NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation | Department of Health | Agriculture and Markets

HARMFUL ALGAL BLOOM ACTION PLAN PALMER LAKE

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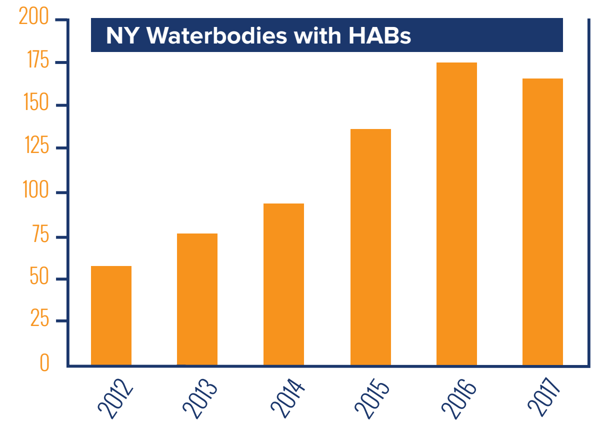
EXECUTIVE SUMMARY

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.

PALMER LAKE

Putnam County

Palmer Lake, a 14-acre manmade lake in Putnam County, is one of the 12 priority lakes impacted by HABs. The lake is a part of the Croton System of New York City water supply reservoirs and is a tributary to the Croton Falls Reservoir. There are no public beaches on the lake, but private club members have access to seasonal swimming and water recreation on the lake.

Based on historical data and water quality monitoring conducted in 2016-17, Palmer Lake was designated as an “impaired waterbody” due to excessive nutrients, algal growth, and reduced water clarity, which could impact recreational uses in the lake.

The significant sources of phosphorus loading in the lake are:

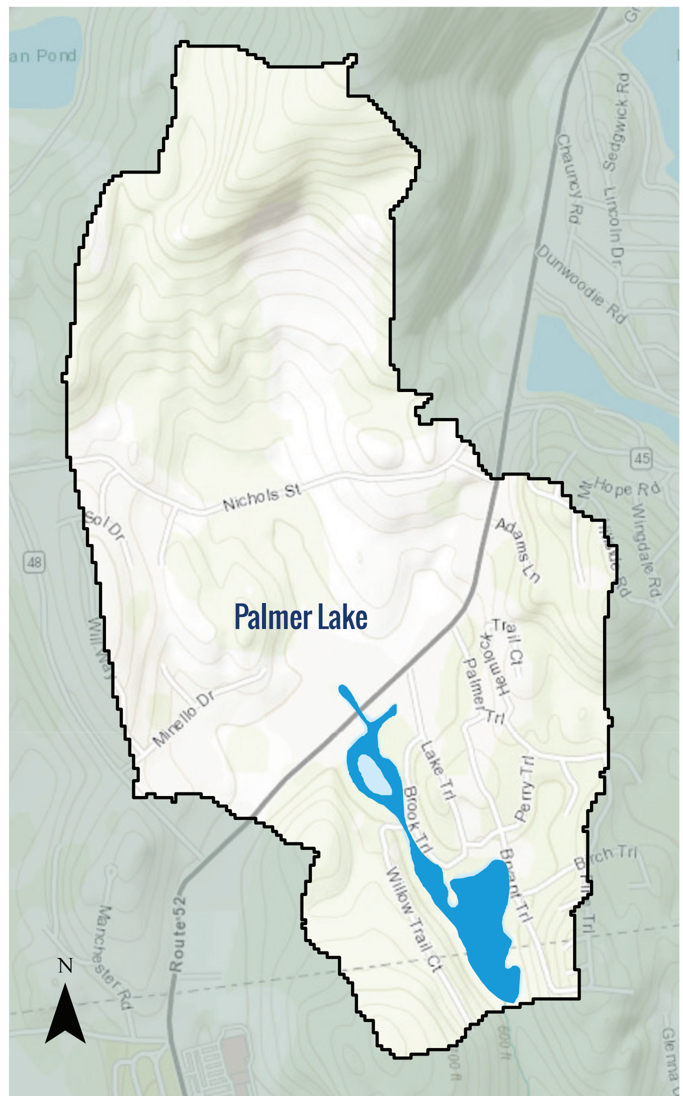
- Phosphorous inputs associated with septic system discharge; and
- Nonpoint source nutrient inputs from the contributing watershed.

