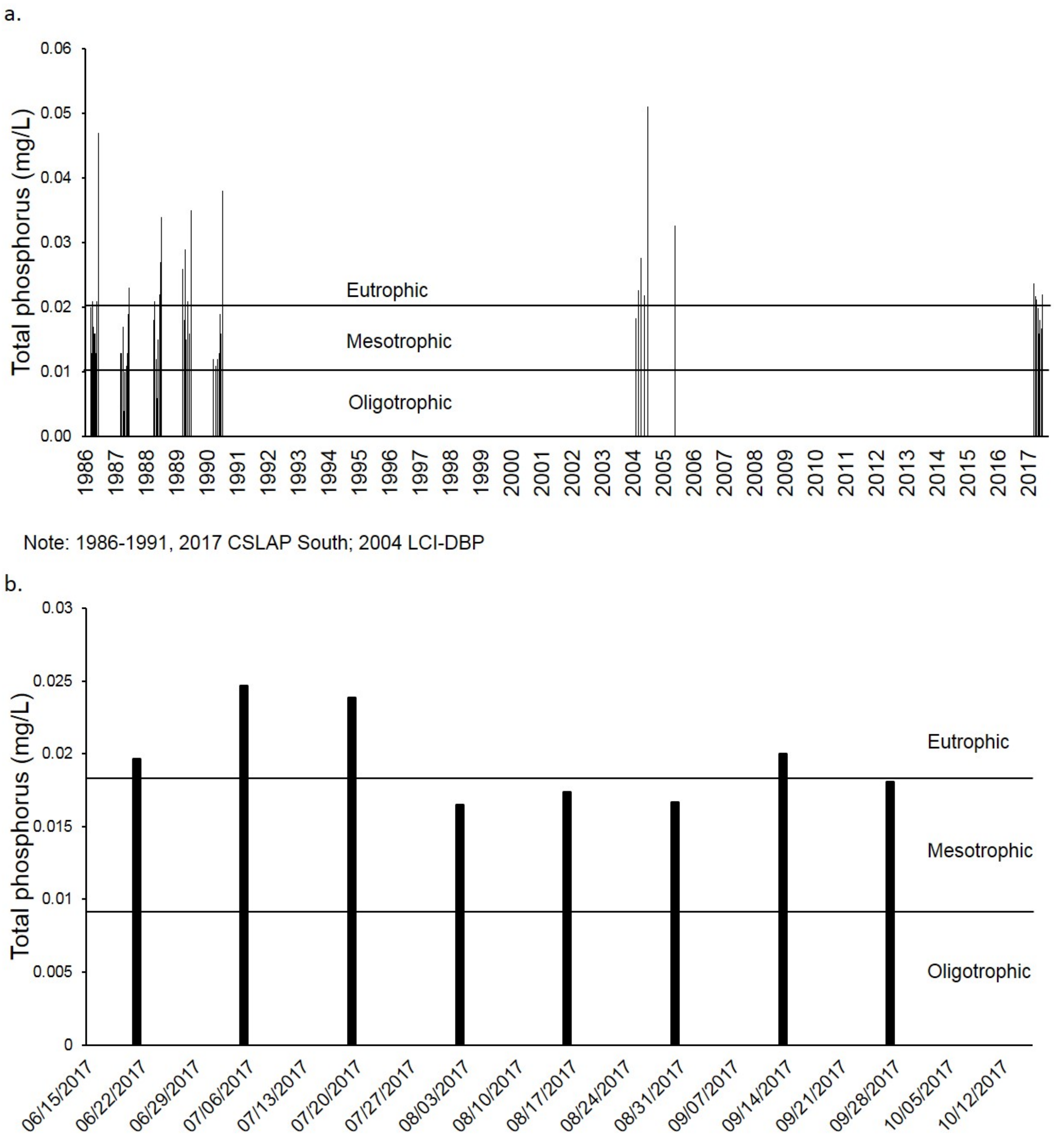


Figure 7. (a) Long-term (1986-2017) total phosphorus (mg/L) data from the Southern sampling location. (b) Total phosphorus concentration data from the Northern station in 2017 (CSLAP).

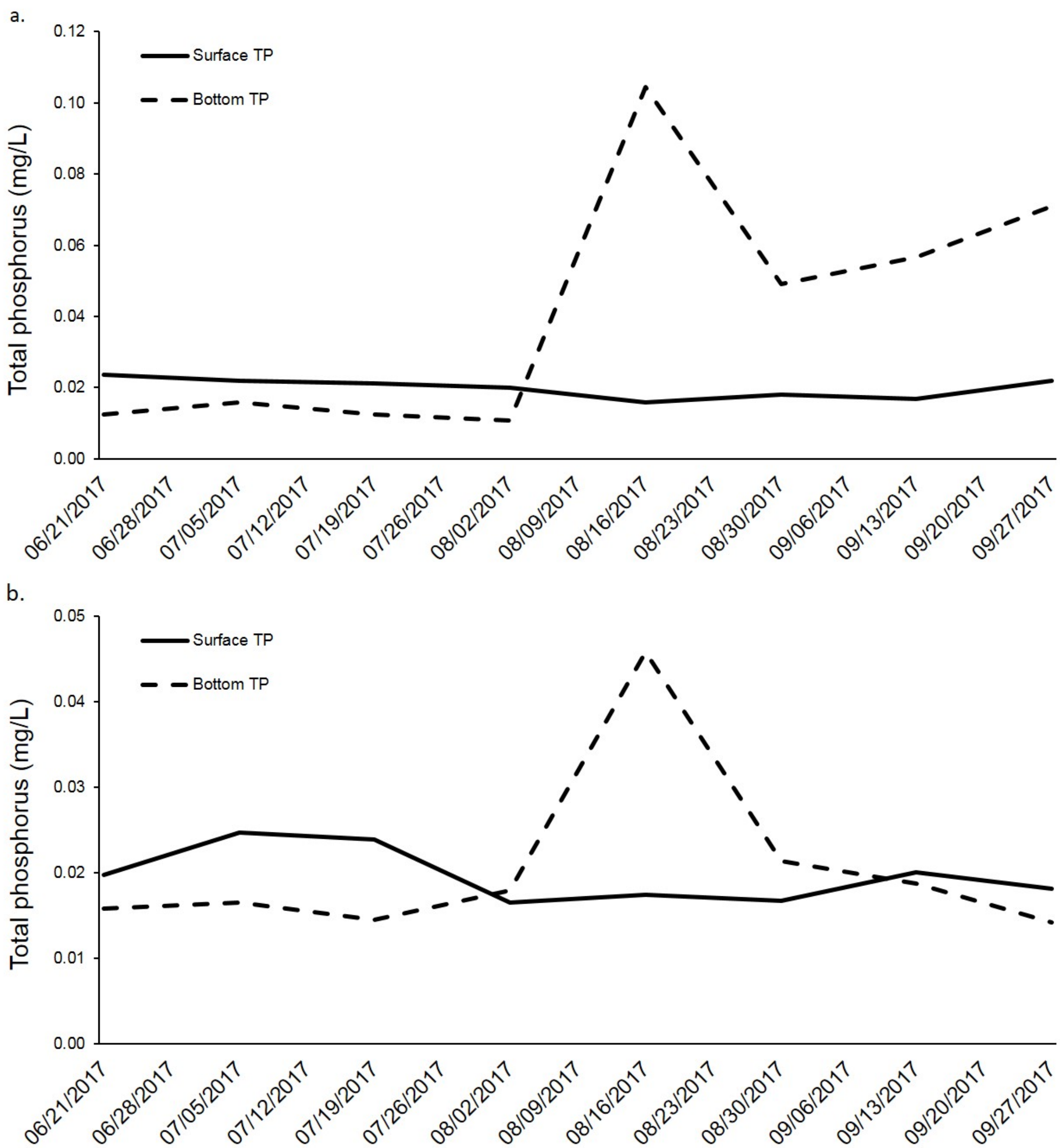


Figure 8. Surface and bottom total phosphorus (mg/L) concentration from the (a) South and (b) North sampling locations in 2017 (CSLAP).

In 2017, TN concentrations were higher from late-June to early-August and then dropped to a season low in mid-August (**Figure 9**). Concentrations from the North basin were higher than the South basin in June and early-July. However, concentrations in the South basin were generally higher than the North basin throughout the remainder of the growing season.

The relative concentrations of nitrogen and phosphorus can influence algal community composition and the abundance of cyanobacteria. Ratios of TN to TP in lakes can be used as a suitable index to determine if algal growth is limited by the availability of nitrogen or phosphorus (Lv et al. 2011). The ratio of TN:TP may determine whether HABs occur, with cyanobacteria blooms rare in lakes where mass based TN:TP ratios are greater than 29:1 (Smith 1983, Filstrup et al. 2016). Certain cyanobacteria taxa are capable of utilizing atmospheric dinitrogen (N_2), which is unavailable to other phytoplankton, providing a competitive advantage to N-fixing cyanobacteria when nitrogen becomes limiting. Ratios of TN:TP, by mass were typically between 10 and 25 in 2017 (**Figure 10**).

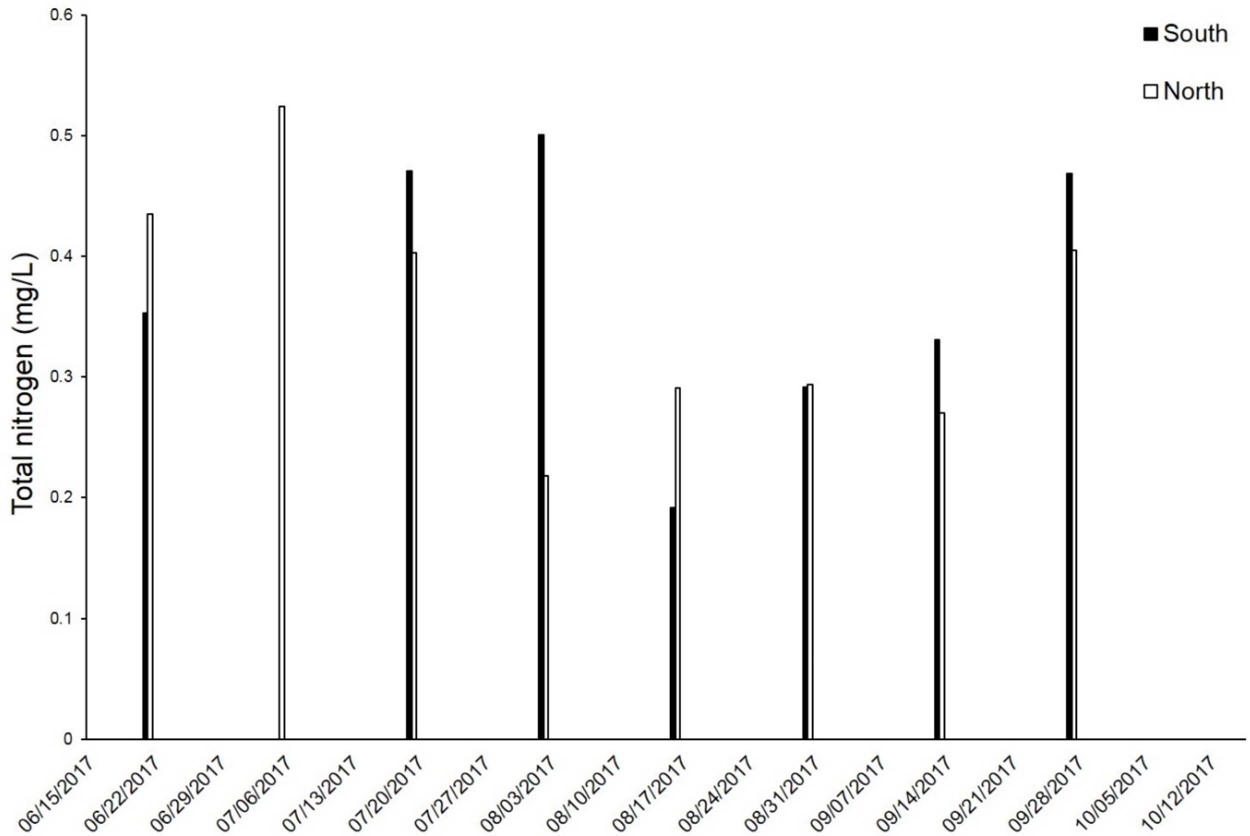


Figure 9. Total nitrogen concentrations (mg/L) from the South (black bars) and North (white bars) in 2017 (CSLAP).

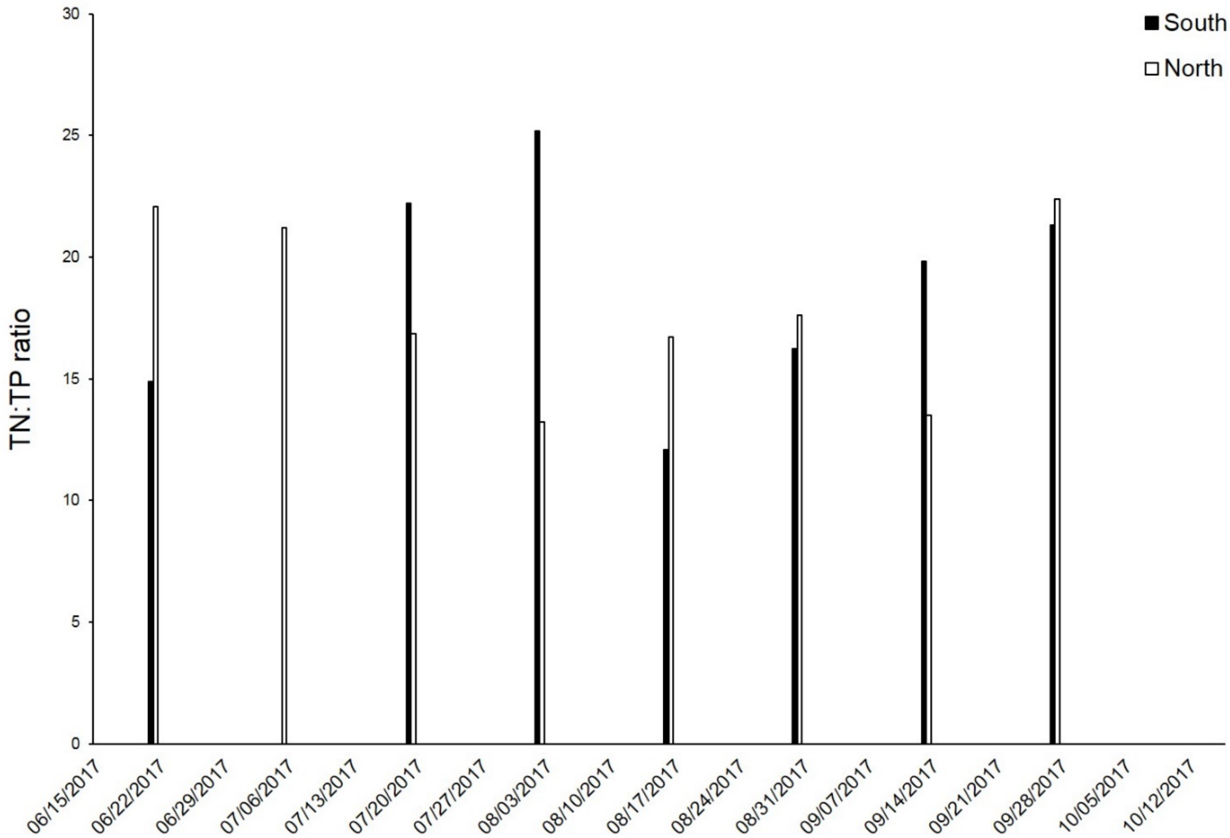


Figure 10. Total nitrogen (TN) to total phosphorus (TP) ratios (by mass) from the Southern (black bars) and Northern (white bars) in 2017 (CSLAP).

6.3 Biological Conditions

Currently, Conesus Lake has fewer aquatic invasive species compared to other lakes in the area. Conesus Lake has six known aquatic invasive species (CLWC 2013):

- Eurasian watermilfoil, *Myriophyllum spicatum*
- Curly-leaf pondweed, *Potamogeton crispus*
- Zebra mussel, *Dreissena polymorpha*
- Alewife, *Alosa pseudoharengus*
- Common carp, *Cyprinus carpio*
- European rudd, *Scardinius erythrophthalmus*

Certain invasive species may influence the frequency and duration of HABs. For instance, cyprinid fish species – common carp and European rudd – can increase sediment suspension and associated nutrients in the water column based on their feeding behavior. These species feed on benthic macroinvertebrates found within the sediment and increase suspended sediment and nutrients during active feeding that may be utilized by cyanobacteria.

Alewife may also contribute to increased prevalence of HABs. Specifically, alewife consumption of large zooplankton may increase abundance of phytoplankton and cyanobacteria because fewer zooplankton are present to control algae abundance. In addition to a general decrease in zooplankton abundance, the smaller zooplankton, which are less likely to be consumed by alewife, are less efficient at grazing on phytoplankton (Brooks and Dodson 1965). The decline in large zooplankton, such as *Daphnia,* in lakes through predation has been speculated to increase cyanobacteria dominance in summer months (Couture and Watzin 2008). As noted earlier, the introduction of alewives to Conesus Lake in the 1970s probably contributed to significant water quality degradation for many years.

Eurasian watermilfoil and curly-leaf pondweed are of major concern in Conesus Lake because these species often grow in large dense beds, outcompeting and crowding out native aquatic vegetation. The dense beds of these aquatic invasive species provide less suitable habitat for fish and other aquatic life and can 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 Conesus Lake.

Dreissenid mussels (e.g., zebra mussels) can influence phytoplankton composition by selectively filter feeding algae, preferentially selecting phytoplankton which can result in increased prevalence of cyanobacteria (Vanderploeg et al. 2001). Additionally, dreissenid mussels are often found in nearshore zones, and coupled with their high filtration rates of algae and subsequent elimination of wastes, can concentrate nutrients in nearshore zones (Hecky et al. 2004). Shifting nutrient concentrations to nearshore areas may result in greater incidence of shoreline HABs.

Chlorophyll-a is a main photosynthetic pigment of all algae, including cyanobacteria, and is often used as a proxy variable to estimate the amount of algae present. Chlorophyll-a concentrations in Conesus Lake were typically greater on average than 2 µg/L, but below 8 µg/L (**Figure 11**), again indicating mesotrophic conditions. Trend analyses indicated that annual average chlorophyll-a concentrations increased significantly at the South location ($p = 0.048$, $\tau = 0.212$) from 1986 to 2017 (**Figure 11a**). Seasonal trends in chlorophyll-a mirrored water clarity trends, with higher concentrations from June to early August, lower concentrations through mid-September, and higher concentrations in late September. In 2017 (**Figure 11b**), seasonal trends were typical for Conesus Lake in both the Southern and Northern basins, with increasing chlorophyll-a concentrations occurring in the Southern basin in late August and the Northern basin in late September.

Summer average chlorophyll-a concentrations in Conesus Lake are typically above the 4.0 μg/L threshold for Class AA lakes and the 6.0 μg/L threshold for Class A lakes proposed by Callinan et al. (2013). Both thresholds were also exceeded historically in Conesus Lake with a summer average chlorophyll-a concentration of 7.9 reported in the 1990s (Callinan et al. 2013). Callinan et al. (2013) indicated that average summer chlorophyll-a concentrations between 4-6 μg/L would be sufficient to reach or exceed the existing USEPA maximum contamination level of 80 μg/L total trihalomethanes concentration for drinking water (USEPA 2006). Total trihalomethanes concentrations are used as a measure of DBPs in drinking water systems. During water treatment, DBPs form when an oxidizing agent (e.g. chlorine) reacts with natural organic matter (NOM). Sources of NOM in lakes include external (e.g. leaves) and internal sources (e.g. algae). Although measured chlorophyll-a concentrations are above the proposed threshold, the concentrations near the location and depth of water supply intake pipes are likely to be reduced compared to the surface measurements.