There has been one confirmed HAB in the lake, a localized occurrence in 2017. It is not known if other HABs have occurred in the lake.

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 Palmer Lake, including the following:

- Construct a wastewater treatment plant (WWTP) and install infrastructure required to connect 300 houses or a subset of residences;
- Dredge bottom sediment to reduce re-sedimentation and introduction of legacy, sediment-bound phosphorus; and
- Continue to improve stormwater management within the watershed.



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.

PALMER 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 Palmer 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 Palmer 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.

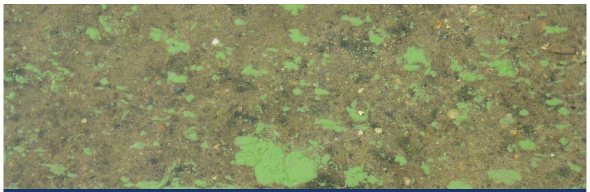
Research, Surveillance, and Monitoring:

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:

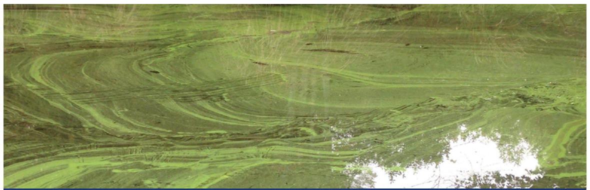
State laws and programs help control pollution and reduce nutrients from entering surface waters. State funding is available for municipalities, soil and water conservation districts, and non-profit organizations to implement projects that reduce nutrient runoff.

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.

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1. Introduction

1.1 Purpose

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

These resources, and the plants and animals they harbor, provide both the State and the local communities a wealth of public health, economic, and ecological benefits including potable drinking water, tourism, water-based recreation, and other 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 Palmer 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 into the future.

1.2 Scope, Jurisdiction and Audience

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

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

Based on these criteria, the Governor's HABs initiative has selected 12 New York State waterbodies that are representative of waterbody types, lake conditions, and vulnerability to HABs throughout the State. Palmer Lake, with its swimming beach, recreational opportunities, and proximity to the New York City drinking water supply, was selected as one of the priority waterbodies, and is the subject of this HABs Action Plan.

The intended audiences for this Action Plan are as follows:

- Members of the public interested in background information about the development and implications of the HABs program
- New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), and New York State Department of Agriculture and Markets (NYSDAM) officials associated with the HABs initiative
- State agency staff who are directly involved in implementing or working with the NYS HABs monitoring and surveillance program
- Local and regional agencies involved in the oversight and management of Palmer Lake (e.g., Putnam County Soil and Water Conservation District [SWCD], Departments of Health [DOH], and the New York City Department of Environmental Protection [NYCDEP]).
- Lake residents, managers, consultants, and others that are directly involved in the management of HABs and water quality in Palmer Lake.

Analyses conducted in this Action Plan provide insight into the processes that potentially influence the formation of HABs in Palmer Lake, and their spatial extents, durations, and intensities. Implementation of the mitigation actions recommended in this HABs Action Plan are expected to reduce the likelihood of blooms in Palmer 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 Palmer Lake, and has produced this Action Plan to identify the primary factors triggering HAB events, and to facilitate decision-making to minimize the frequency, intensity, and duration of HABs.

2. Lake Background

2.1 Geographic Location

Palmer Lake is a 14-acre man-made lake located in Putnam County, approximately 50 miles north of New York City, and approximately seven miles west of the New York/ Connecticut state line (**Figure 1**). Portions of Palmer Lake and its watershed are within the limits of two towns, Carmel and Kent (**Figure 2**). The Lake and its surrounding lands are currently managed by the residents of the Hill and Dale Country Club with deeded lake rights.

2.2 Basin Location

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

Palmer Lake is located within the Lower Hudson River basin in southeastern New York, which includes most of Westchester, Putnam, Orange, Ulster, Columbia, and Albany Counties; much of western and central Dutchess, eastern Greene, and southern Rensselaer Counties; and smaller parts of New York (Manhattan), Bronx, Rockland, Sullivan, Schoharie and Schenectady Counties (NYSDEC 2018a). Palmer Lake is also part of the Croton watershed which consists of 375 square miles within Putnam, Dutchess, and Westchester counties. Palmer Lake is tributary to Croton Falls reservoir, which is part of the New York City drinking water supply. The Croton System provides approximately 10% of the New York City drinking water supply, through the Croton Water Treatment Plant. The Palmer Lake watershed is 460 acres and is contained entirely in Putnam County.