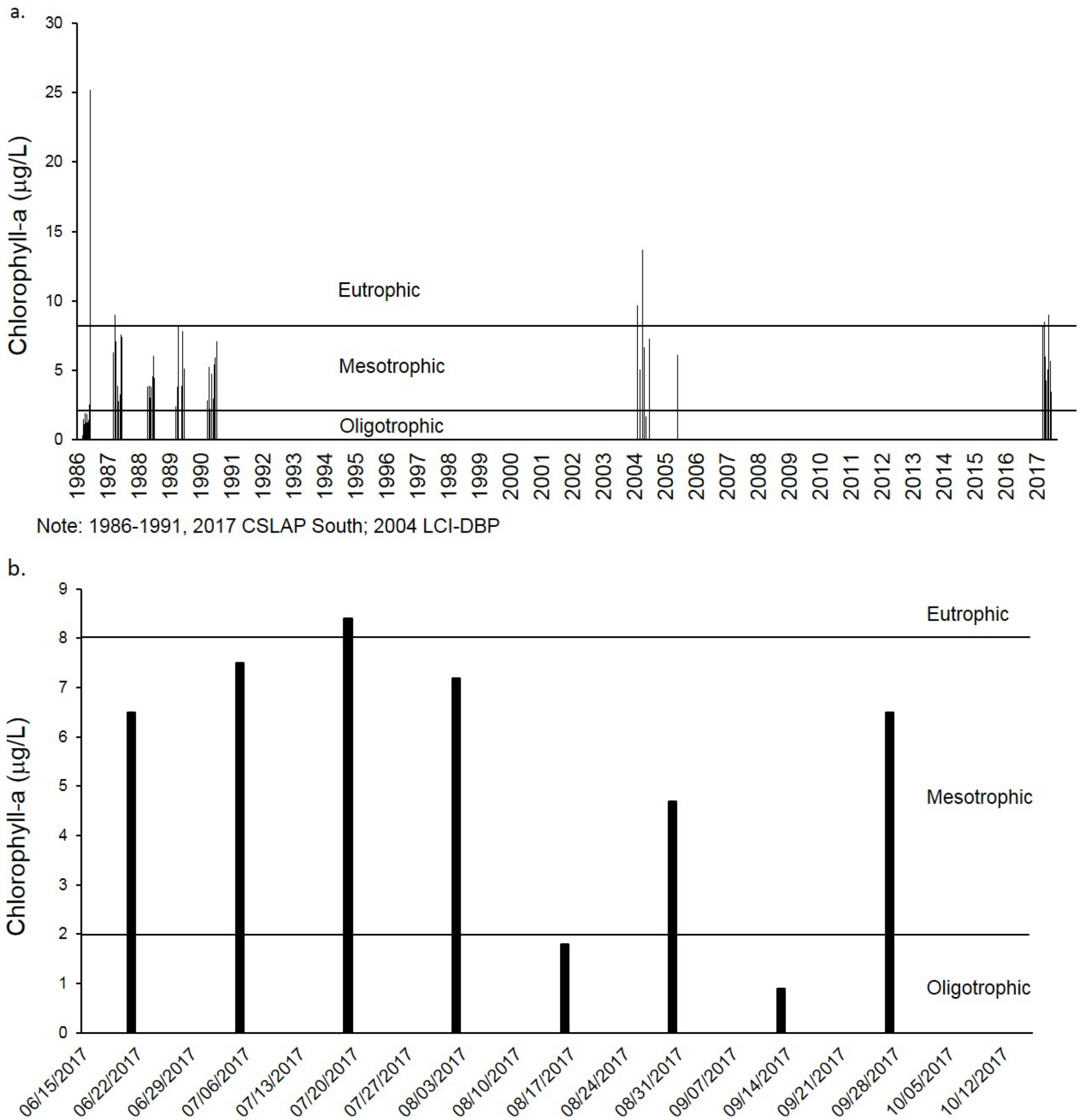


Figure 11. (a) Long-term (1986-2017) chlorophyll-a (µg/L) data from the South sampling location. (b) Chlorophyll-a concentrations from the North station in 2017 (CSLAP).

6.4 Other Conditions

Results from the macroinvertebrate assessments of four Conesus Lake tributaries from the RIBS program include (DEC/DOW, BWAM/SBU):

- Conesus Inlet in Scottsburg in 1999 reflected the following:
    - Water quality was considered non-impacted with very good water quality.
    - Aquatic life is considered to be fully supported.

- South Branch of McMillan Creek in Conesus (at East Lake Road) in 2009 reflected the following:
    - Water quality is slightly impacted.
    - Despite minor impacts, aquatic life is considered to be fully supported.
- North Branch of McMillan Creek in Conesus (at Federal Road) in 2014 reflected the following:
    - Water quality was considered non-impacted with very good water quality.
    - Aquatic life is considered to be fully supported.
- Wilkins Creek in Lakeville (at East Lake Road) in 2009 reflected the following:
    - Moderately impacted (poor) water quality.
    - Sensitive taxa were reduced, and the distribution of major taxonomic groups was significantly different from what is naturally expected.
    - Aquatic life was considered to be impaired.

Monitoring efforts to assess the impacts of BMPs on nutrients, sediment, and other materials to Conesus Lake are summarized below. See **Section 5.2** for additional details on the USDA program and monitoring efforts.

North McMillan Creek (control watershed)

Water quality data from 2011 indicated that water quality leaving this watershed is not degraded and that all water quality indicators, except sodium, have not changed from the 2003 to 2007 period. Increased sodium concentrations are likely associated with the application of deicing salt to roads.

Cottonwood Gully

Assessment of the 2011 sampling data using the developed Stream Water Quality Indices indicated that improvements to water quality from BMPs implemented within the watershed have persisted. The only exception to this trend is the increased concentration of suspended reactive phosphorus in 2011 compared to the 2003 to 2007 period. Elevated suspended reactive phosphorus in 2011 is likely a result of fertilization practices.

Graywood Gully

Major decreases in the export of nutrients and sediment in this watershed were observed after extensive implementation of BMPs in 2002 and 2003. Spring sampling in 2012 indicated that water quality indices had improved or remained stable since the 2003 to 2007 period. Elevated total reactive phosphorus and total Kjeldahl nitrogen were present in samples collected during rain events in 2012, suggesting that during rain events sediment and nutrient loads are similar to measurements prior to BMP implementation.

Sand Point Gully

Agricultural BMPs implemented in this watershed include rotational grazing plans, infrastructure to prevent animal access to streams, and two gully plugs and drainage tiles installed in 2002. Initial monitoring (2003-2007) of water quality indicated that mean concentrations of sediments and nutrients, except for nitrate, did not change. Nitrate concentrations significantly decreased after the implementation of BMPs. Water quality conditions in 2012 were as good or better than the 2003 to 2007 period. Increases in sediment and nutrient loads were observed during storm events in 2012.

Long Point Gully

In response to removing dairy cattle in 2002 and reducing crop acreage in 2003 in this watershed, major reductions in nitrate, TP, and soluble reactive phosphorus were observed during the 2003 to 2007 period. In 2012, nutrient concentrations were elevated during runoff events when compared to the 2003 to 2007 period. Nitrate concentrations were elevated in samples collected during events and non-events.

Sutton Point Gully

Approximately 60% of the farm fields within this watershed were converted from cultivated field crops to alfalfa during the 2003 to 2007 USDA project. In response, major reductions in sediment loading were achieved during the 2003 to 2007 period. This watershed was not included in the 2011 and 2012 monitoring efforts.

Overall, the implementation of BMPs within the experimental sub-watersheds improved water quality conditions and these improvements either continued or remained stable. Soluble reactive phosphorus was the least likely water quality index to have long lasting improvements, likely a result of fertilization practices within the watershed. Long Point Gully watershed was the only system to not improve in any water quality index between the 2003-2007 period and the 2011-2012 sampling efforts. Again, this is attributed to fertilization practices in the watershed.

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. At this time, the estimated chlorophyll-a concentrations are reported as a concentration index due to the limited number of field measurements to calibrate the model to the other NYS lakes; 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 (**Figure 12**), estimated chlorophyll-a concentrations are generally less than 10 µg/L. Higher estimated chlorophyll-a concentrations (approximately 20 µg/L) are often observed at the north end of the lake where depths are shallow (less than 20 feet). The remote sensing estimates may be interpreting other features such as algal mats, submerged aquatic vegetation, and the lake bed as chlorophyll-a in this shallow area. The shallow area at the south end of the lake tends to have lower chlorophyll-a concentration estimates than the north. Abnormally high chlorophyll-a concentrations were estimated from the July 23, 2015 satellite imagery. The potential triggers for this event are discussed in the following section.

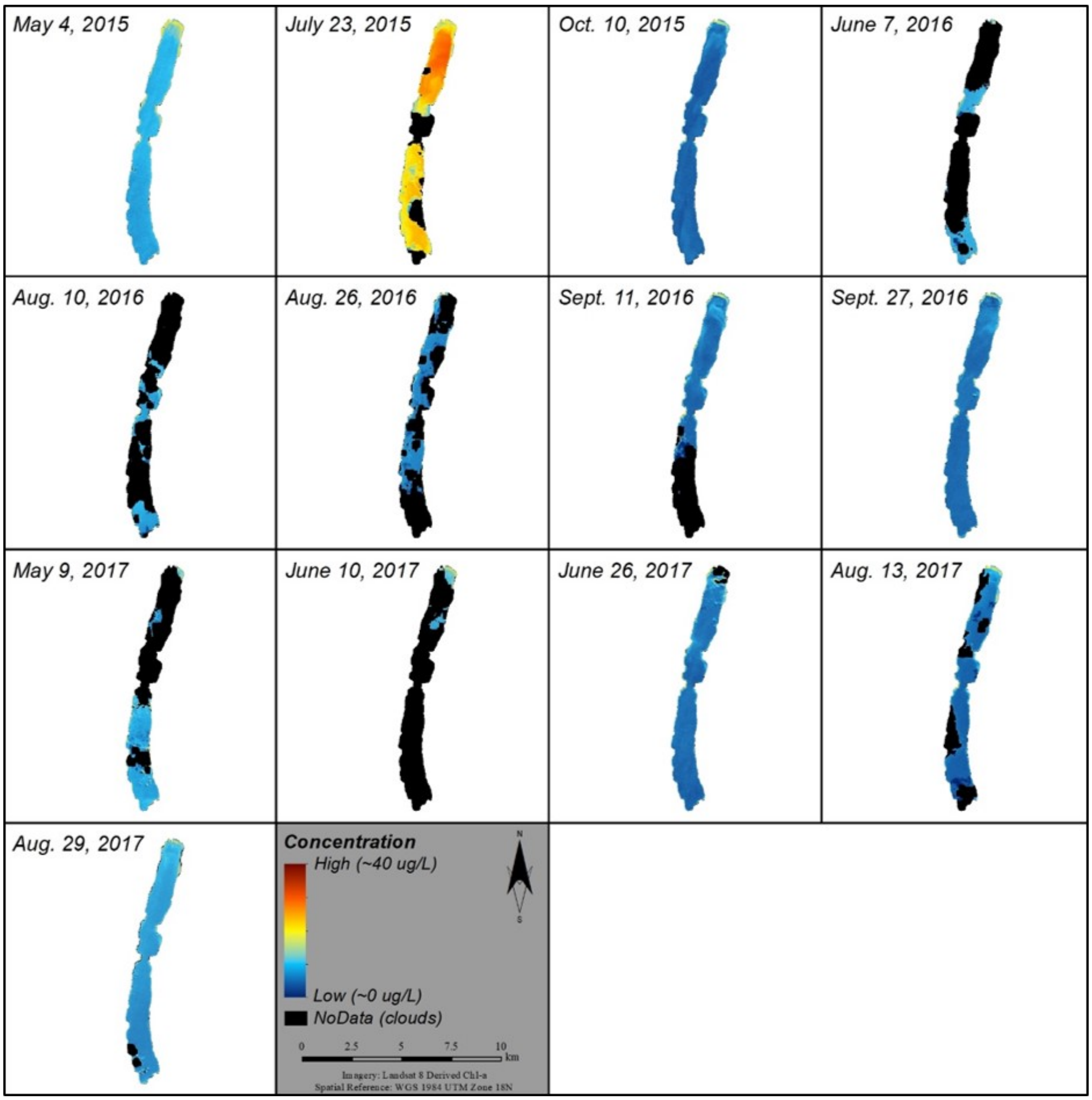


Figure 12. Estimated chlorophyll-a concentrations in Conesus Lake, 2015 to 2017.

The estimated chlorophyll-a concentrations from the remote sensing analysis were extracted at the CSLAP monitoring stations to compare the estimates with the measured chlorophyll-a concentrations (**Figure 13**). The figures indicate there was relative agreement between the measured and estimated concentrations when there is coincident data. Chlorophyll-a concentrations were not measured in 2015 and 2016 through CSLAP; however, the remote sensing results provide some insight into these time periods with missing in-lake water quality monitoring data.

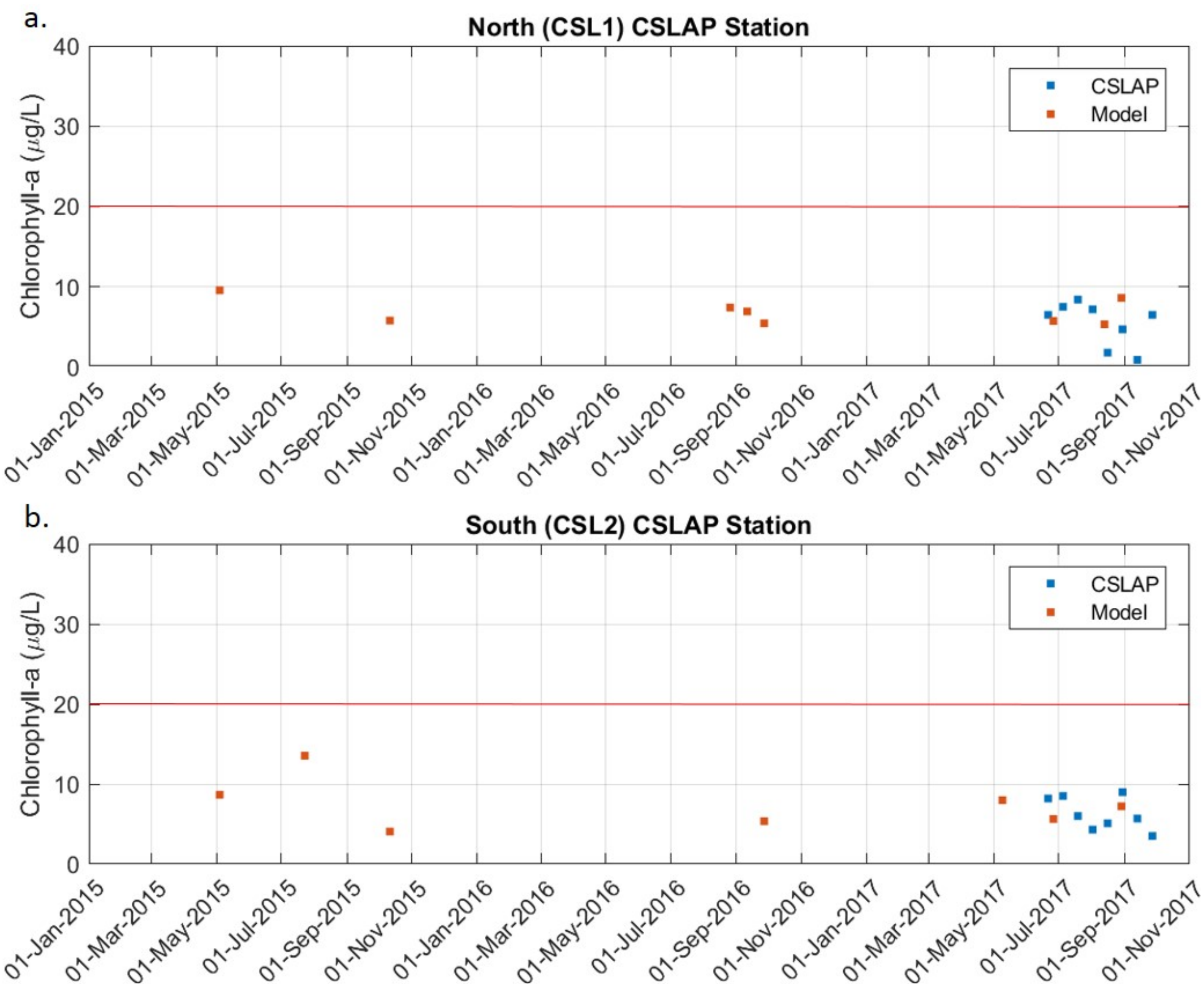


Figure 13. Estimated (CSLAP, blue squares) and estimated (Landsat 8, orange squares) chlorophyll-a concentrations from Conesus Lake, 2015 to 2017. The red lines represent the upper threshold of chlorophyll-a concentrations (20 µg/L) for which the remote sensing algorithm was tested in Lake Champlain (Trescott 2012).

7. Summary of HABs

New York State possesses one of, if not the most comprehensive HABs monitoring and notification programs in the country. The NYSDEC and NYSDOH collaborate to document and communicate with New Yorkers regarding HABs. Within NYSDEC, staff in the Division of Water, Lake Monitoring and Assessment Section oversee HAB monitoring and surveillance activities; identify bloom status; communicate public health risks; and conduct outreach, education, and research regarding HABs. The NYSDEC HABs Program has adopted a combination of visual surveillance, algal concentration measurements, and toxin concentration to determine bloom status. This process is unique to New York State and has been used consistently since 2012.

The NYSDEC HABs Program has established four levels of bloom status:

- **No Bloom**: evaluation of a cyanobacteria bloom (HAB) report indicates low likelihood that a cyanobacteria bloom is present
- **Suspicious Bloom**: NYSDEC staff determined that conditions fit the description of a HAB, based on visual observations and/or digital photographs. Laboratory analysis has not been done to confirm if this is a HAB. It is not known if there are toxins in the water.
- **Confirmed Bloom**: Water sampling results have confirmed the presence of a HAB which may produce toxins or other harmful compounds (BGA chlorophyll concentrations ≥ 25 µg/L and/or microscopic confirmation that majority of sample is cyanobacteria and present in bloom-like densities). For the purposes of evaluating HABs sample, chlorophyll-a is quantified with a Fluoroprobe (bbe Moldaenke) which can effectively differentiate relative contributions to total chlorophyll-a by phytoplankton taxonomic group (Kring et al. 2014). BGA chlorophyll-a concentrations (attributed to most types of cyanobacteria) are utilized by the NYSDEC HABs Program for determining bloom status. This method provides an accurate assessment of cyanobacteria density and can be accomplished more quickly and cost effectively than traditional cell counts.
- **Confirmed with High Toxins Bloom**: Water sampling results have confirmed that there are toxins present in sufficient quantities to potentially cause health effects if people and animals come in contact with the water through swimming or drinking (microcystin ≥ 20 µg/L (shoreline samples) or microcystin ≥ 10 µg/L (open water samples).

The spatial extent of HABs are categorized as follows:

- **Small Localized**: Bloom affects a small area of the waterbody, limited from one to several neighboring properties.
- **Large Localized**: Bloom affects many properties within an entire cove, along a large segment of the shoreline, or in a specific region of the waterbody.
- **Widespread/Lakewide**: Bloom affects the entire waterbody, a large portion of the lake, or most to all of the shoreline.

- **Open Water**: Sample was collected near the center of the lake and may indicate that the bloom is widespread and conditions may be worse along shorelines or within recreational areas.

7.1 Ambient Lake HABs History

Conesus Lake, along with some of the other Finger Lakes, has received considerable attention by state agencies, non-governmental organizations, community interest groups, lake users, water suppliers, and other stakeholders because of the documented presence of HABs in the lake in recent years. HAB surveillance on Conesus Lake is overseen by Livingston County; bloom reports are evaluated through a Blue Green Algae Detection and Response Plan developed by the Conesus Lake Watershed Council and overseen by the Livingston County Department of Health (LCDOH), although some reports are provided directly to NYSDEC. When lake observations of potential HABs are collected, they are compiled and assigned a status, per NYSDEC's *Harmful Algal Blooms Program Guide* (NYSDEC 2017) and as described above.

According to anecdotal evidence, Conesus Lake has historically experienced small localized HABs along shorelines and in coves during the late summer months and into the fall, but there are limited sampling data to document these blooms. An offshore HAB consisting primarily of *Microcystis aeruginosa* occurred following a calm windless night in September 2004, with elevated levels of cyanotoxins reported (Makarewicz et al. 2009b). The surface scum associated with this bloom dissipated within one hour of the onset of increasing winds, and subsequent sampling indicated that the bloom was no longer detectable. According to NYSDOH-supplied water chemistry data and a few reported observations from NYSDEC (Region 8), the LCDOH, and the general public, HAB observations were more consistently reported in the lake since 2014, on multiple occasions in most years as follows:

- 2014 – 2 observations, one in August, one in September
- 2016 – 7 observations, two in June, four in October, one in November
- 2017 – four observations, one in July and three in September

Blooms may have occurred at other times, but were not reported to the NYSDEC. The spatial extents of all HABs during 2014, 2016, and 2017, when reported, were identified as small localized, and the status of 10 of the 11 reports were determined to be Suspicious Blooms, indicating the NYSDEC determined that conditions fit the description of a HAB based on visual observations and/or digital photographs, but a sample was not collected for laboratory analysis. On October 18, 2016 a sample was collected and laboratory analysis indicated BGA chlorophyll was above the NYSDEC threshold for a Confirmed Bloom. The Confirmed HAB was reported by the NYSDEC Region 8 off the shoreline of Vitale Park near the outlet to Conesus Creek. The LCDOH described three small localized areas of suspected cyanobacterial blooms in this area and sampled close to shore for BGA chlorophyll-a and cyanotoxins (i.e., toxins produced by BGA). A visual HAB scum persisted through November and into early December 2016 near Vitale Park at the lake's north end (CLWC 2016).

Suspected HABs have also been reported at various locations in the lake. In 2016, HABs were documented along the lake's eastern and southwestern shorelines in June. In September and October of that year, HABs occurred along the northeastern shoreline of the lake. HABs were also reported to have occurred in the lake in summer and early fall 2015 along Vitale Park and the lake's northeast shoreline, and along the west-central shoreline off Long Point Park (CLWC 2015).

7.2 Drinking Water and Bathing Beach HABs History

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 detects been found in finished water. To date, no samples of finished water have exceeded the 0.3 µg/L microcystin health advisory limit (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 USEPA 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 USEPA started monitoring for their Unregulated Contaminant Monitoring Rule 4 (UCMR 4) which includes several HAB toxins. In 2018, the USEPA 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 ELAP is offering certification for laboratories performing HAB toxin analysis, starting in spring 2018, 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 noted in **Section 3.2** it is never advisable to draw drinking water from a surface source unless it has been treated by a public drinking water system regardless of the presence of HABs (NSF P477; NYSDOH 2017).

Because Conesus Lake is a source of drinking water for several lakeside communities, there is a concern that cyanotoxins could be withdrawn through the lake's intakes and incorporated into the Geneseo and Avon water supply systems. As discussed in **Section 3.2**, the public water supply use of Conesus Lake is currently fully supported despite: 1) the lake's susceptibility to contamination from high nutrient inputs from agricultural use of much of the surrounding area and other nutrient sources, including internal nutrient loading, and 2) the potential for increased occurrence of disinfection by-products as a result of water treatment measures to combat elevated phytoplankton (including cyanobacteria) concentrations and corresponding increases in organic matter (NYSDEC 2015c). The NYSDOH sampled both PWSs on August 27, 2014 due to concern over a bloom; all finished water indicated non-detectable levels of cyanotoxins, and Avon's raw water indicated 0.008 μg/L of microcystin. This concentration is well below the USEPA's Health advisories for microcystin in finished drinking water of 0.3 µg/L for pre-school (< 6 years) children and 1.6 µg/L for school-age children and adults (USEPA 2015). No interruption of water supply from Conesus Lake attributable to HABs has been reported.

Beach closures (**Figure 14**) in Conesus Lake have historically been attributable to elevated coliform concentrations. However, beach closures more recently have been frequently associated with cyanobacteria blooms. As discussed in **Section 3.3**, public bathing and recreational use of the lake are impaired based on several indicators of eutrophication in the lake, including excess algae and HABs (NYSDEC 2015c). A summary of the observations and impacts of HABs on bathing beach recreational use at Conesus Lake from 2013 to 2016 is presented below based on beach closure data provided by NYSDOH (**Figure 14**)

- 2013: 1 lost beach day (Camp Stella Maris beach)
- 2014: 40 lost beach days (9 at Long Point Park public beach; 8 at Camp Stella Maris beach; 23 at Southern Shores Campground)
- 2015: 0 lost beach days
- 2016: 5 lost beach days (3 at Camp Stella Maris beach; 2 at Southern Shores Campground).

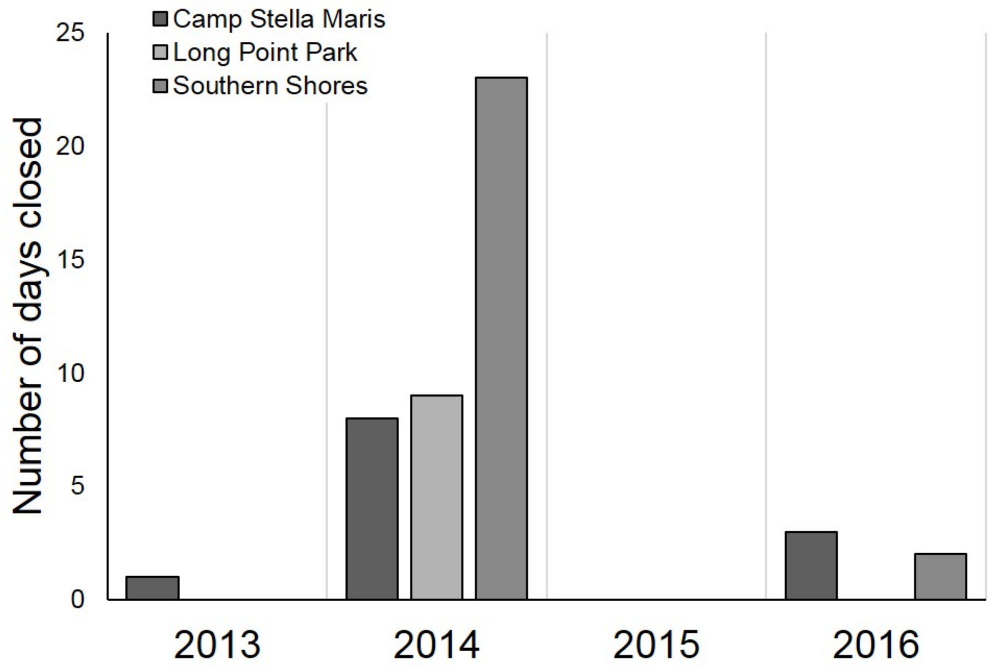


Figure 14. Documented beach closures in Conesus Lake (2013-2016) (Source: NYSDOH).

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

Table 3. HABs guidance criteria.			
NYSDEC Bloom Categories			
Confirmed	**Confirmed w/ high toxins**		**Suspicious**
	Open water	**Shoreline**	
[BGA Chl-a] >25 µg/L	[Microcystin] > 10 µg/L	[Microcystin] > 20 µg/L	Visual evidence w/out sampling results
NYSDOH Guidelines			
Closure		**Re-open**	
Visual evidence (sampling results not needed).		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	

7.3 Other Bloom Documentation

Cyanobacteria Chlorophyll-a

Cyanobacteria cell counts and/or chlorophyll-a (BGA) concentrations can be used to trigger HABs alert and advisory systems. BGA chlorophyll-a concentrations were quantified with a FluoroProbe (bbe Moldaenke) for the sample collected in October 2016 from the confirmed shoreline HAB. The skim sampling strategy used for this work likely documents the worst-case conditions of shoreline blooms. The BGA chlorophyll-a concentration reported from the October 2016 confirmed HAB was 24,825 µg/L, considerably higher than the 25 µg/L NYSDEC Confirmed Bloom threshold.

Cyanotoxins

Some cyanobacteria taxa also produce toxins (cyanotoxins) that are harmful to people and pets. As a result, several different toxins are monitored during blooms. Microcystin is the most commonly detected cyanotoxin in New York State (NYSDEC 2017). The 20 µg/L microcystin "high toxin" threshold for shoreline blooms was, like the BGA chlorophyll-a criterion, established based on WHO criteria. A water quality sample collected during the October 2016 HAB and tested for cyanotoxins revealed non-detectable concentrations of microcystin; thus, concentrations were below both the NYSDEC 20 µg/L "high toxin" threshold and the 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. 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.

The absence of detectable concentrations of cyanotoxins during cyanobacteria accumulations in Conesus Lake is consistent with the findings of Bosch et al. (2015). Water quality samples collected at five locations in Conesus Lake's northern basin were analyzed via bioassays and determined to not contain detectable concentrations of microcystin, even in samples collected during large blooms containing both colonial and single-celled cyanobacteria taxa (Bosch et al. 2015).

Cyanobacteria Taxa

*Dolichospermum (*formerly *Anabaena)*, a filamentous, nitrogen-fixing genus of cyanobacteria, and *Woronichinia*, a genus characterized by spherical or ovate cells that form colonies and sub-colonies, were identified as densely populating the water sample collected during the October 2016 Confirmed HAB. Both *Dolichospermum* and *Woronichinia* are known to produce cyanotoxins.

Dolichospermum may have a competitive advantage in nitrogen-limited lakes given its ability to fix nitrogen; however, its presence at high densities in Conesus Lake during blooms is likely not attributable to its nitrogen-fixing ability given that Conesus Lake is phosphorus-limited. *Microcystis* may have the capacity to selectively outcompete other algae in lakes such as Conesus Lake, as its ability to regulate its buoyancy provides an edge in relatively warm, stratified systems that experience infrequent wind-driven mixing during the growing season. However, Bosch et al. (2015) reported that *Microcystis* blooms are more likely to occur during the fall and are less frequent than blooms of other taxa.

7.4 Use Impacts

Swimming in Conesus Lake has been adversely impacted due to temporary beach closures attributable to HABs in recent years. Public bathing and other recreational uses of the lake in the northern Main Lake segment were assessed as “impaired” by elevated nutrients, uncontrolled rooted aquatic vegetation (including the invasive Eurasian watermilfoil), excessive algae (including cyanobacteria), and low water transparency, as described in the WI/PWL fact sheet for Conesus Lake (NYSDEC 2015b). Accordingly, other related lake conditions such as aesthetics can be considered similarly impacted by excessive algae and rooted plants. The lake’s aesthetic conditions are described as “poor” due to nuisance aquatic vegetation and HABs. Drinking water impacts from HABs are relevant for Conesus Lake given that the Geneseo and Avon water supply systems draw water directly from the lake.

7.5 HABs and Remote Sensing

Remote sensing images 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 Dansville is plotted with hourly air temperature. The weekly average and long-term average (14 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.

Suspicious or confirmed HABs were not reported by NYSDEC in Conesus Lake in 2015. The Conesus Lake Watershed Council's 2015 Annual Report Card (CLWC 2015) describes a small localized HAB on July 22, 2015 at Vitale Park (at the north end of the lake), and other small localized HABs on October 8 at Long Point, Vitale Park, and along the northeast shoreline. The modeled chlorophyll-a concentrations on July 23, 2015 were elevated (**Figure 15**), supporting the field observation from July 22. In the two weeks leading up to the satellite image, below average air temperatures, 1.5 inches of rain, and periods of stronger winds aligned with the axis of the lake indicated a greater influence of fetch length and wind mixing. There were also three very warm days in the week before the image.

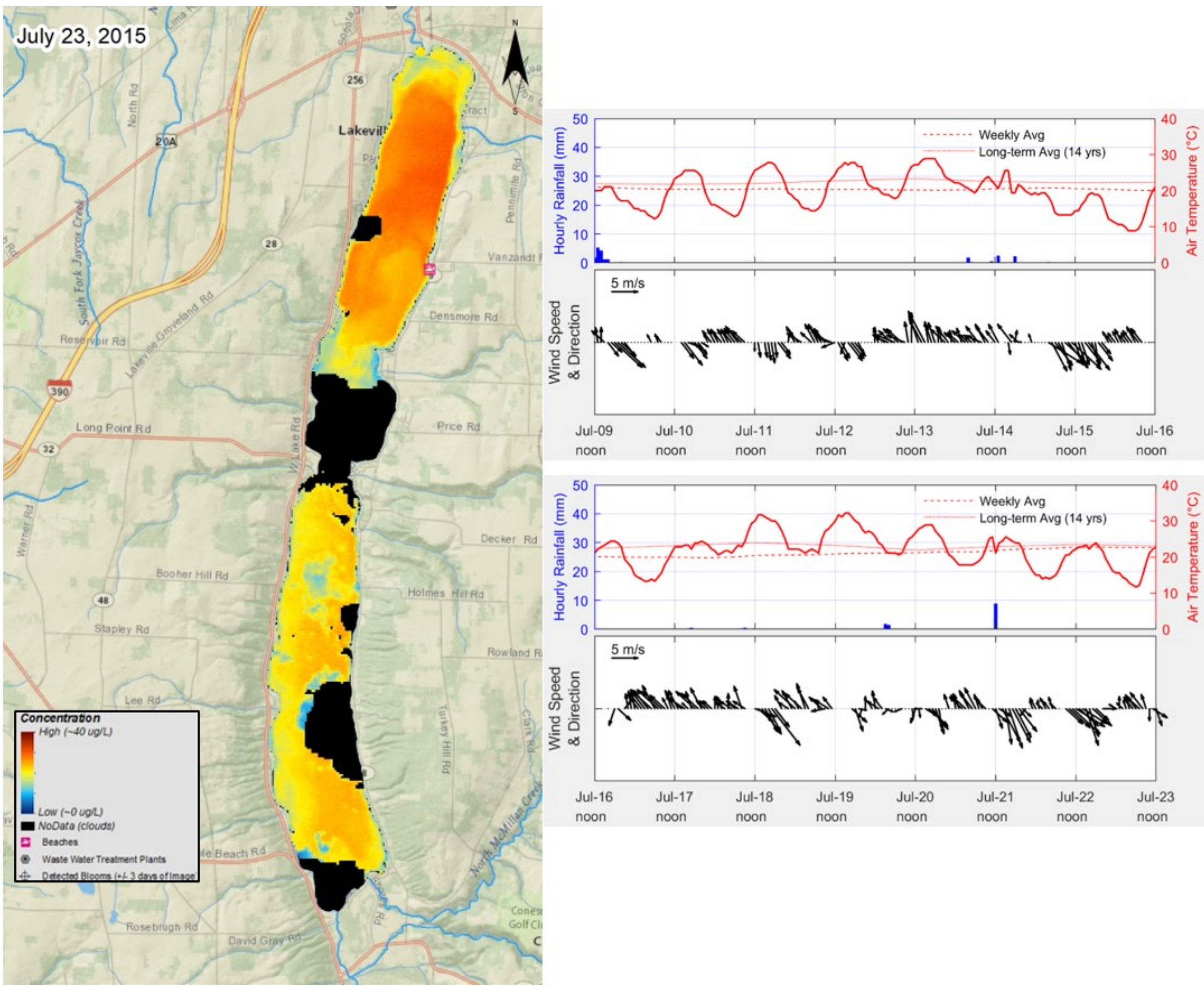


Figure 15. Estimated chlorophyll-a concentrations in Conesus Lake on July 23, 2015.

Suspicious or confirmed HABs were reported in Conesus Lake in late June and October 2016. The HABs extents were small localized, or extents were not reported. Only one remoting sensing image from June was useable, based on cloud cover, and no images from October were usable. The modelled chlorophyll-a concentrations on June 7, 2016 (see **Figure 12**) were low in the areas not affected by clouds. The modelled chlorophyll-a concentrations on September 27, 2016, two to three weeks prior to the reported HABs, are shown in **Figure 16**. The modelled chlorophyll-a concentrations were generally low (approximately 5 µg/L), except for the north shore where estimated concentrations were elevated. A period of relatively calm wind conditions and heavy rainfall (~ 3.5 inches) on October 20 and 21 preceded the HABs reported on October 21, 2016.

Suspicious or confirmed HABs were reported in Conesus Lake in July and September 2017. The HABs extents were small localized, or extents were not reported. Unfortunately, the July and September satellite imagery were not useable due to extensive cloud cover. Measured chlorophyll-a concentrations over this period were between 5 and 10 µg/L (CSLAP). The modelled chlorophyll-a concentrations on August 29, were approximately 10 µg/L, with concentrations up to 20 µg/L along the shore (particularly at the tributaries) (**Figure 17**). Approximately 0.8 inch of rain fell on August 22, which may explain the elevated concentrations at the mouths of the tributaries.

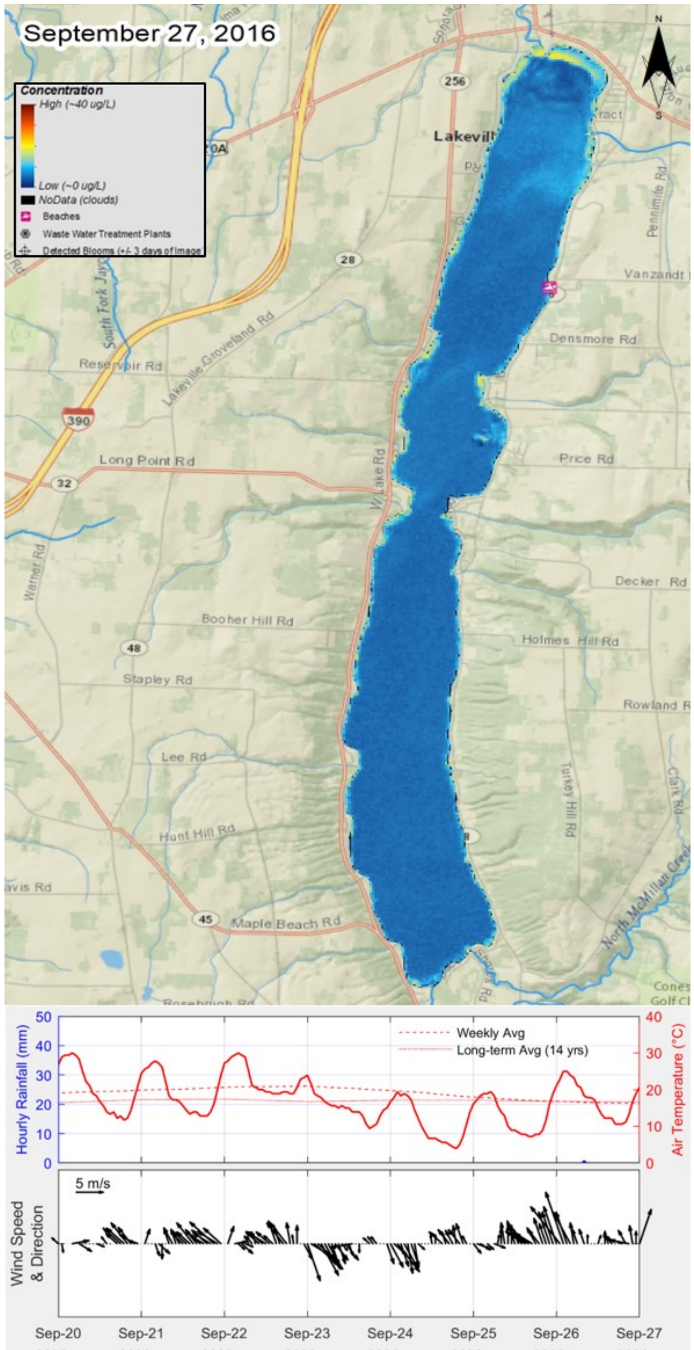


Figure 16. Estimated chlorophyll-a concentrations in Conesus Lake on September 27, 2016.

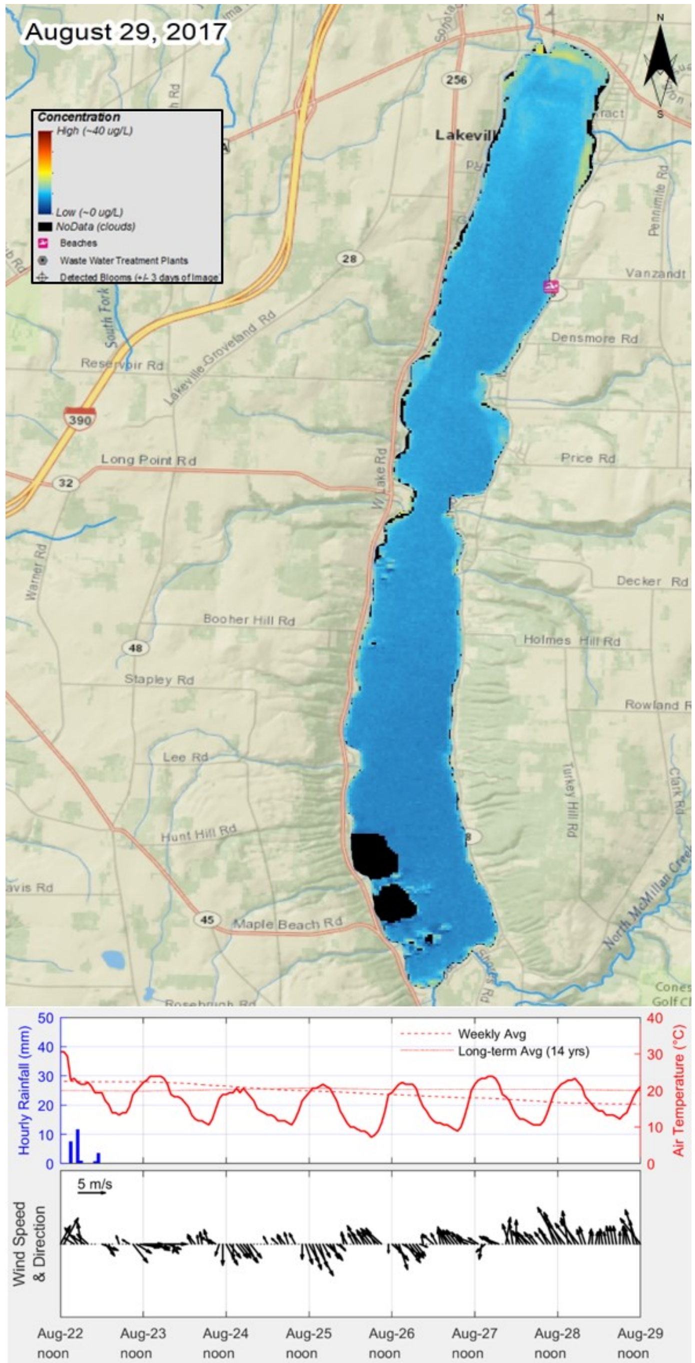


Figure 17. Estimated chlorophyll-a concentrations in Conesus Lake on August 29, 2017.