2.3 Morphology

Palmer Lake is shallow, with a mean depth of 1.2 meters (4 feet) and a maximum depth of 2.2 meters (7 feet) (CSLAP 2017). The lake is 586 feet above mean sea level and is oriented northwest to southeast (**Figure 2**). The surface area of the lake is 14 acres, measuring 2,450 feet long and 625 feet wide at its widest point, with a shoreline perimeter of 8,465 feet (NYSDEC 2018a). The Palmer Lake watershed drains primarily forested and residential lands, with open water and wetlands representing a small portion of the watershed. Agricultural use in the watershed is also limited (CSLAP 2017).

Palmer Lake's watershed to lake surface area ratio is 33:1, a relatively high value that contributes to elevated watershed pollutant loading and a low hydraulic retention time (see **Section 2.4**). The shallow depths and high watershed to lake area ratio contribute to significant temperature fluctuations (including elevated temperatures during summer months), high productivity, and wind-aided mixing. These characteristics can result in conditions that are favorable to HABs.

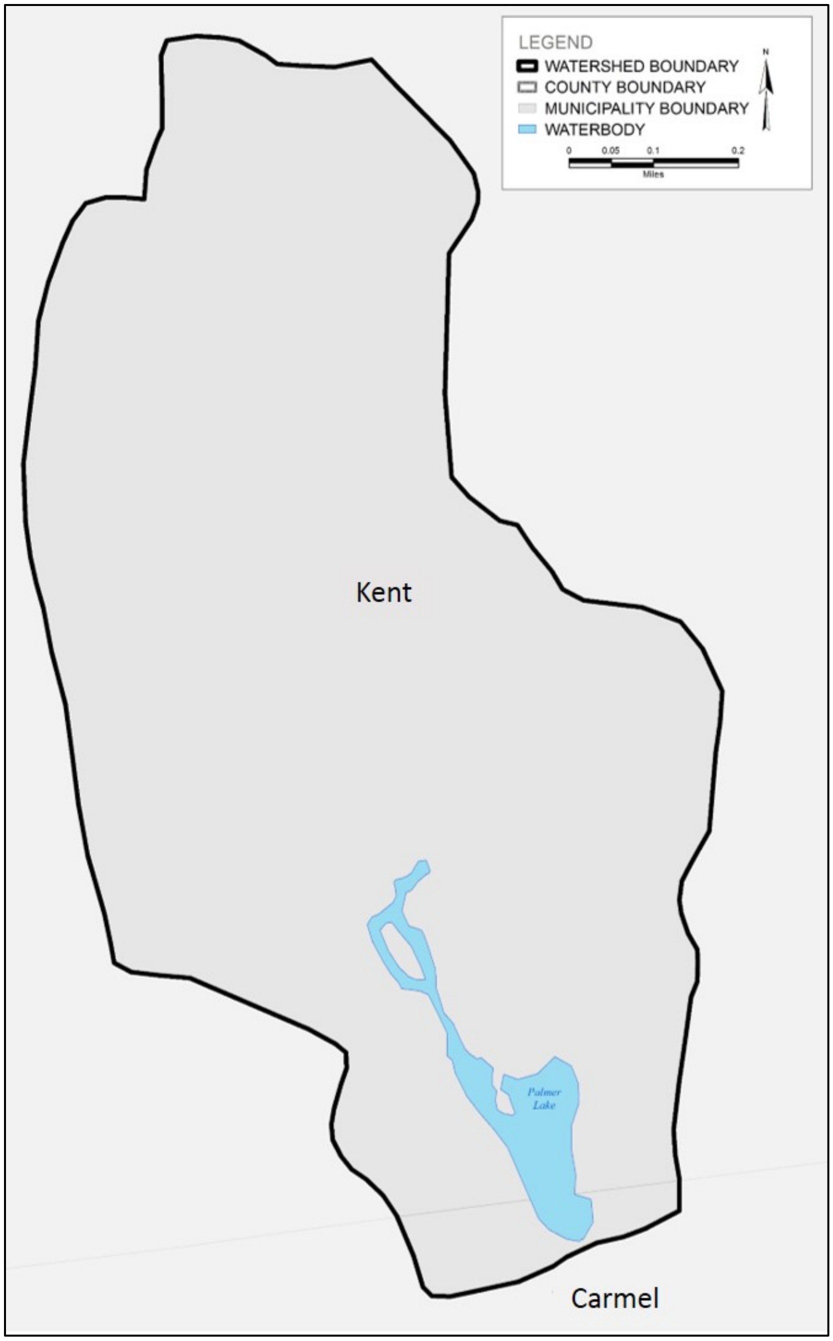

Figure 2. Political boundaries within the Palmer Lake watershed.