In summary, the remote sensing data indicate that chlorophyll-a concentrations tend to increase after rainfall events or during periods of calm wind conditions. Statistical analyses conducted with Conesus Lake-specific data are additionally suggestive of these meteorological drivers (see **Section 9**). Higher chlorophyll-a concentrations may develop near the mouths of the tributaries and along the north shore. In these shallow areas, however, the remote sensing might also be picking up algal mats, submerged aquatic vegetation, and the lake bed. Additional research is warranted to better understand the influence of these factors on the estimated chlorophyll-a concentrations for further application of the Landsat 8 remote sensing.

The percentage of the Conesus Lake surface area with an estimated chlorophyll-a concentration greater than 10 µg/L and 25 µg/L is summarized in **Table 4**. Cyanobacteria cell counts and/or BGA chlorophyll-a concentrations less than 25 µg/L is NYSDEC's criteria for "no-bloom" (refer to **Section 7.2** for more information). 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 4. Percent (%) of water surface area with an estimated chlorophyll-a concentration (µg/L) above and below 10 µg/L and 25 µg/L in Conesus Lake (2015 to 2017).

Date	% less than		% greater than or equal		% No data
	10 µg/L	25 µg/L	10 µg/L	25 µg/L	
2015-05-04	55	99	45	0	1
2015-06-05	0	0	0	0	100
2015-07-23	0	55	77	22	23
2015-09-09	2	3	0	0	97
2015-09-25	0	1	0	0	99
2015-10-11	95	99	4	0	1
2016-06-07	17	23	7	0	77
2016-06-23	0	0	0	0	100
2016-08-10	16	23	6	0	77
2016-08-26	36	40	3	0	60
2016-09-11	54	61	7	0	39
2016-09-27	93	99	6	0	1
2017-05-09	29	41	12	0	59
2017-06-10	2	6	4	0	94
2017-06-26	88	96	8	0	4
2017-08-13	67	73	6	0	27
2017-08-29	78	95	17	0	5

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 Total Maximum Daily Load (TMDL).

The WI/PWL assessments reflect data and information drawn from numerous NYSDEC 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 Conesus Lake (**Appendix E**) reflects monitoring data collected in 2017. Conesus Lake is required to support its best uses as a source of water supply for drinking, primary and secondary contact recreation uses, and fishing use.

Conesus Lake is assessed as an impaired waterbody due to primary and secondary contact recreation uses that are impaired due to beach closures related to harmful algal blooms and excessive nutrients (phosphorus). In addition, drinking water supply use is stressed due to elevated chlorophyll-a levels that create the potential for the formation of disinfection by-products in finished potable water. Internal recirculation of nutrient loads from lake sediment is the major source of nutrient load to the lake, contributing to roughly 80 percent of the phosphorus. Agricultural activities in the watershed have also been identified as a significant source of phosphorus loading to the lake.

Conesus Lake is included on the NYS Section 303(d) List of Impaired/TMDL Waters for phosphorus, resulting low dissolved oxygen.

Lake processes, such as water column mixing and lake circulation, can greatly influence the spatiotemporal availability of nutrients and resulting HABs. Mixing events, either wind driven or seasonal mixing, can result in large fluxes of nutrient concentrations by bringing nutrient rich water up from deeper parts of a lake to the surface layers. Mixing events and upwelling in Conesus Lake could potentially have a large influence on nutrient concentrations from late-July to early-September due to elevated concentrations of phosphorus present in the lake’s hypolimnion. Phosphorus is released from benthic sediment during the extended oxygen depletion of the hypolimnion, which results in redox related processes occurring at the sediment-water interface.

Table 5. WI/PWL severity of use impact categorization (*Source*: NYSDEC 2015b).	
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 *discourage* 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.

8.2 Source Water Protection Program (SWAP)

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, Concentrated Animal Feeding Operations (CAFOs), NYSDEC WI/PWL listings, local health department drinking water history and concerns, and existing lake/watershed reports. A SWAP for the Conesus Lake public drinking supply sources was completed. Although the information provides a historical perspective, the drinking water systems and/or land uses may have changed. Conesus Lake public drinking supply sources need updated assessments to understand the current impacts to best protect water quality. NYSDEC and NYSDOH are working with stakeholders to build a sustainable statewide program to assist and encourage municipalities to develop and implement Source Water Protection Programs (SWPP) in their communities.

Conesus Lake is used as a public water supply for the Villages of Avon and Geneseo and serves a total population of over 20,000 in Livingston County. The SWAP conducted by the NYSDOH in 2004 determined that the Conesus Lake water supply had an elevated susceptibility to contamination due to agricultural activities within the watershed. The most recent annual water quality assessment indicated no contaminants exceeded the regulatory threshold for finished (treated) water (CLWC 2018).

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.

8.3 Lake Scorecard

Results from CSLAP activities are forwarded to the New York State Federation of Lake Associations (NYSFOLA) and NYSDEC and are combined into a scorecard detailing potential lake use impact levels and stresses. The scorecards represent a preliminary assessment of one source of data, in this case CSLAP. The WI/PWL updates include the evaluation of multiple data sources, including the CSLAP scorecard preliminary evaluations. The 2017 scorecard for Conesus Lake suggests potable water source may be impaired due to elevated algae concentrations, and recreational activities and aesthetic conditions are threatened due to algae blooms. The swimming use was considered to be “supported/good” in 2017 (**Figure 18**).

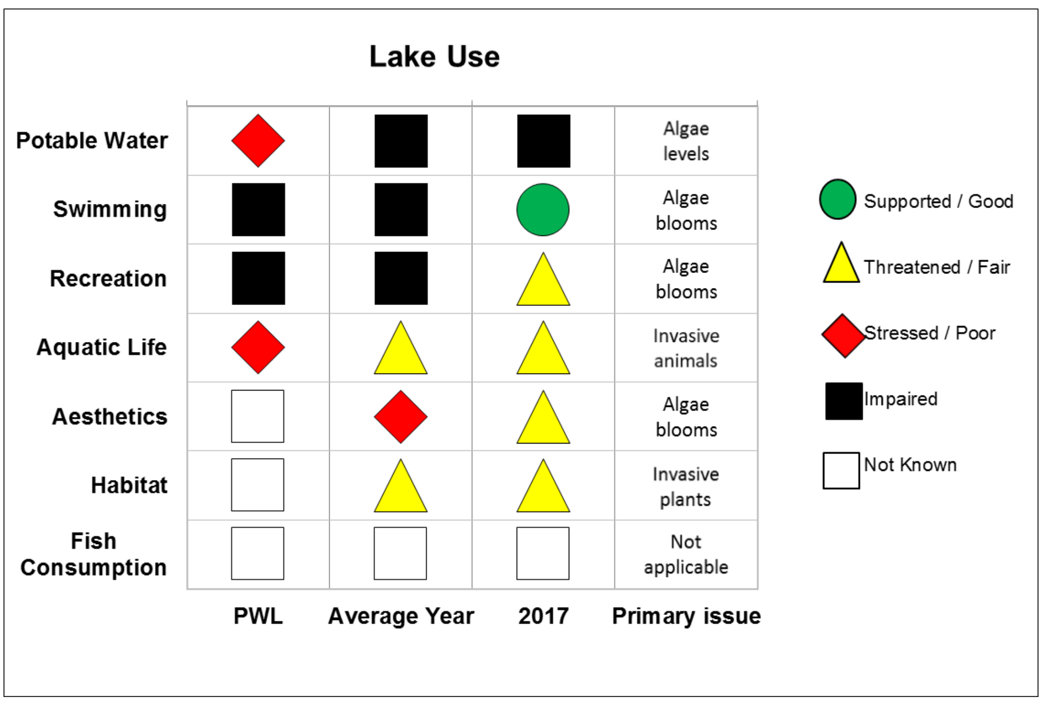


Figure 18. Conesus Lake 2017 CSLAP scorecard.

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 been 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. It should be noted that while this analysis may provide some preliminary insight into state-scale patterns, it is simplistic in that is does not account for important local, lake-specific drivers of HABs such as temperature, wind, light intensity, and runoff events.

Conesus Lake exhibits several factors- elevated phosphorus readings, presence of dreissenid mussels, relatively long fetch length- that render the lake susceptible to HABs. These conditions may be exacerbated by seasonal release of nutrients from bottom to surface waters under conditions of periodic anoxia.

To evaluate if lake-specific HAB triggers, in addition to those observed at the state scale, were important at Conesus Lake, additional statistical analyses were performed with data spanning from 2014 to 2017. All available HAB observations (bloom/no bloom) were aligned by date with meteorological information (e.g., temperature, precipitation, and wind speed) from the Dansville Municipal Airport station. Estimated maximum wave heights were calculated from wind speed and direction data, fetch distances across the lake, and water depths along the fetch length. The fetches were measured in 10 degree increments along the compass rose, taking the longest distance across the lake. Using these data, an hourly wave hindcast covering the duration of the wind field measurements was generated (Donelan 1980). Note that water quality variables were not assessed in this analysis because water quality measurements only aligned with HAB observations in 2017.

As with the statewide data analysis, logistic regression was used to test whether meteorological variables could explain the occurrences of HABs. Because weather variables hypothesized to influence HABs can be correlated (e.g., maximum wind speed and wave height), the logistic regression was performed in two ways: (1) using the original meteorological data as explanatory variables and (2) by first performing a Principal Components Analysis (PCA) on the explanatory variables and using the PCA axes as explanatory variables in the logistic regression. Principal components analysis is helpful when evaluating data sets with correlated variables because it can recast the original data as an uncorrelated set of “axes” (*i.e.*, linear equations) that are representative of the original input data.

Based on the logistic regressions, increased precipitation the day of an event was significantly correlated with recorded HABs in Conesus Lake ($p = 0.001$, **Figure 19**). Additionally, the data suggest calm water conditions (e.g., minimum wave activity) in the preceding 5 days leading up to an event may influence HABs in Conesus Lake, however, this correlation was not statistically significant ($p = 0.055$).

To fully understand the likely triggers of HABs in Conesus Lake, additional water quality monitoring and associated HABs observations should be collected. Nutrient and water chemistry information aligned with HAB observations (both presence and absence) in subsequent years will complement the meteorological analyses.

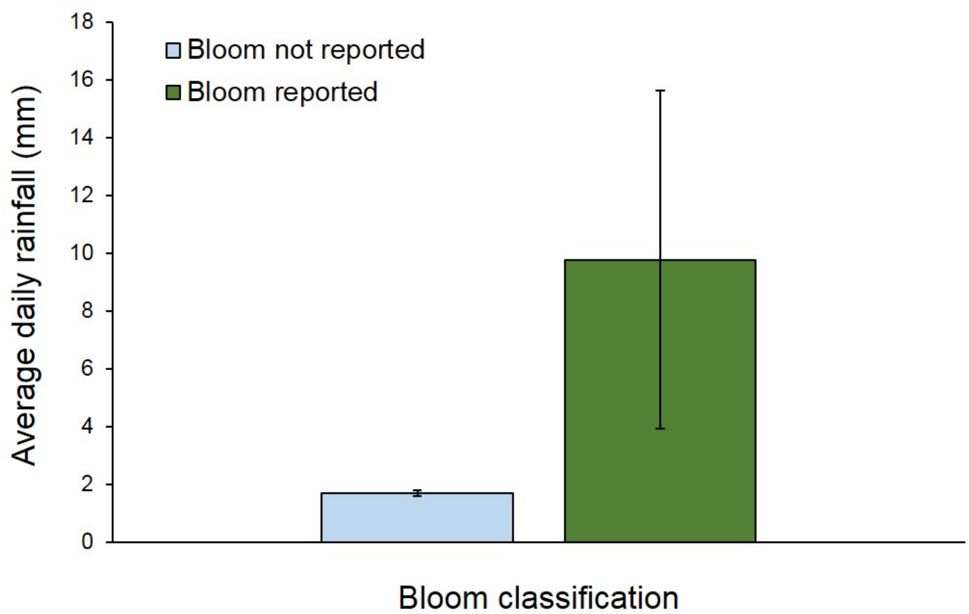


Figure 19. Average daily rainfall (mm, ± standard error) during reported HAB events (green bar) and when a bloom was not reported (blue bar).

10. Sources of Pollutants (triggering HABs)

NYSDEC's Loading Estimator of Nutrient Sources (LENS) screening tool was used to estimate land use proportions and identify potential nutrient pollutant sources in the Conesus Lake watershed. With a surface area of approximately 5.34 square miles (14 km^2), Conesus Lake is one of the smallest Finger Lakes, but has a relatively large drainage basin to surface ratio (12:1), which contributes to current external nutrient loading, and legacy nutrients that can impact water quality through current internal loading.

The greatest source of phosphorus loading to Conesus Lake is estimated to be from internal loading (**Section 10.3**, below). Nutrient inputs also include nonpoint sources from various land use types within the Conesus Lake watershed, particularly agriculture.

10.1 Land Uses

Based on NYSDEC's LENS model analysis, the watershed comprises the following land use types (**Figure 20**):

- Natural areas = 46%
- Developed land = 7%
- Agriculture = 40%
- Open water = 7%

If the open water is excluded from the Conesus Lake land use breakdown, approximately 50% of the watershed is natural areas, while approximately 43% of the watershed is agricultural. As depicted in **Figure 21a**, much of the forested land within the Conesus Lake watershed is found in the southeastern extent.

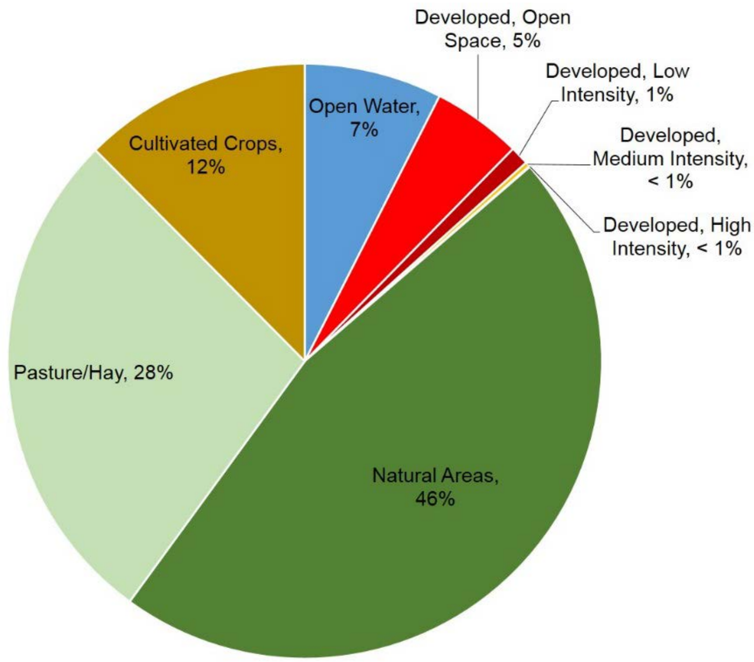


Figure 20. Land use categories and percentages for the Conesus Lake watershed. Natural areas include forests, shrublands, grasslands, and wetlands.

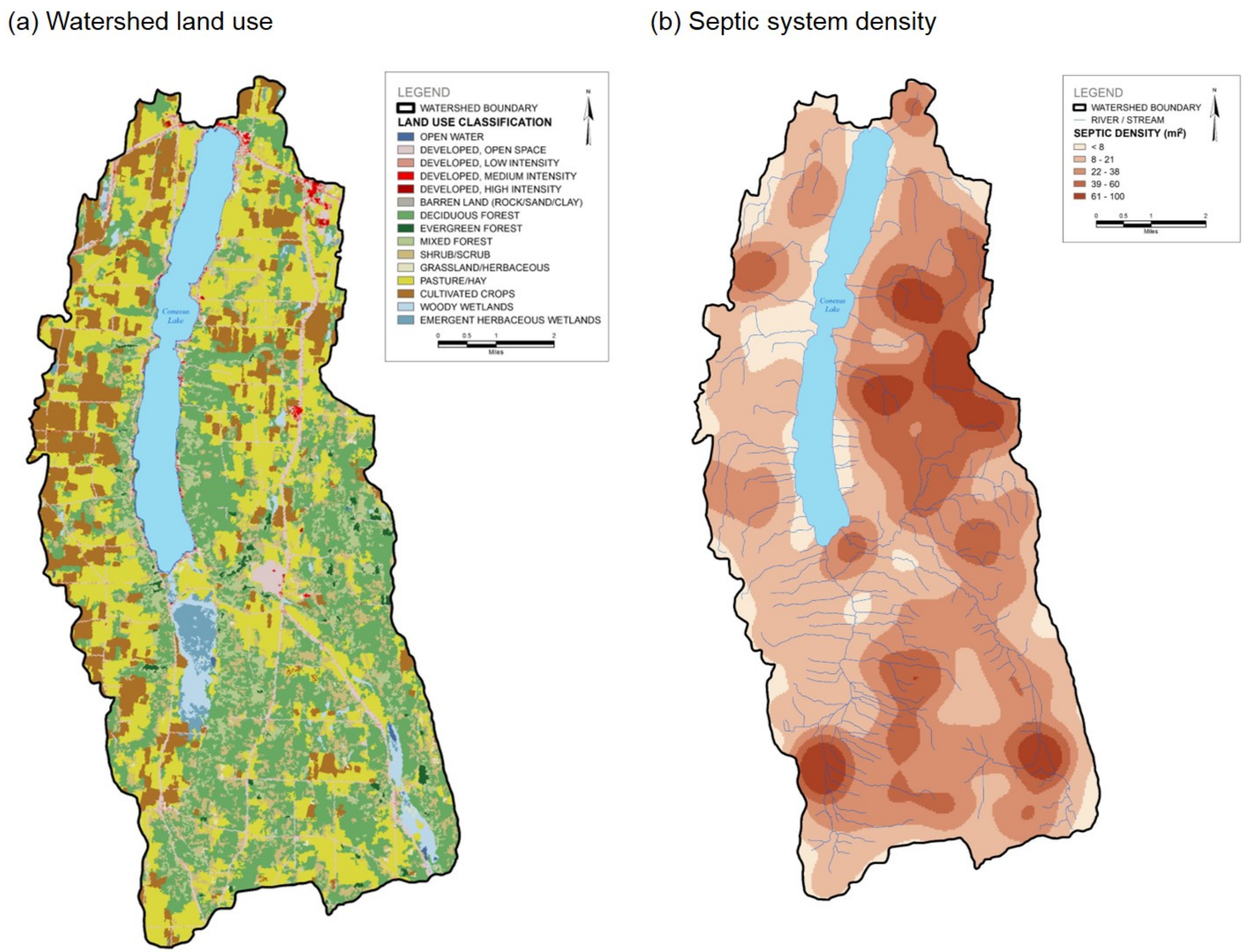


Figure 21. (a) Watershed land use and (b) septic system density in the Conesus Lake watershed.

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 been 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.

This Action Plan should be considered the first step of an adaptive management approach to HABs in Conesus Lake. Any completed TMDL or 9E plan developed for Conesus Lake will supplement the loading assessment included in this report. At that time, this Action Plan can be updated to reflect current and better understanding of Conesus Lake.

The LENS model analysis suggests that external nutrient loading composed approximately 20% of the total annual phosphorus budget for Conesus Lake. These nonpoint sources include agriculture (15% of total phosphorus loading), developed (4% of total phosphorus loading), and natural areas such as forested, shrubland, grassland,

and wetland (1% of total phosphorus loading) land uses. Septic systems can also contribute to external nutrient loading to lakes, and, compared to other Finger Lakes, the Conesus watershed has relatively high septic densities in its eastern portion (**Figure 21b**). The potential contribution of these septic systems may warrant further evaluation because the soluble reactive phosphorus associated with septic systems is particularly conducive to growth of cyanobacteria.

10.3 Internal Pollutant Sources

Internal loading of phosphorus has been estimated to account for up to 80% of the annual total phosphorus load in Conesus Lake based on the LENS model analysis. Although internal loadings are known to be a large component of the phosphorus loading, uncertainty around contribution of internal loading should be considered when developing management actions.

Conesus Lake has historically received externally-derived nutrients, and over time, much of the excess phosphorus has been deposited into the bottom sediments. This phosphorus can be re-suspended or released under certain conditions:

- During lake stratification, depleted oxygen concentrations in the hypolimnion allow for the mobilization of phosphorus from sediment to the water column. During mixing events or lake turnover, this phosphorus can become available to algae (including cyanobacteria) in the epilimnion, potentially leading to HABs.
- Die-offs and decomposition of organic material (e.g., aquatic plants and animals), which increase biotic utilization of oxygen (i.e., respiration), leading to decreased oxygen concentrations at depth.

As noted previously, Conesus Lake is part of a class of large shallow lakes (together with Chautauqua and Honeoye) that have a thin hypolimnion susceptible to experiencing very high TP concentrations later in summer due to anoxic conditions, and therefore, internal loading of TP may be very important in these lakes.

10.4 Summary of Priority Land Uses and Land Areas

As described in **Sections 10.2** and **10.3**, loading occurs predominately through internal nutrient loading, with other sources of phosphorus from nonpoint sources derived from agricultural, developed, and forested land uses. Note that the TMDL being completed by NYSDEC will supersede the loading estimates included in this report.