The wind rose in **Appendix A** indicates that the prevailing winds influencing Palmer Lake during the June to October interval of 2006-2017 were stronger out of the south-southwest and northeast, as measured from the Danbury Municipal Airport. This predominant wind pattern results in a fetch length of 1,000 to 625 feet given the northwest to southeast orientation of the lake. Note that given the relatively small surface area of Palmer Lake, the prevailing strong wind patterns may not have a significant impact on the accumulation of cyanobacteria at any particular location, as a bloom would likely impact the entire lake.

2.4 Hydrology

Palmer Lake's hydraulic retention time, or the amount of time water spends in a lake, is estimated to be 19 days (CSLAP 2017) which is a relatively low value resulting from the Lake's high watershed to lake surface area ratio. This annualized value of retention time may be substantially longer during the summer months (Princeton Hydro LLC. 2014), which might offset the potential benefits of the low retention time “flushing” excess nutrients. There are two inflowing tributaries to Palmer Lake and one outflowing tributary. One of the inflowing tributaries originates from a small pond located approximately 150 feet east of the lake. This tributary is unnamed and discharges surface water to the northeast lobe of the lake immediately west of Bryant Trail. The other inflow to the lake is an unnamed stream that flows from the north through forested/shrub wetlands before discharging to the lake’s north end. Michaels Brook receives water from the lake at its southern end, and flows into the Croton Falls Reservoir.

2.5 Lake Origin

The Hill and Dale community originally comprised summer retreat homes built in the late 1920s. With advancements in transportation in the Kent/Carmel area and easier commuting to nearby urban areas, residents winterized their homes and settled permanently in the community (HDCC 2018). Palmer Lake was created as an impoundment to Michaels Brook for the recreational benefit to community homeowners.

3. Designated Uses

3.1 Water Quality Classification – Lake and Major Tributaries

Palmer Lake is a Class B waterbody under the New York Codes, Rules, and Regulations (6 NYCRR Part 864.6), which means that it is best intended for contact recreation (i.e., swimming and bathing), non-contact recreation (i.e., boating and fishing), aesthetics, and aquatic life. The primary uses of Palmer Lake are described in the following sections, and the New York state classification system is provided in **Appendix B**.

The eastern unnamed tributary is identified as a Class C water, best used for fishing, fish propagation and survival. Class C water quality is suitable for primary and secondary contact recreation, unless other factors limit the use for these purposes. The northern tributary is a Class B watercourse. Michaels Brook, the outlet of the lake, is a B-classified watercourse, and discharges to the Croton Lake Reservoir, one of New York City’s public water supply reservoirs. The occurrence of HABs in Palmer Lake represents a potential threat to downstream water bodies, including those that serve as potable water sources for New York City. Additional discussion is provided in **Sections 3.2** and **3.7**.

3.2 Potable Water Uses

Palmer Lake is a part of the Croton System of New York City water supply reservoirs and is a tributary to the Croton Falls Reservoir. The Croton System supplies the City with approximately 10% of its drinking water (NYC Water 2013). An agreement between the New York City Department of Environmental Protection (NYCDEP) and the Croton Watershed communities (including the Palmer Lake area) is in place to provide programmatic guidance and funding for watershed protection (NYSDEC 2008).

While Palmer Lake is not used as a source of potable drinking water, the U.S. Environmental Protection Agency (USEPA) sets health advisories to protect people from being exposed to contaminants in drinking water for those waterbodies that are used for this purpose. As described by the USEPA: “The Safe Drinking Water Act provides the authority for the 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 1000-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 HAB toxin found.

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

3.3 Public Bathing Uses

There are no public bathing areas or beaches at Palmer Lake. A community bathing beach is present on the eastern shoreline of the lake and enjoyed by the Hill and Dale Country Club homeowners and their guests during the summer months. Swimming is permitted in the beach area under the supervision of a licensed lifeguard (HDCC 2018).

Given the prevailing wind patterns in Palmer Lake (**Appendix A**), the community bathing beach along the northeastern shoreline may be susceptible to beach closures and negative effects on public health based on the potential for HABs to accumulate in this portion of the lake from southwesterly winds. In addition, non-HAB blooms that may occur have the potential to accumulate due to winds. However, as noted above, the small surface area and fetch for the lake may minimize bloom accumulations in any portion of the lake, including swimming beaches or common recreational areas.

3.4 Recreation Uses

The Palmer Lake area has four miles of walkways and trails connecting residents and recreational areas, including Palmer Lake. As discussed in **Section 3.3**, Hill and Dale Country Club residents and their guests enjoy seasonal swimming at the community beach. Other popular water activities including kayaking, canoeing, catch-and-release fishing, and walking. Lydia Park, which surrounds a small section of the lake, offers playgrounds, multi-use fields, and tennis and basketball courts to Hill and Dale residents and guests (HDCC 2018).

3.5 Fish Consumption/Fishing Uses

Based on Palmer Lake's morphometry, it is expected to support a typical assemblage of warmwater fish species, several of which are important recreationally and may be taken for consumption. These species include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigromaculatus*), and common carp (*Cyprinus carpio*). Recently, Palmer Lake obtained a permit to be stocked with grass carp. New York State fishing regulations are applicable in Palmer Lake for both regular fishing and ice fishing. No stocking of fish is known to occur. There are no fish consumption advisories specific to Palmer Lake (NYSDOH 2018a); however, the lake is included in the Hudson Valley/Capital District region fish consumption advisory, where it is recommended that fish consumption be limited to no more than four meals per month.

3.6 Aquatic Life Uses

As a Class B watercourse, Palmer Lake is suitable for the reproduction and survival of fish (such as those described above in **Section 3.5**), shellfish, and wildlife. The generally shallow depths and warm waters of the lake are not conducive to sustaining populations of coldwater fishes such as trout. The aquatic life use based on NYSDEC's most recent (May 2011) Waterbody Inventory/Priority Waterbodies List (WI/PWL) assessment was not assessed. However, CSLAP water quality data indicated that the aquatic life use was "supported/good" in average years and in 2017, suggesting that this use was being met (CSLAP 2017).

Quantitative data of Palmer Lake fish populations were collected by Hill and Dale Country Club. The qualitative fish species data, coupled with the absence of observed impairment to aquatic life, suggests that the fish assemblage does not significantly modify lower trophic levels in Palmer Lake. As a result, the existing aquatic life assemblage does not appear to be a driver for HABs formations. However, the feeding behavior of common carp, an invasive cyprinid that forages preferentially on benthic macroinvertebrates in lakebed sediments, can increase the suspension of sediment and nutrients into the water column. The increase in nutrient concentrations in the water column may be utilized by cyanobacteria, potentially leading to HABs.

4. User and Stakeholder Groups

Access to Palmer Lake for recreational activities such as fishing, non-motorized boating, and swimming is restricted to Hill and Dale Country Club homeowners with access rights and to guests. Hill and Dale Property Owners, Inc. is responsible for the adoption and administrative enforcement of the rules, regulations, and provisions governing the lake, playground, athletic fields and courts, and other recreational areas, as well as construction activities, ordinance adherence, signage, and property maintenance within the Hill and Dale community. These rules and regulations cover specific lake-related activities including swimming, boat motor usage, and recreational restrictions (HDCC 2018).

The Kent Lake Association is a local volunteer group concerned with the quality of nine lakes, including Palmer Lake, in the Town of Kent. The goal of this association is to engage in and discuss their collective knowledge and individual expertise of lake conditions to identify and resolve common issues (Town of Kent 2018a).

As mentioned above, there is no public access to Palmer Lake, limiting the involvement of non-governmental organizations (NGOs), sportsman groups, or other organizations.

5. Monitoring Efforts

5.1 Lake Monitoring Activities

Palmer Lake has been sampled as part of the Citizens Statewide Lake Assessment Program (CSLAP) in 2016 and 2017. Water quality parameters monitored as part of the recent CSLAP sampling in Palmer Lake include:

- Water temperature (˚C)
- Water clarity (Secchi depth)
- Total phosphorus (TP)
- Total nitrogen (TN)
- Chlorophyll-a
- pH
- Conductivity
- HABs indicators, including concentrations of toxins

Another source of water quality data for Palmer Lake was collected by the NYSDEC Lake Classification and Inventory (LCI) Monitoring Program, to support NYSDEC water quality assessments and management activities. The LCI data set for Palmer Lake comprises monthly water quality samples collected in 2010 and in 2013 between June and September.