11. Lake Management / Water Quality Goals

The primary lake management/water quality goal for Conesus Lake is to implement proactive management to minimize HABs through nutrient input reduction to concentrations consistent with Conesus Lake management objectives aligned with the prevention of HABs and the forthcoming Conesus Lake TMDL (see **Section 12.5**). Given the surrounding land use, management actions for Conesus Lake should prioritize reducing contributions of nutrients delivered to the lake via agricultural runoff to the many streams that feed the lake as well as all other contributing sectors. Acute and long-term agriculture-borne phosphorus loads should be minimized to the extent practicable through the strategic application of BMPs in sub-watersheds most responsible for storm event loading.

Notable is that internal loading is an important source of phosphorus in Conesus Lake, based on LENS estimates. Measures to limit phosphorus loading from lakebed sediments is often challenging and costly, and loading from lake sediments is strongly linked with historic and ongoing loading from external sources (such as watershed runoff). Both internal loading and external loading of phosphorus should be considered when making HABs management decisions for Conesus Lake.

12. Summary of Management Actions to Date

12.1 Local Management Actions

Numerous local management actions have been implemented by local communities throughout the Conesus Lake watershed. In 2003 the Conesus Lake Watershed Management Plan was developed by the Livingston County Planning Department and EcoLogic LLC to guide management actions within the watershed. Local management actions implemented within the Conesus Lake watersheds include (LCPD and EcoLogic 2013):

- Agricultural best management practices (BMPs) and conservation practices.
- Incorporation of water quality provisions into local municipality zoning codes.
- Streambank and roadside ditch remediation.
- Roadside ditch stabilization.
- Water and sewer infrastructure improvements.

Agriculture

Since 1997, the demographics of farms within Livingston County have changed. These changes are driven by the consolidation of mid-sized family-owned farms into fewer and larger farms, especially dairy farms. In addition, niche and hobby farms, often equestrian, are increasing in the area. Approximately 52% of acres within Livingston County were in farm ownership or use in 2002 (ACDS LLS 2006). Of this acreage, 23% of Livingston County land in farm use was rented farmland. In 2002, percent of farmland use included:

- Cropland = 48%
- Pastureland = 4%
- Woodland on Farms = 13%
- Other = 5%
- See **Section 10.1** for watershed-specific land use values

The implementation of agricultural and cultural BMPs in the Conesus Lake watershed has reduced agricultural loading of sediments and nutrients to Conesus Lake.

The 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 (NYSSWCC 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 lists 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 Conesus Lake watershed to address important environmental challenges including improving water quality (**Table 6**).

Table 6. Total number of AEM projects conducted in the Conesus Lake watershed (2011-2017).

	Tier 1	Tier 2	Tier 3A	Tier 3B	Tier 4	Tier 5A	Tier 5B
Total number of AEM projects	48	49	10	0	5	0	0

The Livingston County Soil and Water Conservation District has been instrumental in the implementation of both AEM Plans and BMPs.

Streambank and Roadside Ditch Remediation

Between 2004 and 2006, 12 tributaries to Conesus Lake were assessed for excessive streambank erosion, after which, 41 individual stream reaches were recommended for streambank stabilization measures. Of these, 7 reaches were selected for remediation after site specific feasibility, cost, and benefit analyses were completed. Streambank stabilization measures were implemented in 2015 at the 7 reaches (LCPD and EcoLogic 2013).

Roadside ditch remediation efforts by the Towns of Conesus, Geneseo, Groveland, and Livonia and Livingston County have resulted in the stabilization of 10,500 feet of roadside drainage ditches in the Conesus Lake watershed and a reduction in annual sediment loss of more than 50 tons. After the identification of eight priority road segments within the Conesus Lake, ditch stabilization measures were implemented following the design plans developed by the Livingston County Deputy Highway Superintendent.

Water and Sewer Infrastructure Improvements

Over the past decade, several improvements have been made to the public water supply services to towns around Conesus Lake. Actions have included the improvement of redundancy in supply, continued investment in water treatment, and the expansion of service into the Hamlets of Conesus (Town of Conesus) and Scottsburg (Town of Sparta). In addition, the Village of Geneseo has implemented the infrastructure to draw water from Hemlock Lake during emergency situations. Municipalities have received funding for water service improvements by the NYS Environmental Facilities Corporation.

Wastewater services have been extended approximately 36 miles and serve an additional 3,631 units since 2003. Improvements to the Lakeville wastewater treatment facility by the Livingston County Water and Sewer Authority have resulted in reductions of ammonia and oxygen-demanding materials in effluent. Improvement and expansion efforts have been funded through local and NYS funding.

12.2 Funded Projects

Local, State, and Federal funding has supported the implementation and monitoring of BMPs within the Conesus Lake watershed. One program of note was the Conesus Lake USDA project (see **Section 5.2**) which was funded through the Cooperative State Research, Education and Extension Service (CSREES) of the U.S. Department of Agriculture (USDA). The Soil and Water Conservation District also lends cooperative guidance to farmers on an array of issues and provides continuous support to implementation and planning of BMPs.

Investigations on streambank erosion in 12 tributaries to Conesus Lake was funded by a NYS Quality Communities program grant awarded to Livingston County in 2004. Streambank remediation was implemented through funding from a NYS Environmental Protection Fund (EPF) grant awarded to the Town of Livonia in 2008 and 2009. Roadside drainage ditch remediation within the watershed was funded by a NYS EPF grant awarded to the Town of Groveland in 2005.

The Town of Groveland, has served as lead agency in obtaining grant funding to improve drinking water and sewer services for town residents (Town of Groveland 2018). Expansion of public water supply services for municipalities have received funding from the NYS Environmental Facilities Corporation.

Notable 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 NYS Agricultural Nonpoint Source

Abatement and Control Program (ANSACP). These programs have supported the implementation of BMPs within the Conesus Lake watershed. Examples of BMP systems implemented that contribute to an improvement in water quality include erosion control systems, agrichemical handling and storage facilities, terracing, and the use of underground outlets.

Significant funding for implementing the CLWMP recommendations is also provided by the Finger Lakes-Lake Ontario Watershed Protection Alliance (FLLOWPA) through an appropriation form from the New York State Environmental Protection Fund.

12.3 NYSDEC Issued Permits

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 State Pollutant Discharge Elimination System (SPDES) program was authorized to maintain reasonable standards of purity for state waters. NYSDEC issues Multi-Sector General Permits (MSGPs) under the SPDES Program for stormwater discharges related to certain industrial activities.

Several SPDES permitted discharges are located within Livingston County. Of these 14 are in towns bordering Conesus Lake. Only one SPDES permitted facility, Lakeville WWTP, was identified as discharging within the Conesus Lake watershed. This facility discharges into Conesus Creek and does not directly affect water quality of Conesus Lake.

MSGPs have been issued for numerous active facilities in Livingston County (NYSDEC SPDES Permit Program, undated). Some of the facilities are within the Conesus Lake watershed, and therefore may influence water quality conditions in Conesus Lake. Of these MSGP-permitted facilities, only two discharge to waters that flow directly to Conesus Lake. One facility in the Town of Livonia discharges into North Gully. The second facility is in Lakeville and potentially discharges to the North end of Conesus Lake, although, it primarily discharges into Conesus Creek and flows through the municipal separate storm sewer system. Three other MSGP-permitted facilities discharge into Conesus Creek or the Conesus Outlet downstream of Conesus Lake in Lakeville.

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

12.4 Research Activities

Research has been conducted on Conesus Lake to monitor water quality conditions including:

- Finger Lakes Water Hub early-year sampling.
- The Conesus Lake USDA project (see **Section 5.2**).

- Pilot test on the effectiveness of biological control of Eurasian watermilfoil using aquatic weevils.
- Implementation of solar-powered water circulation devices.
- Diversion of North Gully Creek.
- Feasibility of nutrient inactivant application to control internal loading of phosphorus.

Finger Lakes Water Hub early-year sampling

Initial review of Finger Lakes water quality datasets in early 2017 showed that almost no data had been gathered on the state of the lakes in wintertime (November to April). Additional data collection during the winter months may provide additional information on overall water quality and potential for HABs formation during the growing season.

Staff from NYSDEC's Finger Lakes Water Hub, a Region 7-based group focused on HABs and other water quality threats in the Finger Lakes Region, collected water quality samples in February and April 2018 on all eleven Finger Lakes. These sampling efforts were undertaken to characterize important indicators of lake health during winter-early spring and to provide early-year information that can be used for HABs management planning. Temperature, conductivity, pH, dissolved oxygen, and chlorophyll-a were measured from the surface to the bottom of the lake using a YSI probe; Secchi depth also was recorded. Water samples were collected from just below the surface (1.5-meter depth) and at two-thirds of the total depth at one CSLAP site on each lake for analysis of the standard CSLAP parameters (e.g., TP, TN, NOx, ammonia, chloride, calcium, and chlorophyll-a). Samples were either collected from a boat or through the ice. For lakes with surface ice, samples were collected through a hole created by hand-auguring through up to 12 inches of ice. In addition to monitoring water quality, samples also were collected for researchers at SUNY ESF for analysis of algal toxins, zooplankton and phytoplankton, and lake sediments.

While data analysis is ongoing, highlights of observations in the field include: inverse stratification (warmer at the bottom than the top) in the ice-covered lakes, while those remaining ice-free were isothermal (all the same temperature) and well mixed; dissolved oxygen was lower, although not hypoxic, in the lower third of Honeoye and Canadice Lakes than the surface during ice cover, whereas the remaining lakes, even those under ice, were well oxygenated; and water clarity was generally high with Secchi Disk depths greater than 15m in both Skaneateles and Seneca Lakes (both are generally less than 10 m during the growing season).

Pilot test on the effectiveness of biological control of Eurasian watermilfoil using aquatic weevils

A pilot study on the use of weevils to biologically control milfoil in Conesus Lake was conducted in 2005 by SUNY Geneseo. Although a major decline in milfoil abundance was observed at the study site, results were inconclusive on the effectiveness of this type of control due to declines in milfoil abundance throughout Conesus Lake during the project (Bosch et al. 2006). However, it should be noted that this pilot project should not be characterized as a HABs-related mitigation action, since milfoil abundance is not well correlated with HABs occurrences.

Implementation of solar-powered water circulation devices

Three solar-powered water circulation devices were deployed in Conesus Lake in 2006 and 2007 to determine if increasing water circulation would improve water quality and prevent the accumulation of excessive aquatic plants, including algae and cyanobacteria. Funding for the devices was provided by Livingston County using funds from the FLLOWPA, the Conesus Lake Association, and the Towns of Groveland, Conesus, Geneseo and Livonia. The devices had little to no improvement on water quality or algal abundance compared to other Lake samples.

Diversion of North Gully Creek

In 2008, the outlet of North Gully Creek was reconfigured so that water flowing out of the creek flowed northward, away from North Gully Cove and into open waters. The McPherson Point/North Gully Cove area has been characterized by dense growth of Eurasian watermilfoil and an extensive cover of filamentous algae. The objective of the project was to reduce high sediment and nutrient loads from North Gully Creek from entering the cove in hopes that it would reduce milfoil and algae in the cove. Monitoring conducted in 2008 to 2010 by SUNY Geneseo were compared to pre-diversion baseline monitoring and other nearshore areas. No improvements in milfoil and algae were detected.

Feasibility of alum application to control internal loading of phosphorus.

In 2004 a Draft Environmental Impact Statement (DEIS) on the feasibility of using alum (aluminum sulfate) treatments to prevent phosphorus release from sediments in Conesus Lake was conducted. The Livingston County Planning Department and the CLWC technical committee decided to evaluate the potential environmental benefits, risks, and costs associated with an alum treatment program after the magnitude of the internal phosphorus loading to Conesus Lake was understood. Results of the DEIS indicated that an alum treatment program would potentially be effective in Conesus Lake since the lake is phosphorus limited, internal loading is a significant component of the lake's phosphorus budget, external loading is known, and management actions have begun to remediate loading sources and the high alkalinity and circumneutral pH conditions in Conesus Lake mitigate the risk of aluminum toxicity.

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. TMDL and Nine Element (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 the NYSDEC for waterbodies that are on the 303d impaired waters list with a known pollutant.
- 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.

A TMDL for phosphorus in Conesus Lake is in development by the USEPA, Region 2 and NYSDEC due to elevated phosphorus and reduced dissolved oxygen concentrations (USEPA 2017). A LENS assessment has been conducted for the Conesus Lake watershed and was used to identify potential HAB triggers and pollutants sources in this Action Plan (see **Section 10**).

NYSDEC (2015d) has prepared a 9E Plan for the Genesee River Basin. This basin-wide 9E Plan focuses on nutrient and sediment pollution within the 2,490-square mile watershed and the management practices deemed necessary in all major sub-basins, with prioritization of areas within the sub-basins where conservation efforts should be focused.

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 NYSDEC'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 Conesus Lake.

Steering committee members:

- Charlie Braun, Conesus Lake Association
- Gene Bolster, Conesus Lake Association
- Mary Underhill, Conesus Lake Watershed Council
- Karl Czymmek, Cornell ProDairy
- Lisa Cleckner, Finger Lakes Institute
- Jon White, Highgrove Farm
- Mark Grove, Livingston County Department of Health
- Heather Ferrero, Livingston County Planning Department
- Robert Stryker, Livingston County Soil and Water Conservation District (SWCD)
- Michelle Baines, Livingston County Water & Sewer Authority
- John Maxwell, Maxwell Farms
- JoBeth Bellanca, Natural Resources Conservation Service
- Victor DiGiacomo, NYSDAM
- Ed Anna, NYSDEC
- Karis Manning, NYSDEC
- Lewis McCaffrey, NYSDEC
- Pradeep Jangbari, NYSDEC
- Michael Chislock, SUNY Brockport
- Sid Bosch, SUNY Geneseo
- Brenda Donohue, Town of Conesus
- William Wadsworth, Town of Geneseo
- William Carman, Town of Groveland
- Eric Gott, Town of Livonia
- Mark Schuster, Town of Sparta
- Kirk Vanderbilt, Village of Avon
- Margaret Duff, Village of Geneseo
- Bob Leader, Village of Livonia
- Calvin Lathan, Village of Livonia
- Elizabeth Moran, Watershed consultant, EcoLogic, LLC

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 Conesus Lake.
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 Conesus Lake include:

- Internal loading of legacy phosphorus from in-lake sediments.
- Nonpoint source nutrient inputs from the contributing watershed.
- Phosphorus inputs associated with septic system 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, match [financial or in-kind], 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 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 Conesus Lake Priority Projects

13.3.1 Priority 1 Projects

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

Short-term (3 years)

1. Implement runoff reduction BMPs on croplands to reduce stormwater and nutrient runoff and soil erosion from agricultural lands in the watershed. These BMPs would be implemented by local SWCDs and other partners, and include:
    - Establish field erosion control systems (grassed waterways, shaping and grading, and water and sediment control basins (WASCoBs)) to promote stormwater retention and minimize concentrated runoff (e.g., rills, gullies).
    - Stabilize drainage swales through establishment of vegetation and/or installation of check dams.
    - Install control facilities at the outlets of drainage swales (prior to entering the lake or tributaries) to promote sediment and nutrient capture.
    - Implement runoff reduction BMPs for farmsteads: roof runoff management, barnyards, laneways/access roads, and bunk silos.
    - Establish vegetated riparian buffers to inhibit or reduce nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams.
    - Rehabilitate degraded vegetated buffers to improve riparian habitat function on tributaries to Conesus Lake.
    - Complete Comprehensive Nutrient Management Plans (CNMPs) and conservation planning at participating farms.
    - Implement cover crops on cropland that is prone to erosion and nutrient runoff when left unprotected.
2. Install up to six water circulation units and associated appurtenances at one or more suitable lake locations, including Camp Stella Maris beach, to minimize potential impacts from HABs. Prior to implementation, the County or Watershed Council will need to complete an engineering study and apply for and receive regulatory approvals from the NYSDEC, United States Army Corps of Engineers (USACE), and other agencies, as required/needed. It is important that pre- and

post-monitoring be included as part of this priority project to determine the effectiveness of the proposed remediation measure. It may also be useful to have an uncirculated reference site for comparison of results to those areas where circulation units are installed.

3. Complete a hydrodynamic model and engineering assessment to evaluate the feasibility and effectiveness of altering water circulation at the original outlet along Vitale Park in the North Basin (i.e., natural and assisted flow solutions). Prior to implementation, the application for and receipt of regulatory approvals from the NYSDEC, USACE, and other agencies would need to be secured. Specifically, this project could involve:

    - Modification of the original outlet to reduce quiescent conditions that may contribute to HABs in that area. The evaluation would include potential impacts associated with modification of the existing flood control gates at the dam.
    - Replacement of existing culvert with a larger box culvert to increase flow during low lake level conditions.
    - Dredging of the small embayment area adjacent to the original outlet.
    - Improve flow in the original outlet channel by restoring the channel to the original depth established prior to installation of the NYSDEC/USACE lake level dam. Construction of a new lake outlet channel during dam construction has resulted in wind/wave-driven deposition of sediment and decaying organic vegetation and debris. The accumulation of decaying biomass introduces excess nutrients into the warm, shallow, quiescent waters of the old outlet channel and adjoining bay.

Mid-term (3 to 5 years)

1. Complete engineering design of an hypolimnetic aeration and oxygenation system to address and minimize the release of legacy phosphorus from lake sediments. Prior to implementation, regulatory approvals from the NYSDEC, USACE, and other agencies will be needed. The design will need to identify the following:
    a. Number and locations of air diffusers and compressors
    b. Pipe size, dimensions, and material
    c. Detailed cost estimate
2. Complete a limnological study of nutrient inactivant application in deep portions of the North and South Basins to sequester the legacy phosphorus within the bottom sediments.

Long-term (5 to 10 years)

1. If deemed appropriate based on completion of studies, implement one or both internal loading treatment practices identified above (i.e., aeration, nutrient inactivant application). Monitoring their effectiveness at managing internal loading in Conesus Lake should be documented and evaluated to guide future treatments, if applicable.
    a. If aeration is implemented, deploy air diffuser heads, compressors, and associated tubing to targeted portions of the lake based on the results of the engineering design.
    b. If nutrient inactivation is implemented, apply nutrient inactivant to targeted portions of the lake that are likely to be associated with internal phosphorus release based on the results of the bench scale test and limnological study. This project would need to include the following prior to field implementation:
        - Preparation of supplemental environmental impact statement (SEIS) to comply with the State Environmental Quality Review Act (SEQRA), if needed.
        - Apply for and receive regulatory approvals from the NYSDEC, USACE, and other agencies.
        - Note that New York State is developing an approach for safely and legally using nutrient inactivants, and until that process is completed, the use of any inactivants in Conesus Lake is prohibited.

13.3.2 Priority 2 Projects

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

Short-term (3 years)

1. Implement multiple stormwater BMPs to reduce sediment loading into Conesus Lake. Projects may include:
    - Acquiring land and/or establish conservation easements on high-priority, water quality sensitive lands within the watershed.
    - Preserving hillside integrity with vegetation or other stabilizing material to minimize runoff. Utilize natural depressions and sediment catches in roadside ditches, particularly along steep slopes to limit nonpoint source nutrient loads from within the watershed.

- Implementing roadside ditch improvement projects that are likely to contribute the greatest reduction in erosion. Best management practices could include:
    i. Time cleanout to minimize vegetative loss.
    ii. Check dams to reduce water velocity and erosion potential.
    iii. Properly size culverts and stream channels to avoid incision, downcutting, aggradation and other erosion.
    iv. Use vegetative cover to assist in ditch bank stabilization.
- Installing stormwater management basins or wetlands or enhance existing wetlands at Lake inlets or along the tributaries if streams within the Conesus Lake watershed are contributing to high nutrient loads. Such work should be supported by a strategic assessment to identify best locations to situate projects.

Mid-term (3 to 5 years)

1. Install 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, vegetated riparian buffers, sediment traps, and urban treescapes in developed areas. This project should also include replacing improperly sized culverts to maximize flow efficiency and minimize potential impacts on the lake.
2. Stabilize riparian habitat through funding conservation easements and installing vegetative plantings and stream stabilization structures (e.g., rock or log vanes, rock or log revetments). A landscape analysis to identify priority locations needs to be completed prior to implementation. This project may include:
    - Establish vegetated riparian buffers to inhibit or restrict nutrient-rich stormwater runoff and eroded soil from reaching the lake or tributary streams.
    - Rehabilitate degraded vegetated buffers to improve riparian habitat function.

Long-term (5 to 10 years)

1. Prepare and implement a plan to evaluate BMPs to address external loading practices (as guided by the work conducted by J. Makarewicz at SUNY-Brockport) and to guide and sustain future development of BMPs.

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.