Water quality analyses have also been conducted by Princeton Hydro LLC in 2008 and 2014 during the month of September. These assessments were prepared for Hill and Dale Property Owners Inc. and included sampling stations in the lake as well as the inlet (both years) and outlet (2008a). Lake sampling included dissolved oxygen and temperature depth profiles as well as surface and bottom TP concentrations (Princeton Hydro LLC 2008a and 2014).

5.2 Tributary Monitoring Activities

Monitoring of the unnamed tributary entering Palmer Lake from the north was conducted in September 2008 by Princeton Hydro LLC for the Croton Watershed Clean Water Coalition (Princeton Hydro LLC 2008b). Samples were collected from five stream locations and two wetlands between Burr Pond, the streams source, and Palmer Lake. Water quality data included; TP, soluble reactive phosphorus (SRP), dissolved oxygen, conductivity, and pH. Water quality data were representative of base flow conditions due to particularly dry weather conditions prior to the sampling effort; compared to the inter-annual average precipitation there was a 16% reduction in precipitation in August to early September. This sampling effort was designed to collect cursory data prior to the Kent Manor Developmental Site Waste Water Treatment Plant (WWTP) discharging into the tributary. At the time of this monitoring project the WWTP was constructed, but not functional.

6. Water Quality Conditions

Water quality data used in these analyses were limited to those that were collected under a State-approved Quality Assurance Project Plan (QAPP), and analyzed at a laboratory certified under the NYSDOH's Environmental Laboratory Approval Program (ELAP). For Palmer Lake, NYSDEC LCI data were available for 2013 and CSLAP data were available from 2016, and 2017. Thus, trend analyses for annual average data were not conducted due to low sample size.

Table 1 provides a regional summary of surface total phosphorus (TP) concentrations (mg/L) from Palmer Lake compared to New York State lakes. In freshwater lakes, phosphorus is typically the nutrient that limits plant growth; therefore, when excess phosphorus becomes available from point sources or nonpoint sources, primary production can continue unchecked leading to algal blooms. Note that the form of phosphorus is an important consideration when evaluating management alternatives (**Section 13**).

Table 1. Regional summary of average surface total phosphorus (TP) concentrations (mg/L, ± standard error) for New York State lakes (2012-2017, CSLAP and Lake Classification and Inventory (LCI)), and the average surface TP concentration (± standard error) in Palmer Lake (2016-2017, CSLAP).			
Region	**Number of Lakes**	**Average TP (mg/L)**	**Average TP - Palmer Lake (mg/L) 2016 and 2017**
NYS	521	0.034 (± 0.003)	-
NYC-LI	27	0.123 (± 0.033)	-
Lower Hudson	49	0.040 (± 0.005)	0.081 (± 0.02)
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)	-
Western NY	47	0.045 (± 0.008)	-

Regionally, the data provided in **Table 1** indicate that the average TP concentration in Palmer Lake is double the average concentration found throughout the Lower Hudson region. Further, the average TP concentration is four times greater than the New York State water quality guidance value of 0.02 mg/L for lakes, which suggests that future management actions to protect water quality should likely focus on reducing TP concentrations.

Table 2. New York State criteria for trophic classifications (NYSFOLA 2009) compared to average (± standard error) Palmer Lake values in 2016 and 2017 (CSLAP).				
Parameter	**Oligotrophic**	**Mesotrophic**	**Eutrophic**	**Palmer Lake (2016-2017)**
Transparency (m)	>5	2-5	<2	1.2 (± 0.11) (sample size = 14)
TP (mg/L)	<0.010	0.010-0.020	>0.020	0.081 (± 0.02) (sample size = 16)
Chlorophyll a (µg/L)	<2	2-8	>8	NA

HABs have been documented in Palmer Lake (CSLAP 2016), and a summary of previous HAB events in the lake is provided in **Section 7**. Water clarity (based on Secchi depth, m), TP (mg/L), and chlorophyll-a (µg/L) concentrations are used to assess trophic state using New York State criteria (**Table 2**) – throughout 2013, 2016, and 2017 water quality sampling, these indicators reflected eutrophic (high productivity) conditions.

6.1 Physical Conditions

Water clarity can be related to the amount of suspended material in the water column including sediment, algae, and cyanobacteria. Palmer Lake has lower water clarity and higher nutrient and algae levels than other lakes in the Lower Hudson region (CSLAP 2016). Specific factors that appear to have contributed to this condition are provided in the following sections. Water clarity data collected 2013 and 2016-2017 from deeper portions of Palmer Lake were on average less than 2 meters (**Figure 3**), indicating eutrophic (< 2 m, highly productive) conditions. Further, Secchi disk transparency readings did not meet the minimum New York Sanitary Code requirement for siting new bathing beaches (NYSDOH 2018b) of 1.2-meter (4 feet) 40% of the time. Such trophic indicators should continue to be monitored for any changes.

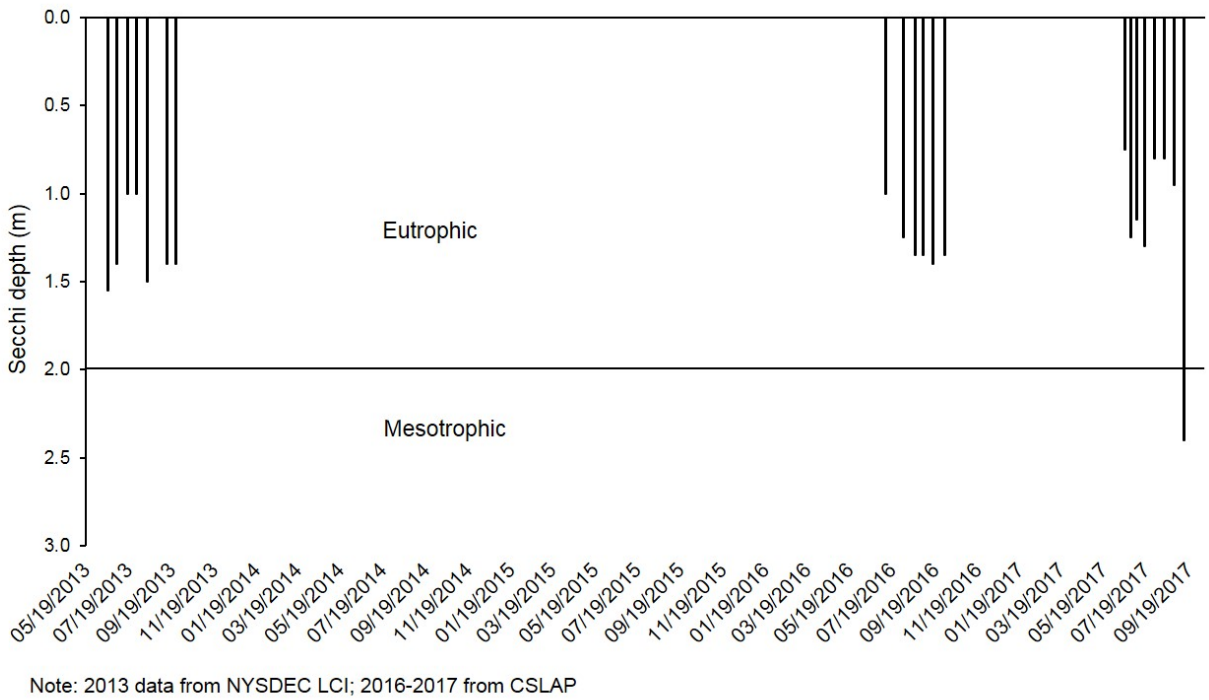

Figure 3. Palmer Lake transparency, measured as Secchi depth (m), in 2013 (LCI) and 2016 and 2017 (CSLAP).

Maximum surface water temperatures in Palmer Lake were between 25°C (77°F, 2017) and 28.5°C (83.3°F, 2013). Typical seasonal trends in temperature are shown for all sampling seasons (**Figure 4**). Understanding temperature changes within a waterbody seasonally, as well as annually, is important in understanding HABs. Most cyanobacteria taxa grow better at higher temperatures than other phytoplankton which give them a competitive advantage at higher temperatures (typically above 25^{o}C) (Paerl and Huisman 2008).