Short-term (3 years)

1. Continue to promote watershed stewardship and the use of BMPs through the Watershed Education Center, Conesus Stewardship Initiative, and additional programming. Topics may include the use of zero phosphorus fertilizer, landscaping BMPs, invasive species spread prevention, green infrastructure practices, shoreline restoration, and erosion control BMPs.
2. The public water systems, with support from the NYSDEC and NYSDOH, should pursue engineering studies to evaluate the potential efficacy of adding additional treatment. If these studies show that adding treatment is appropriate and feasible, then the water systems should then work with NYSDOH and EFC to pursue funding opportunities through programs such as the Drinking Water State Revolving Fund (DWSRF) and Water Infrastructure Improvement Act (WIIA), as well as engage their local elected officials for support.
3. Establish a program to reduce the nutrient input of human waste from failing septic systems and sewer overflows. This project could include:
    - Monitoring, inspecting, and sampling existing septic systems within the Conesus Lake watershed to maximize the functional capacity of these systems and minimize nutrient contribution.
    - Implementing an inspection program to identify and eliminate illicit storm sewer connections to reduce the frequency of combined sewer overflow events.
    - Creating a public outreach/ communications plan to educate residents on means to minimize impacts on water quality.
    - Establishing a revolving fund for assisting homeowners with the costs of illicit storm sewer disconnection.
    - Creating a cost-sharing program to implement a septic system repair and replacement program for qualifying households, and a funding program to connect private systems to municipal sewer systems if they fail to meet the separation distance(s) specified for that municipality.

Long-term (5 to 10 years)

1. Implementing multiple water quality improvement BMPs to minimize the effect of residential, commercial and industrial development on natural features (streams and steep slopes). These projects could include:
    - Natural shoreline restoration to improve water quality and create habitat for aquatic and terrestrial species.

- Voluntary land acquisition for conversion of residential vacant land into passive recreation space or parkland.
- Training of municipal land use officials on stormwater management and the protection of steep slopes.
- Creation of land use regulations to assist in stormwater management and the protection of steep slopes.

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:

Short-term

1. Emphasize phosphorus source control in stormwater planning, targeting areas with potentially high levels of phosphorus runoff, particularly in those communities with relatively high percentages of impervious cover, small lot sizes, and/or compacted soils.
2. Implement Agricultural Environmental Management (AEM) plans for farms where these plans are not in place and identify best application of funds through available grant programs. Develop and implement whole farm nutrient management plans designed to maximize nutrient use while minimizing nutrient loss.

    a. Minimize the need to winterspread on agriculture land through the effective development of farm AEM plans.

    b. Apply nutrient management activities on farms in the Graywood Gully sub-watershed of the lake where the agricultural cover type comprises 74% of the sub-watershed area.
3. Stop or reduce application of herbicides to rights-of-way and stream banks at road crossings.

Long-term

1. Review existing Concentrated Animal Feeding Operation (CAFO) plans and identify areas for improvement.
2. Evaluate the presence of forest pests that affect hemlock, ash, spruce, and other tree species that are currently integral to watershed stabilization. Disruption by these pest species could exacerbate erosion and nutrient loading to Conesus Lake. Forest research and management should be implemented to extent feasible to identify and control these and other pests as a proactive means to minimize impacts. Strategic planting of species less susceptible to impacts of

infestation should be undertaken in areas where canopy loss will result in significant system destabilization.

3. Explore opportunities to enhance, restore, or create wetlands within the watershed to reduce nutrient and sediment loads. **Figure 22** depicts locations in the Conesus Lake watershed with either hydric, very poor or poorly drained soils, but are not currently mapped as “wetlands” according to the National Wetland Inventory (NWI) database. These locations in the watershed may be best positioned for wetland-related opportunities to improve water quality.

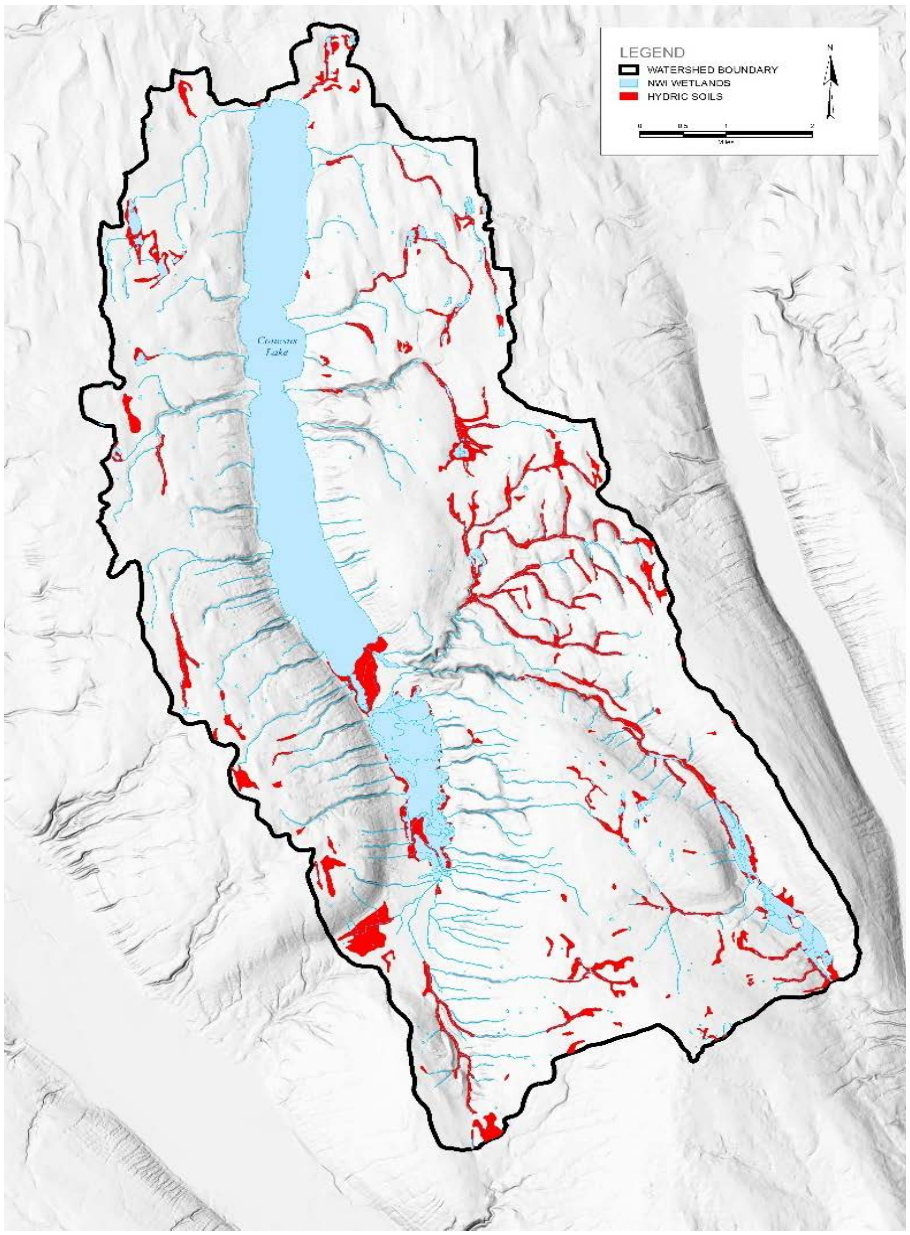


Figure 22. Locations (depicted in red) of either hydric, very poor, or poorly drained soils in the Conesus Lake watershed. Note the hydric soil locations presented are non-overlapping with National Wetland Inventory (NWI) mapped wetlands.

13.5 Monitoring Actions

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

Short-term

1. Model water column mixing and nutrient loading:
   - Incorporate parameters into model so that it mimics current conditions in terms of seasonal nutrient and HAB concentrations.
   - Use model to simulate various management options to identify effective means to control HABs
2. Collect and analyze sediment samples to develop a spatial profile of legacy phosphorus concentrations.
3. Collect and analyze surface water samples during summer and fall to identify the following within the epilimnion before, during, and after fall turnover to obtain a greater temporal and spatial resolution in Conesus Lake. Such an approach should focus on:
   - Phosphorus concentrations
   - Species and concentrations of cyanobacteria that are prevalent
   - Align in-lake water quality data collection efforts with overpasses of NASA's Landsat 8 satellite (**Table 7**), 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 7. Landsat 8 overpasses of Conesus Lake from May through October, 2018.

Month	Dates			
May	May 3	May 12	May 19	May 28
June	June 4	June 13	June 20	June 29
July	July 6	July 15	July 22	July 31
August	August 7	August 16	August 23	
September	September 1	September 8	September 17	September 24
October	October 3	October 10	October 19	October 26

4. Collect and analyze hypolimnetic nutrient samples during summer and fall to evaluate conditions that might indicate bloom susceptibility associated with anoxic sediment release or cyanobacteria nutrient scavenging.

5. Develop a map based on the sample results that identifies areas with elevated concentrations of legacy phosphorus that contribute significantly to elevated concentrations of phosphorus and cyanobacteria that could be contributing to HABs.
6. Continue annual CSLAP sampling to evaluate impacts from storm events and long-term trends in phosphorus loading and occurrences of HABs in the lake.
7. Expand CSLAP sampling locations to additional areas of the lake, including nearshore zones. Current monitoring locations are offshore and may not provide the most useful data and information for identifying area-specific triggers for HABs in the lake.
8. Supplement the understanding of the algae species contributing to blooms through taxonomic analysis of samples collected during conditions favorable for HABs formation (i.e., still conditions, elevated water temperatures, recent nutrient inputs). Knowledge of the dominant cyanobacteria in the lake allows for development of species-specific implementation strategies for controlling and managing their abundance.
9. Supplement data on cyanotoxin concentrations during confirmed and suspected blooms.
10. Continue water quality study/monitoring efforts in Lake tributaries to provide a long-term data set of nutrient concentrations and other water quality parameters that can be used to evaluate Lake health and predict HAB formations.
11. Characterize dissolved oxygen concentrations at depth during the summer months, to evaluate the potential for low dissolved oxygen at depth leading to internal loading.
12. Identify certified laboratories that lake water samples can be sent to locally to streamline the testing process and response.
13. Conduct water quality sampling in tributaries and/or in discharge points in the lake during or following heavy rainfall events, as permissible, to document nutrient inputs that may contribute to localized HABs facilitated by storm events. Priority for such sampling efforts should be given to sub-watersheds with larger catchment areas and where land use is predominantly agricultural (as discussed in **Section 6.4**).
14. Collect and evaluate water samples for soluble phosphorus to quantify phosphorus bioavailability for BGA in the lake. In addition, evaluate nonpoint source loadings in the context of soluble phosphorus, the form readily available for algal growth (in contrast to total phosphorus, which includes both soluble and particulate forms).

15. Enhance the understanding of pelagic food web linkages in the lake, as the interactions between algae, zooplankton, and fishes influence the formation and spatial extent of HABs, and the dynamics between these trophic components will themselves be influenced by actions proposed in this Action Plan. Focus for this enhanced understanding should be placed on the nearshore environment, particularly those areas where HABs have been documented historically.

13.6 Research Actions

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 Conesus Lake. 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

To help minimize the stresses that lead to the potential formation of HABs, and their negative effects in Conesus Lake, the following administrative actions are recommended for evaluation:

Short-term

1. Promote the implementation of watershed-scale BMPs for curtailing runoff from farm fields and other agricultural areas, developed land, and forested land.

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 roadside 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., roadside ditch management, emergency stream intervention, erosion and sediment 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 Conesus Lake watershed.
3. Identify opportunities to encourage best management practice implementation through financial incentives and alternative cost-sharing options.
4. Coordinate with the Department of Health to support implementation of 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.

14. References

ACDS, LLC. 2006. Livingston County Agricultural and Farmland Protection Plan. Submitted to the Livingston County Agricultural and Farmland Protection Board.

Auer, M.T., K.A. Tomasoski, M.J. Babiera, M. Needham, S.W. Effler, E.M. Owens, and J.M. Hansen, 1998. Phosphorus Bioavailability and P-Cycling in Cannonsville Reservoir. Lake and Reservoir Management 14:278-289.

Auer, M.T., Downer, B.E., Kuczynski, A., Matthews, D.A., and S.W. Effler. 2015. Bioavailable Phosphorus in River and Wastewater Treatment Plane Discharges to Cayuga Lake. 28 p.

Baker, D. B., Confesor, R., Ewing, D. E., Johnson, L. T., Kramer, J. W., and Merryfield, B. J. 2014. Phosphorus loading to Lake Erie from the Maumee, Sandusky and Cuyahoga rivers: The importance of bioavailability. Journal of Great Lakes Research, 40(3), 502-517.

Bosch, I., Connors, D., McCabe, C., Wong, G., Bowling, A., and Kubik, A. 2015. Linkage Between Water Column Mixing of Phosphorus and Onset of Cyanobacteria Blooms in Conesus Lake, (NY). State University of New York at Geneseo. Report submitted to the Livingston County Planning Department. December 1, 2015.

Bosch, I., Groveman, B., Bonk, E., and St. James, E. 2006. Population Status of the Milfoil Weevil and its Possible Impact of Eurasian Watermilfoil in Conesus Lake One Year After Weevil Augementation. Summary Report, State University of New York, Geneseo, Department of Biology.

Brooks, J.L., and Dodson, S.I. 1965. Predation, body size, and composition of plankton. Science. 150(3692), pp.28-35.

Callinan, C.W. 2001. Water Quality Study of the Finger Lakes. New York State Department of Environmental Conservation, Division of Water. July. 73 pp. https://www.dec.ny.gov/docs/water_pdf/synopticwq.pdf.

Callinan, C.W., Hassett, J.P., Hyde, J.B., Entringer, R.A. and Klake, R.K. 2013. Proposed nutrient criteria for water supply lakes and reservoirs. *Journal AWWA*, *105*(4), pp.157.

Carpenter, S.R. 1983. Submersed macrophyte community structure and internal loading: relationship to lake ecosystem productivity and succession. Lake and Reservoir Management, 2, pp.105-111.

Carpenter, S.R. and D.M. Lodge. 1986. Effects of submersed macrophytes on ecosystem processes. Aquatic botany, 26, pp.341-370.

CLA (Conesus Lake Association). 2016a. Conesus Lake – The Facts. http://www.conesuslake.org/index.php/lake-information/lake-facts.

CLA. 2016b. About the CLA. http://www.conesuslake.org/index.php/about-the-cla.

CLA. 2016c. ConesUS Lake Stewardship. http://www.conesuslake.org/index.php/lake-watershed/stewardship-initiative.

CLWC (Conesus Lake Watershed Council). 2013. Invasive Species Prevention and Response Plan. http://fingerlakesinvasives.org/wp-content/uploads/2015/01/Final_DRAFT_CLWC_IS_PLAN.pdf.

CLWC. 2015. Conesus Lake Annual Report Card: 2015. http://www.co.livingston.state.ny.us/DocumentCenter/View/4684.

CLWC. 2016. Conesus Lake Annual Report Card: 2016. http://conesuslake.org/index.php/water-quality/318-2016-conesus-lake-annual-report-card.

Conley, D. J., H.W. Paerl, R.W. Howarth, D.F. Boesch, S.P. Seitzinger, K.E. Havens, C. Lancelot, and G.E. Likens. 2009. Controlling eutrophication: nitrogen and phosphorus. Science, 323(5917), 1014-1015.

Cooke, G.D., E.B. Welch, S.A. Peterson, and S.A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs. Taylor and Francis, CRC Press, Boca Raton, Florida.

Couture, S.C., and Watzin, M.C. 2008. Diet of invasive adult white perch (*Morone americana*) and their effects on the zooplankton community in Missisquoi Bay, Lake Champlain. Journal of Great Lakes Research 34: 485-494.

DePinto, J.V. 1982. An Experimental Apparatus for Evaluating Kinetics of Available Phosphorous Release from Aquatic Particulates. Water Research 16:1065-1070.

Dodds, W.K. 2003. Misuse of Inorganic N and Soluble Reactive P Concentrations to Indicate Nutrient Status of Surface Waters. Journal of North American Benthological Society 22:171-181.

Donelan, M.A. 1980. Similarity theory applied to the forecasting of wave heights, periods and directions. In: Proceedings of Canadian Coastal Conference. National Research Council of Canada, pp. 47-61.

Effler, S.W., M.T. Auer, F. Peng, M.G. Perkins, S.M. O'Donnell, A.R. Prestigiacomo, D.A. Matthews, P.A. DePetro, R.S. Lambert, and N.M. Minott, 2012. Factors Diminishing the Effectiveness of Phosphorus Loading from Municipal Waste Effluent: Critical Information for TMDL Analyses. Water Environment Research 84:254-264.

eRegulations. 2017. Finger Lakes and Tributary Regulations. http://www.eregulations.com/newyork/fishing/finger-lakes-and-tributary-regulations/.

Faassen, E.J., Veraart, A.J., Van Nes, E.H., Dakos, V., Lurling, M., and Scheffer, M. 2015. Hysteresis in an experimental phytoplankton population. Oikos 124: 1617-1623.

Filstrup, C.T., Heathcote, A.J., Kendall, D.L., and Downing, J.A. 2016. Phytoplankton taxonomic compositional shifts across nutrient and light gradients in temperate lakes. Inland Waters 6:234-249.

FLLT (Finger Lakes Land Trust). 2018. Mission & Vision. http://www.fllt.org/about/mission/.

Forest, H.S., Wade, J.Q., and Maxwell, T.F. 1978. The Limnology of Conesus Lake. In: Lakes of New York State. Vol. I. Ecology of the Finger Lakes. J.A. Bloomfield, Ed. Academic Press, NY. pp. 122-221.

Halfman, J. 2017. Water Quality of the Eight Eastern Finger Lakes, New York: 2005-2016. Finger Lakes Institute, Hobart and William Smith Colleges. 51 pp.

Hecky, R.E., Smith, R.E.H., Barton, D.R., Guildford, S.J., Tayler, W.D., Charlton, M.N., and Howell, T. 2004. The nearshore phosphorus shunt: a consequence of ecosystem engineering by dreissenids in the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. 61(7): 1285-1293.

Jones, G.J. and Poplawski, W. 1998. Understanding and management of cyanobacterial blooms in sub-tropical reservoirs of Queensland, Australia. Water Science and Technology 37:161-168.

Kleinman, P. J., Sharpley, A. N., McDowell, R. W., Flaten, D. N., Buda, A. R., Tao, L., and Zhu, Q. (2011). Managing agricultural phosphorus for water quality protection: principles for progress. Plant and soil, 349(1-2), 169-182.

Kring, S.A., Figary, S.E., Boyer, G.E., Watson, S.B., and Twiss, M.R. 2014. Rapid in situ measures of phytoplankton communities using the bbe FluoroProbe: evaluation of spectral calibration, instrument intercompatibility, and performance range. Can. J. Fish. Aquat. Sci. 71(7): 1087-1095.

LCPD (Livingston County Planning Department) and EcoLogic. 2002. State of Conesus Lake: Watershed Characterization Report. May 2002.

LCPD and EcoLogic. 2003. Conesus Lake Watershed Management Plan. March 2003.

LCPD and EcoLogic. 2013. Conesus Lake Watershed Characterization Report Update.

Lee, G. F., Jones, R. A., and Rast, W. 1980. Availability of phosphorus to phytoplankton and its implications for phosphorus management strategies. Phosphorus Management Strategies for Lakes, 259, 308.

Livingston County. 2018a. About the Lake. http://www.co.livingston.state.ny.us/788/About-the-Lake.

Livingston County. 2018b. Conesus Lake Watershed Council. http://www.co.livingston.state.ny.us/112/Watershed-Council.

Livingston County. 2018c. Conesus Lake Blue-Green Algae Early Detection and Rapid Response Plan. http://www.co.livingston.state.ny.us/DocumentCenter/View/3236.

Logan, T. J., and Adams, J. R. 1981. The Effects of Reduced Tillage on Phosphate Transport from Agricultural Land. OHIO STATE UNIV COLUMBUS DEPT OF AGRONOMY.

Lv, J., Wu, H. and Chen, M. 2011. Effects of nitrogen and phosphorus on phytoplankton composition and biomass in 15 subtropical, urban shallow lakes in Wuhan, China. *Limnologica-Ecology and Management of Inland Waters*, *41*(1), pp.48-56.

Makarewicz, J.C., Lewis, T.W., and Pettenski, D. 2012. Stream Water Quality Assessment of Long Point Gully, Graywood Gully, and Sand Point Gully: Conesus Lake Tributaries Spring 2012. The Department of Environmental Science and Biology, The College at Brockport State University of New York.

Makarewicz, J.C., Lewis, T.W., and Snyder, B. 2011. The Development of a Stream Water Quality Assessment Index to Evaluate Stream Health Conesus Lake Tributaries: Spring 2011. The Department of Environmental Science and Biology, The College at Brockport, State University of New York.

Makarewicz, J.C., Lewis, T.W., Bosch, I., Noll, M., Herendeen, N., Simon, R., Zollweg, J., and Vodacek, A. 2009a. The impact of agricultural best management practices on downstream systems: Soil loss and nutrient chemistry and flux to Conesus Lake, New York, USA. J. Great Lakes Res. 35:23-36.

Makarewicz, J.C., Boyer, G.L., Lewis, T.W., Guenther, W., Atkinson, J., and Arnold, M. 2009b. Spatial and temporal distribution of the cyanotoxin Microcystin-LR in the Lake Ontario ecosystem: coastal embayments, rivers, nearshore and offshore, and upland lakes. J. Great Lakes Res. 35:83-89.

Mantzouki, E., Visser, P.M., Bormans, M., Ibelings, B.W. 2016. Understanding the key ecological traits of cyanobacteria as a basis for their management and control in changing lakes. Aquatic Ecology 50: 333-350.

Moran, E.C., and Woods, D.O. 2009. Comprehensive watershed planning in New York State: The Conesus Lake example. J. Great Lakes Res. 35:10-14.

Murdock, E.E. 2010. Skaneateles Lake Demonstration Project Case Study Report. Prepared for the United States Environmental Protection Agency, Office of Wastewater Management, Washington, D.C., by the City of Syracuse, Department of Water, Syracuse, New York.

Noges, P., Noges, T., Ghiani, M., Sena, F., Fresner, R., Friedl, M., and Mildner, J. 2011. Increased nutrient loading and rapid changes in phytoplankton expected with climate change in stratified South European lakes: sensitivity of lakes with different trophic state and catchment properties. Hydrobiologia 667:255-270.

NYFalls.com. 2013. Conesus Lake – New York's Finger Lakes. http://nyfalls.com/lakes/finger-lakes/conesus/.

NYSDEC (New York State Department of Environmental Conservation). 2003. The 2001 Genesee River Basin Waterbody Inventory and Priority Waterbodies List. Encompassing all or portions of Allegany, Cattaraugus, Genesee, Livingston, Monroe, Ontario, Orleans, Steuben and Wyoming Counties. Bureau of Watershed Assessment and Management, Division of Water. March 2003.

NYSDEC. 2014. Conesus Lake Fish Stock Assessment 2001-2009. https://digitalcommons.brockport.edu/cgi/viewcontent.cgi?article=1042&context=wr_misc.

NYSDEC. 2015a. 2015 Fish Stocking in Livingston County. http://www.dec.ny.gov/outdoor/23250.html.

NYSDEC. 2015b. Waterbody Inventory/Priority Waterbodies List Fact Sheets: Conesus Creek Watershed. https://www.dec.ny.gov/docs/water_pdf/wigeneseeconesus.pdf.

NYSDEC. 2015c. Vision Approach to Implement the Clean Water Act 303(d) Program and Clean Water Planning. 66 pp.

NYSDEC. 2015d. Genesee River Basin: Nine Key Element Watershed Plan for Phosphorus and Sediment. Division of Water. Bureau of Resource Management. Albany, NY. September 2015.

NYSDEC. 2017. Harmful Algal Blooms Program Guide. Version 1.

NYSDEC. 2018a. Genesee River Watershed. https://www.dec.ny.gov/lands/48371.html.

NYSDEC. 2018b. Conesus Lake. https://www.dec.ny.gov/outdoor/25575.html, https://www.dec.ny.gov/outdoor/36554.html, HYPERLINK "https://www.dec.ny.gov/outdoor/36554.html"

NYSDEC. 2018c. Conesus Inlet Wildlife Management Area. https://www.dec.ny.gov/outdoor/24432.html.

NYSDOH (New York State Department of Health). 2017. Harmful Blue-green Algae Blooms: Understanding the Risks of Piping Surface Water Into Your Home. https://www.health.ny.gov/publications/6629.pdf

NYSDOH. 2018a. Finger Lakes Region Fish Advisories. https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/regional/fingerlakes.htm

NYSDOH. 2018b. Part 6, Subpart 6-2 Bathing Beaches. https://www.health.ny.gov/regulations/nycrr/title_10/part_6/subpart_6-2.htm.

NYSSWCC (New York State Soil & Water Conservation Committee). 2018. Agricultural Environmental Management. https://www.nys-soilandwater.org/aem/.

Paerl, H., and Huisman, J. 2008. Blooms like it hot. Science 320:57-58.

Prestigiacomo, A. R., Effler, S. W., Gelda, R. K., Matthews, D. A., Auer, M. T., Downer, B. E., and Walter, M. T. (2016). Apportionment of bioavailable phosphorus loads entering Cayuga Lake, New York. JAWRA Journal of the American Water Resources Association, 52(1), 31-47.

Reichwaldt, E.S. and Ghadouani, A. 2012. Effects of rainfall patterns on toxic cyanobacterial blooms in a changing climate: Between simplistic scenarios and complex dynamics. Water Research 46:1372-1393.

Ritter, W. F., & Shirmohammadi, A. (Eds.). 2000. Agricultural nonpoint source pollution: watershed management and hydrology. CRC Press. 342p.

Trescott, A., 2012. Remote Sensing Models of Algal Blooms and Cyanobacteria in Lake Champlain, ScholorWorks@UMass Amherst, Amherst, 2012.

Sharpley, A. N., Daniel, T., Gibson, G., Bundy, L., Cabrera, M., Sims, T., and Parry, R. 2006. Best management practices to minimize agricultural phosphorus impacts on water quality.

Smith, V.H. 1983. Low nitrogen to phosphorus ratios favor dominance by blue-green algae in lake phytoplankton. Science 221(4611): 669-671.

Smith, C.S., and M.S. Adams. 1986. Phosphorus transfer from sediments by Myriophyllum spicatum. Limnology and Oceanography, 31(6), 1312-1321.

Sonzogni, W. C., Chapra, S. C., Armstrong, D. E., & Logan, T. J. 1982. Bioavailability of phosphorus inputs to lakes. Journal of Environmental Quality, 11(4), 555-563.

Toth, L.G. and Padisak, J. 1986. Meteorological factors affecting the bloom of *Anabaenopsis-raciborskii* Wolosz (Cyanophyta, Hormogonales) in the shallow Lake Balaton, Hungary. Journal of Plankton Research 8:353-363.

Town of Groveland. 2018. Town of Groveland and Conesus Lake. http://www.grovelandny.org/About_Us/Conesus_Lake_/conesus_lake_.html.

Town & Village of Geneseo, NY. 2012. Annual Drinking Water Quality Report for 2012: Geneseo Village Public Water Supply. https://geneseony.org/village/pdf/2012WaterQuality.pdf.

USEPA (United States Environmental Protection Agency). 1998. National Strategy for the Development of Regional Nutrient Criteria. EPA-822-F-98-002. water.epa.gov/scitech/swguidance/standards/criteria/nutrients/strategy/nutsy.cfm.

USEPA. 2006. National Primary Drinking Water Regulation: Stage 2 Disinfection and Disinfection Byproducts Rule, *Federal Register*, Parts 9, 141 and 142.

www.federalregister.gov/articles/2006/01/04/06-3/national-primary-drinking-water-regulations-stage-2-disinfectants-and-disinfection-byproducts-rule.

USEPA. 2015. Drinking Water Health Advisory for Cyanobacterial Microcystin Toxins. EPA-820R15100. https://www.epa.gov/sites/production/files/2017-06/documents/microcystins-report-2015.pdf.

USEPA. 2016. Draft Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. EPA Document Number: 822-P-16-002. December 2016.

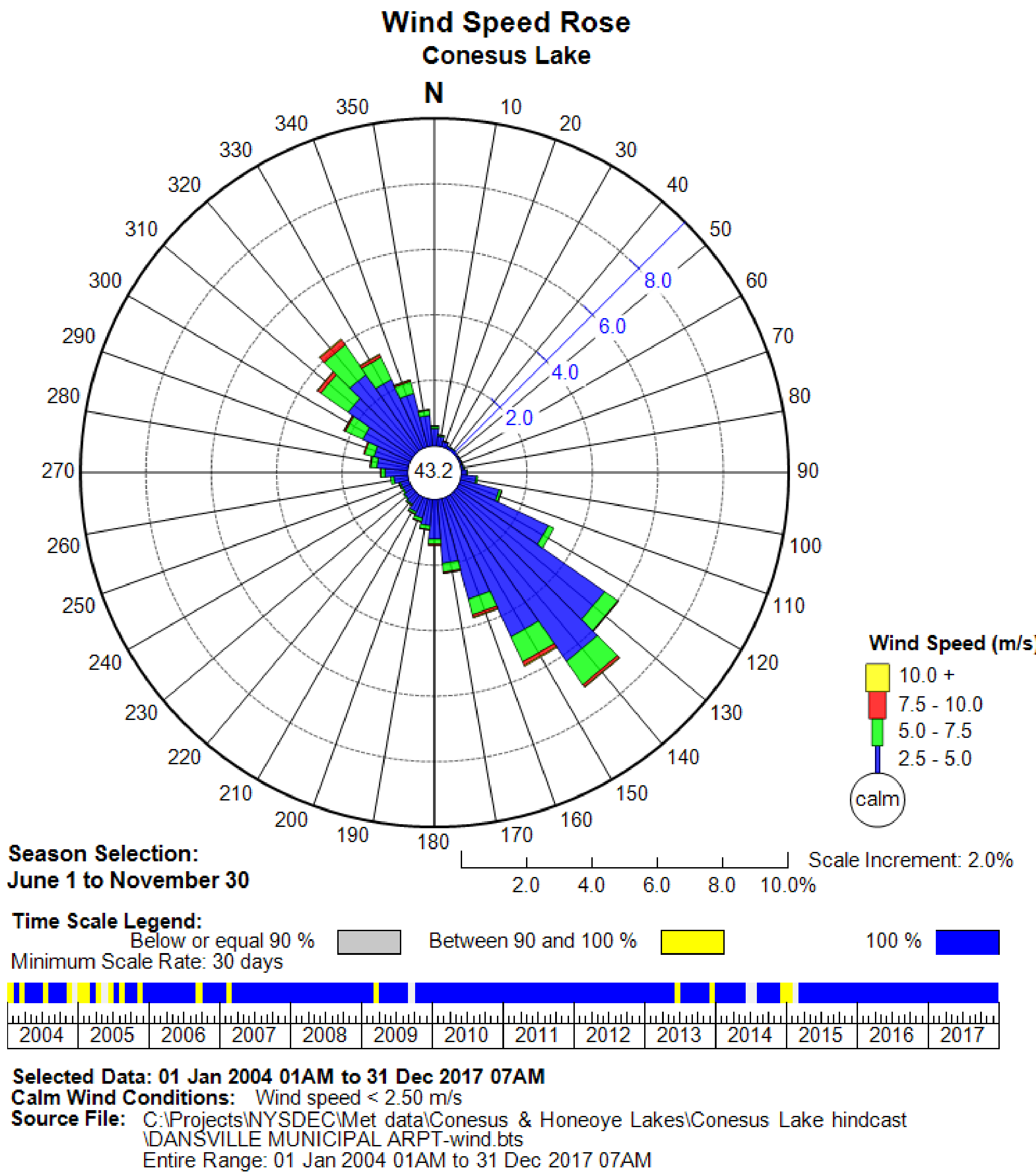
USEPA and NYSDEC. 2017. Total Maximum Daily Load (TMDL) for Phosphorus in Conesus Lake (Draft), Livingston County, New York. November 8, 2017.

Vanderploeg, H. A., Liebig, J. R., Carmichael, W. W., Agy, M. A., Johengen, T. H., Fahnenstiel, G. L., and Nalepa, T. F. 2001. Zebra mussel (*Dreissena polymorpha*) selective filtration promoted toxic *Microcystis* blooms in Saginaw Bay (Lake Huron) and Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 58: 1208-1221.

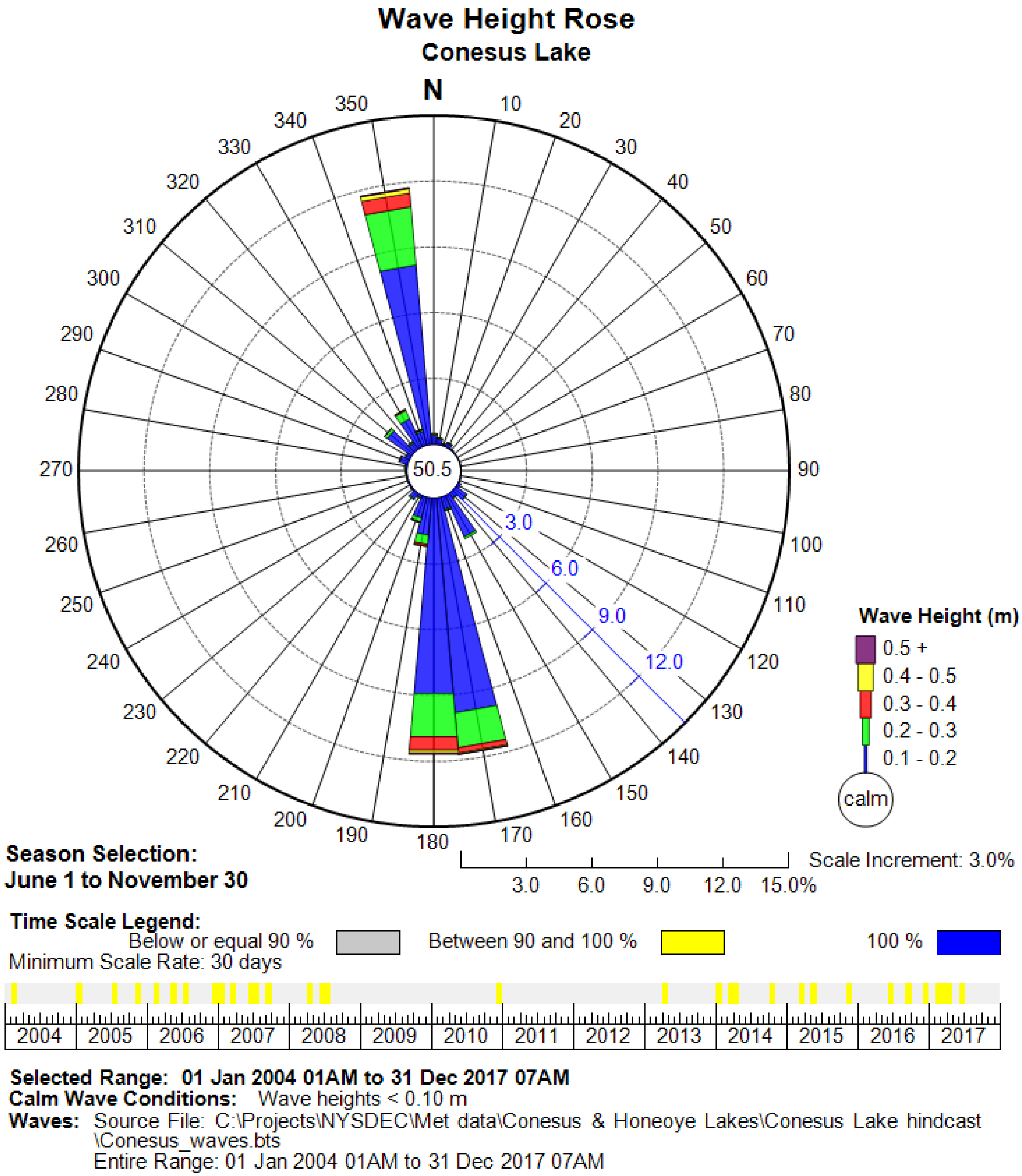
Young, T.C., J.V. DePinto, S.E. Flint, S.M. Switzenbaum, and J.K. Edzwald, 1982. Algal Availability of Phosphorus in Municipal Wastewater. Journal of Water Pollution Control Federation 54:1505-1516.

Zhou, H., Wang, J., Wan, J., and Jia, H. 2010. Resilience to natural hazards: A geographic perspective. Natural Hazards. 53. 21-41.

Appendix A. Wind and Wave Patterns



Wind speeds at Conesus Lake from 2004 to 2017 (June through November) indicate that stronger winds were generally out of the northwest, and southeast.



Wave height patterns from 2004 to 2017 (during the months of June through November) indicate wave heights were greater in the northern and southern extents of Conesus Lake. Wave heights were calculated with data from Dansville Municipal Airport.

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[1]. 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**.

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

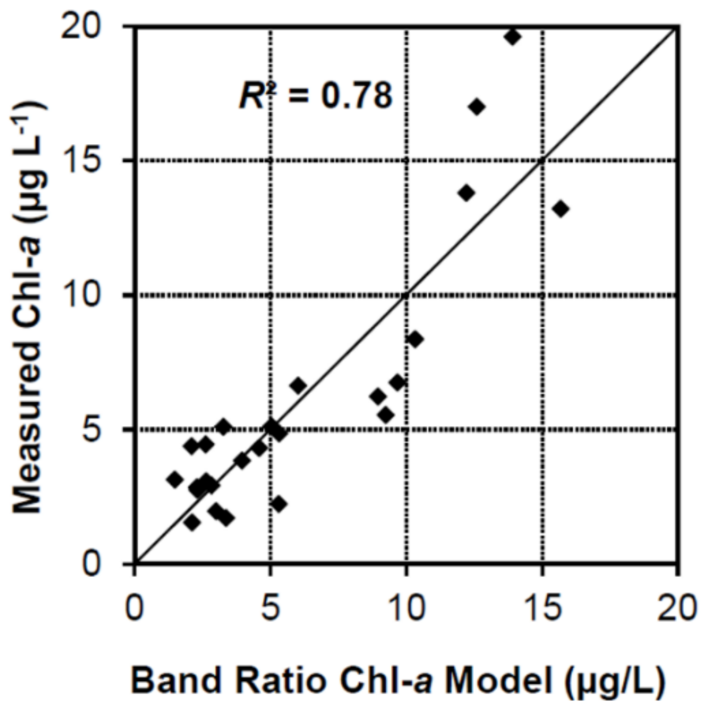


Figure C1. Measured and modeled chlorophyll-a concentrations for Lake Champlain, from Trescott 2012.

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[2]. 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

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

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 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.

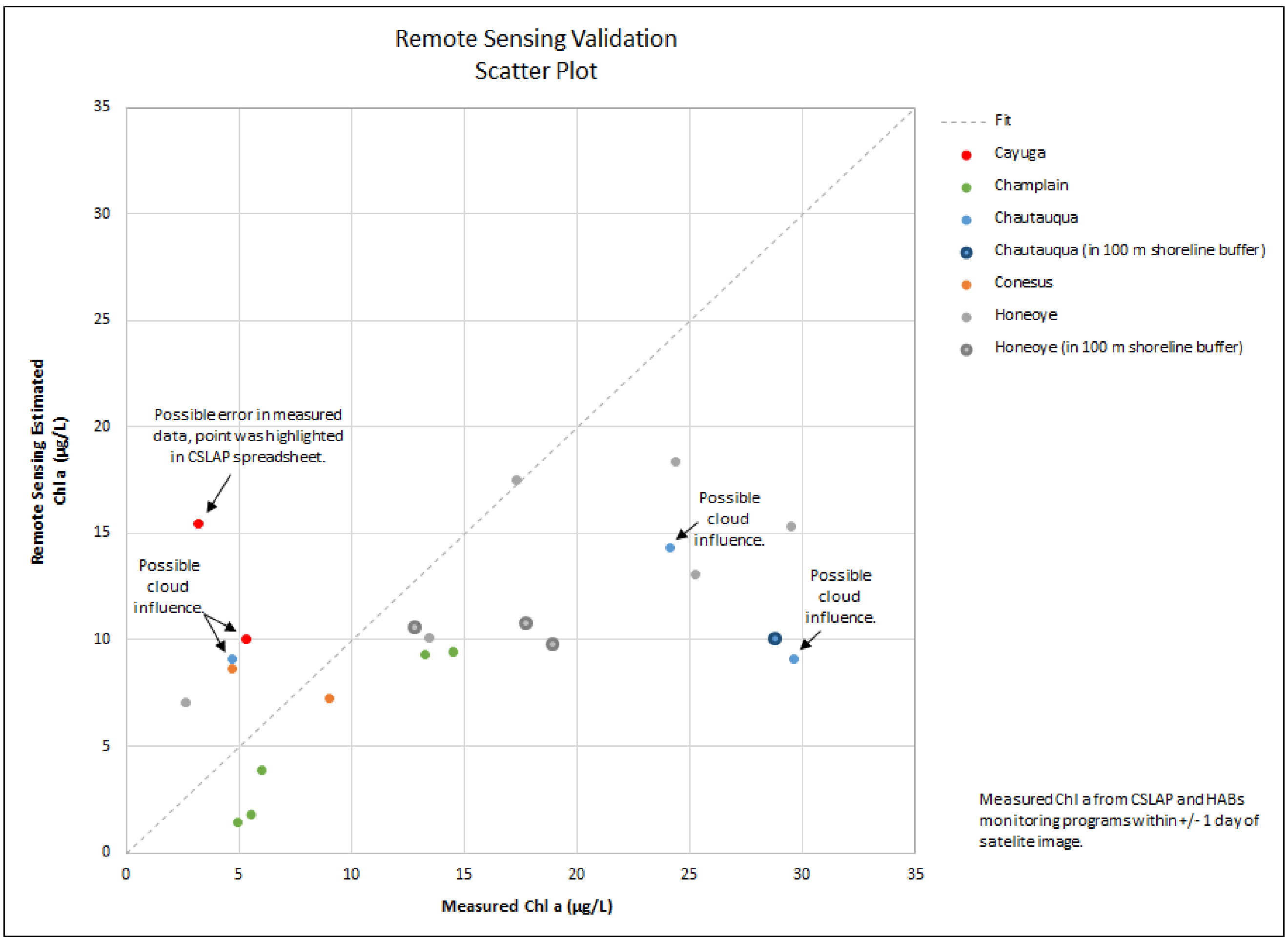


Figure C2. Measured and modeled chlorophyll-a concentrations for Cayuga Lake, Lake Champlain, Chautauqua Lake, Conesus Lake, and Honeoye Lake (2016-2017 data).

Limitations of the Method

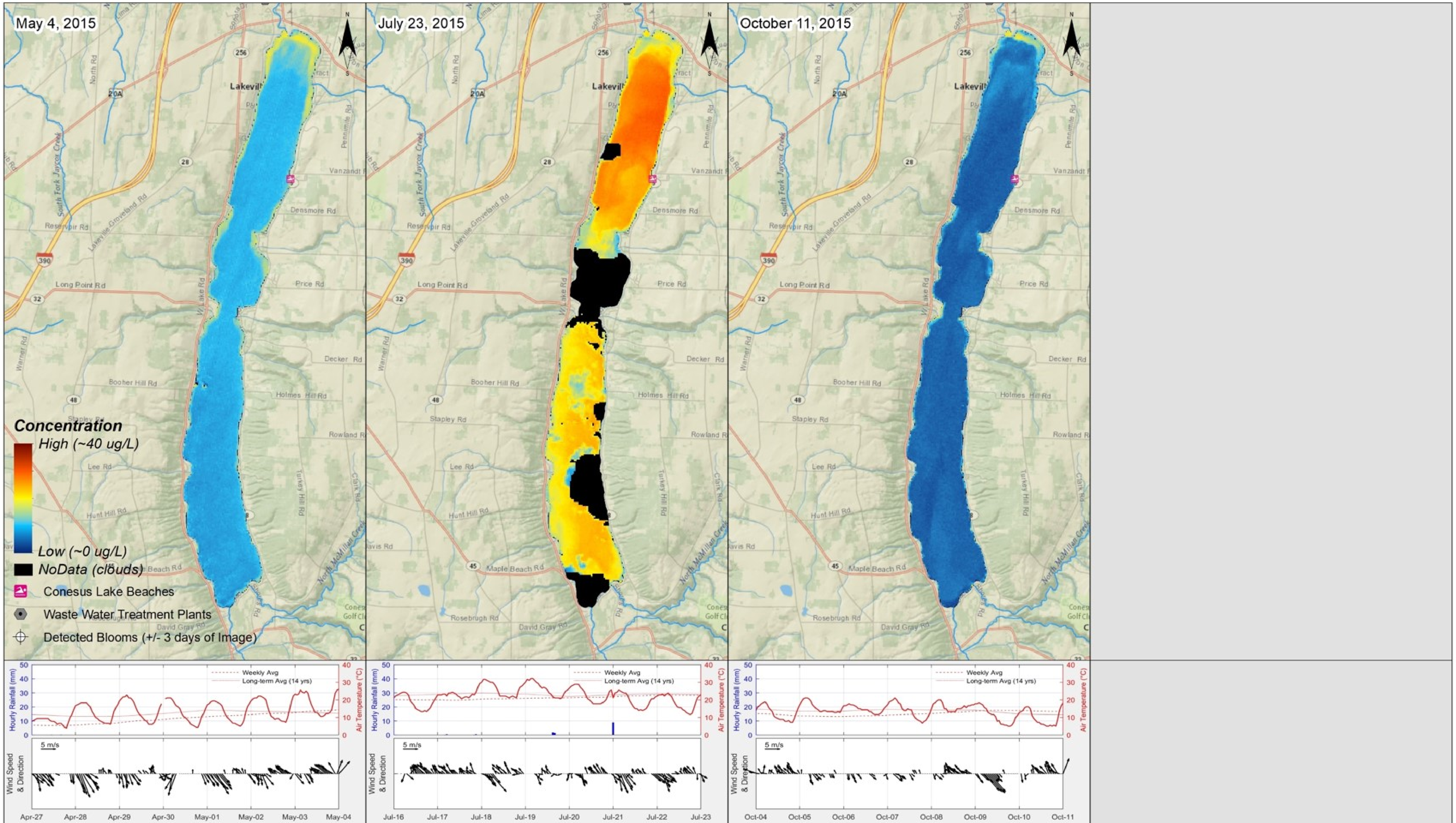
The remote sensing chlorophyll-a model was developed for Lake Champlain using four years of coincident in-situ chlorophyll-a measurements and Landsat 7 imagery. The model was calibrated and cross-validated using samples that were collected within one day of the satellite overpasses and imagery that was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



1:80,000

0 1 2 Miles

0 1 2 3 Kilometers

Plots

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

Satellite Derived Chlorophyll a

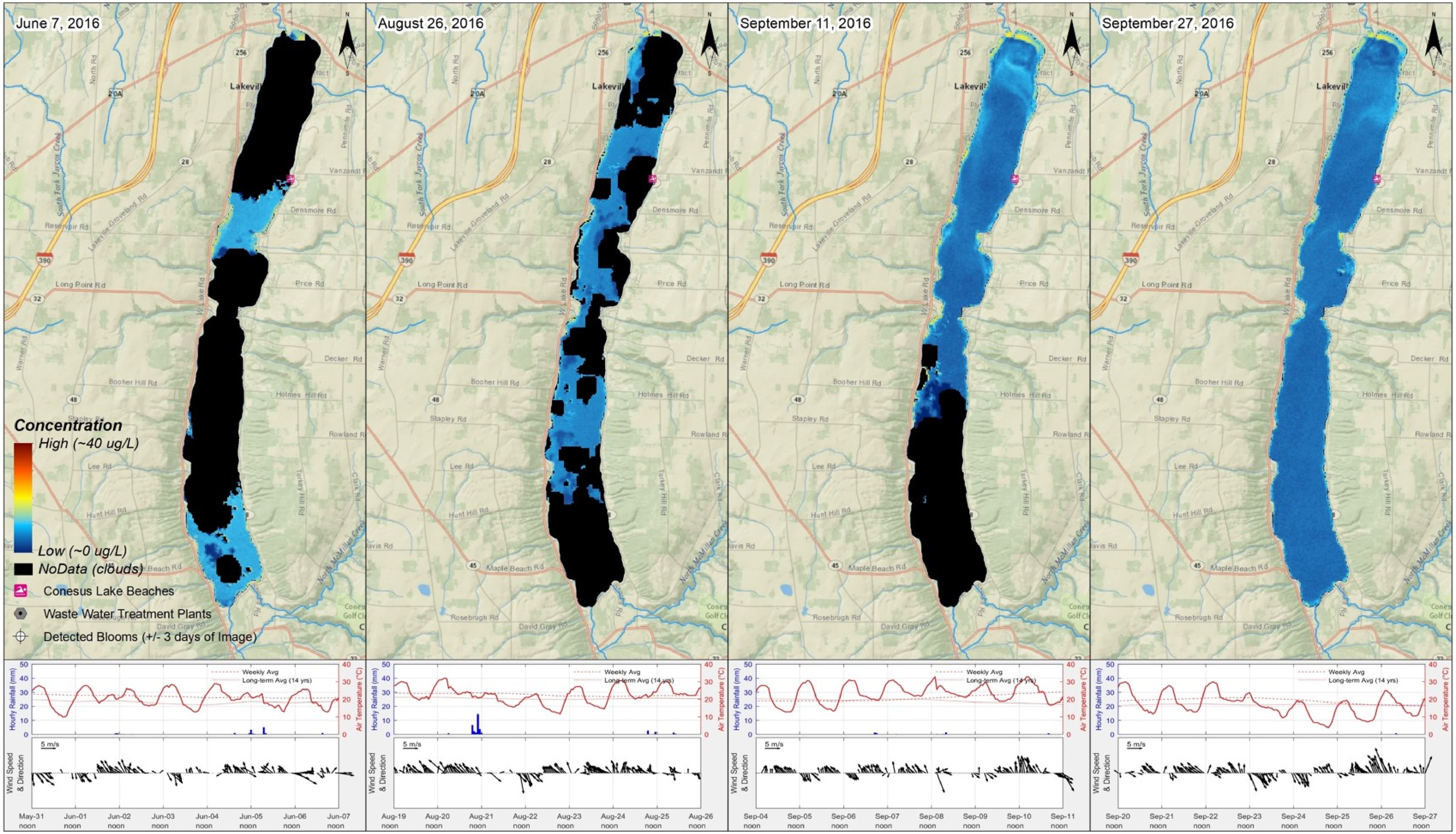
Chl-a Data is Derived from NASA's LandSat 8 Satellite

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



1:80,000

0 1 2 Miles

0 1 2 3 Kilometers

Plots

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

Satellite Derived Chlorophyll a

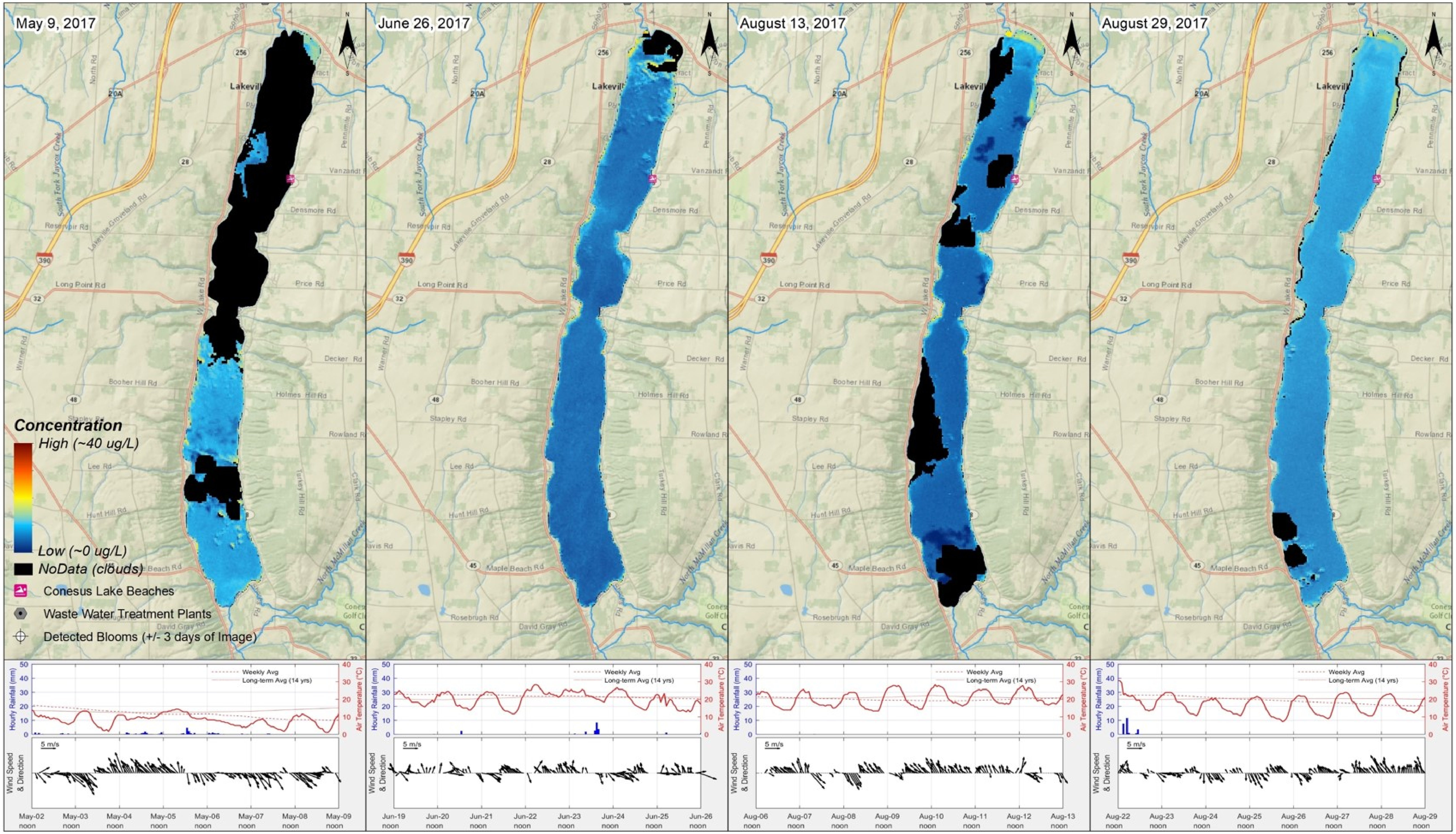
Chl-a Data is Derived from NASA's LandSat 8 Satellite

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



1:80,000

0 1 2 Miles

0 1 2 3 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

Appendix D. NYSDEC Water Quality Monitoring Programs

Extracted information from http://www.dec.ny.gov/chemical/81576.html

Appendix E. WI/PWL Summary

Conesus Lake (0402-0004) **Impaired**

Waterbody Location Information

Revised: 05/01/2018

Water Index No:	Ont 117- 40-P67	**Water Class:**	AA
Hydro Unit Code:	Conesus Creek (0413000301)	**Drainage Basin:**	Genesee River
Water Type/Size:	Lake/Reservoir 3207.6 Acres	**Reg/County:**	8/Livingston (26)
Description:	entire lake		

Water Quality Problem/Issue Information

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

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

Known: Algal/Plant Growth, NUTRIENTS (PHOSPHORUS), Problem Species (Eurasion Watermilfoil), Low D.O./Oxygen Demand (Oxygen Demand)

Suspected: Chlorine (disinfection by-products), Silt/Sediment

Unconfirmed: Chloride/Salts, Other Pollutants (THM precursors), Pathogens, Pesticides, Priority Organics (PCBs)

Source(s) of Pollutant(s)

Known: Agriculture, INTERNAL LOADING

Suspected: Habitat/Hydrological Modification, On-Site/Septic Syst

Unconfirmed: ---

Management Information

Management Status: Funding for Strategy Implementation Needed

Lead Agency/Office: DOW/BWRM

IR/305(b) Code: Impaired Water Requiring a TMDL (IR Category 5)
Impaired Water, Pollution not a Pollutant (IR Category 4c)

Further Details

Overview

Conesus Lake is assessed as an impaired waterbody due to primary and secondary contact recreation uses known to be impaired by elevated nutrient loads and aquatic vegetation growth. Agricultural nonpoint sources are thought to be a significant contributor to the nutrient loads. Internal recycling nutrient loads are also believed to be significant. The eutrophic conditions of the lake also affect aquatic life and water supply uses.

Use Assessment

Conesus Lake is a Class AA waterbody required to support and protect the best use as a source of water supply for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing use.

Conesus Lake is used as a public supply for the Villages of Avon and Geneseo and serves a total population of over 10,000. The most recent annual water quality report indicates no contaminants in finished (treated) water exceed regulatory limits. A Source Water Assessment by the NYSDOH conducted in the early 2000s found some elevated susceptibility to contamination due to agricultural activity in the watershed. However, it is important to note that SWAP reports estimate the potential for untreated drinking water sources to be impacted by contamination and do not address the quality of treated finished potable tap water. This level of susceptibility is also typical of many water supplies that experience no impacts to water supply use and reflects the need to protect the resource. (NYSDOH, Source Water Assessment Program, 2005)

The evaluation of potable water use focuses on the source water prior to treatment, and does not necessarily reflect the quality of water distributed for use after treatment. Monitoring of water quality at the tap is conducted by local water suppliers and public health agencies. Water supply use of Conesus Lake is considered to be stressed due to elevated algae levels and other organic matter, which when exposed to water treatment disinfection can result in by-products (DBPs). The Consumer Confidence Report for the Village of Geneseo from 2014 through 2016 indicated total trihalomethane (TTHM) levels that occasionally reach or exceed the stage II maximum contaminant level (MCL), although most readings are well below the MCL. NYSDEC/DOW, BWAM/LMAS, April 2018)

Primary and secondary contact recreation are considered to be impaired due to elevated nutrients (phosphorus), excessive algae, dense rooted aquatic vegetation and poor water clarity. These uses are also impaired by the frequent closure of several beaches due to harmful algal blooms. These blooms have resulted in periodic closure of several public beaches on Conesus Lake, as overseen by the Livingston County Department of Health and the Blue Green Algae Detection and Response Plan developed by the Conesus Lake Watershed Council. Some of these blooms have also been documented by SUNY Geneseo. There were 40 days of beach closures at Southern Shores Beach, Camp Stella Maris Beach or Long Pont Park due to HABs in 2014, but fewer than 10 days of closures in other recent years. Dense rooted aquatic vegetation severely impacts the bathing use of this lake. Non-contact recreation (boating, fishing) is also affected by excessive aquatic vegetation and the presence of invasive plant growth (Eurasian watermilfoil). Aesthetic conditions of the lake are considered to be poor due to algal blooms and excessive aquatic vegetation. (DEC/DOW, BWAM/LMAS, July 2013; April 2018)

Fishing use is considered to be supported but stressed based on the occurrence of episodic (summer) dissolved oxygen depletion in deep waters of the Lake. The depressed D.O. is the result of eutrophic conditions resulting from high nutrient levels. In spite of the episodic low D.O., the lake provides enough refuge for warmwater species the support a productive fishery for warmwater sportfish and panfish. Northern pike, smallmouth bass, largemouth bass and walleye comprise the sportfishery; yellow perch, bluegills, pumpkinseed and brown bullhead are the principal panfish.

Over the years the species balance has shifted. During the 1960's, Conesus Lake produced an outstanding walleye fishery and yellow perch ice fishing. But these populations diminished over the 1970s and 80s likely due to invasive alewives. More recently the perch and walleye fisheries appear to be improving and the Lake continues to produce excellent fishing for bass, northern pike, bluegills and sunfish. Stocking of tiger muskellunge began in the 1990s. Zebra mussels, which can have a significant ecological impact, have been documented in the lake. While it is likely that zebra mussels affect phytoplankton (algae and cyanobacteria) dynamics in the lake, the effect of these invasive mussels on other aquatic life is not known. (DEC/DOW, BWAM/LMAS, April 2018)

Fish Consumption use is considered to be unassessed. There are no health advisories limiting the consumption of fish from this waterbody (beyond the general advice for all waters). However due to the uncertainty as to whether the lack of a waterbody-specific health advisory is based on actual sampling, fish consumption use is noted as unassessed. (NYSDOH Health Advisories and NYSDEC/DOW, BWAM, April 2018)

Water Quality Information

Water quality sampling of Conesus Lake has been conducted through the NYSDEC Lake Classification and Inventory (LCI) in 1985 and 2005, Citizens Statewide Lake Assessment Program (CSLAP) from 1986 through 1991 and in 2017, and a Finger Lakes Water Quality effort in the late 1990s and mid 2000s, as well as by various other academics and researchers. Results of this sampling indicate the lake is best characterized as mesoeutrophic to eutrophic, or highly productive. Chlorophyll/algal levels frequently exceed criteria corresponding to impacted recreational uses, while phosphorus concentrations are typically high. Lake clarity measurements indicate water transparency typically meet the recommended minimum criteria for swimming beaches. The hypolimnion of the lake becomes anoxic during mid to late summer, with dissolved oxygen levels dropping to near zero in a significant portion of the hypolimnion. Summary reports from this sampling will be posted on the websites from NYSDEC (http://www.dec.ny.gov/lands/77853.html) and the New York State Federation of Lake Associations (http://www.nysfola.org/cslap/). (DEC/DOW, BWAM/LMAS, July 2015; April 2018)

The NYSDEC HABs Notification Program confirmed the presence of HABs in Conesus Lake during the recreational seasons of 2014 through 2017. In 2017, Conesus Lake was on the HABs Notification List for 8 weeks. The blooms in 2017 were small localized blooms.

Source Assessment

Internal recirculation of nutrient loads from lake sediment is the major source of nutrient load to the lake, contributing 80 percent of the phosphorus. Agricultural activity in the lake watershed occurs in approximately 40 percent of the watershed and is considered to be a significant source of nutrient load. Instances of concentrated animal waste releases into the streams in the lake watershed have been documented by the county. Additionally, this is the most heavily developed of the Finger Lakes. There has been some sewering of nearshore residences, but onsite septic impacts are suspected of contributing to water quality impacts. (DEC/DOW, BWAM/LMAS and Region 8, July 2015).

Management Actions

NYSDEC is currently developing a TMDL/watershed plan to address the phosphorus loads in the Lake. Previous considerable local community and stakeholders efforts have been committed to addressing water quality concerns in the Lake. These include sewer extensions to better address wastewater discharges, nearly $2 million in federal, state and local funding to install various BMPs in the watershed, amended zoning regulation and public education efforts. (DEC/DOW, BWRM, April 2018).

This waterbody is considered a highly-valued water resource due to its drinking water supply classification and as a multi-use lake. On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Conesus Lake was identified for inclusion in this initiative as it is vulnerable to HABs and is a critical drinking water source. (DEC/DOW, BWRM, April 2018).

Section 303(d) Listing

Conesus Lake is included on the current (2016) NYS Section 303(d) List of Impaired/TMDL Waters. The waterbody is included on Part 1 of the List as a waterbody requiring development of a TMDL or other strategy to address phosphorus and the resulting Low D.O. (DEC/DOW, BWAM/WQAS, May 2017)

Segment Description

This segment includes the total area of the entire lake. The lake is designated Class AA.

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 Conesus Lake 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.