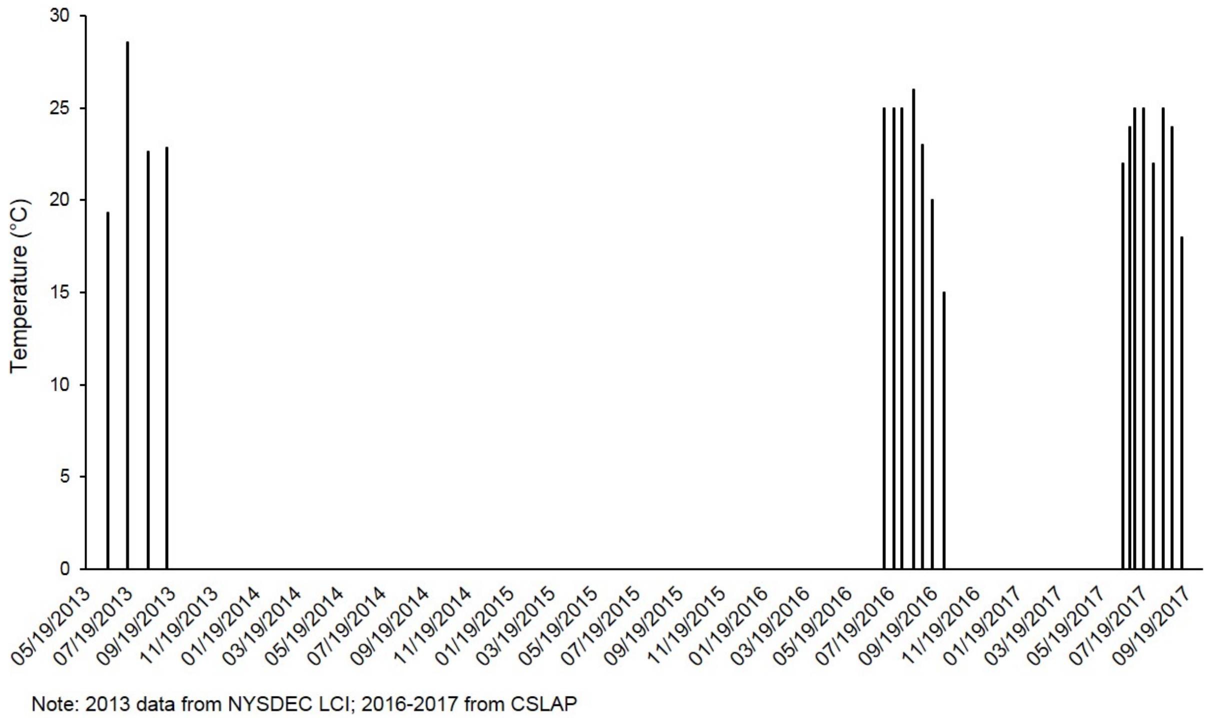

Figure 4. Surface water temperatures (°C) in Palmer Lake, in 2013 (LCI) and 2016 and 2017 (CSLAP).

6.2 Chemical Conditions

Results from Past Studies

Princeton Hydro LLC (2008, 2014) conducted water quality studies in 2008 and 2014, which showed elevated phosphorus concentrations above the New York water guidance value of 0.02 mg/L for lakes. Temperature and dissolved oxygen depth profiles indicated that Palmer Lake is not stratified and is typically well mixed. In 2008, depleted dissolved oxygen concentrations were observed at the bottom (3.99 mg/L) of the lake near the dam and in the outlet (1.67 mg/L) from the lake. In addition, 2008 total phosphorus (TP) concentrations were elevated near the lake bottom (0.104 mg/L) and in the outlet (0.068 mg/L), compared to surface (0.028 mg/L) and inlet (0.039 mg/L) concentrations. Depleted dissolved oxygen and elevated TP concentrations may have been the result of the decomposition of dense beds of aquatic vegetation observed at the sampling location (Princeton Hydro LLC 2008).

Current Analysis

Based on average summer TP concentrations, Palmer Lake can be characterized as eutrophic (highly productive) (**Figure 5**). TP concentrations in Palmer Lake did not follow a general seasonal pattern, with peak concentrations occurring early (June) during two years (2013 and 2016) and late (September) in 2017. Annual average (± standard deviation) TP concentrations varied greatly among years, with concentrations ranging from 0.048 (±0.018) mg/L in 2016 to 0.114 (±0.073) in 2017. Additional monitoring of TP concentrations in Palmer Lake could better inform long-term water quality trends.

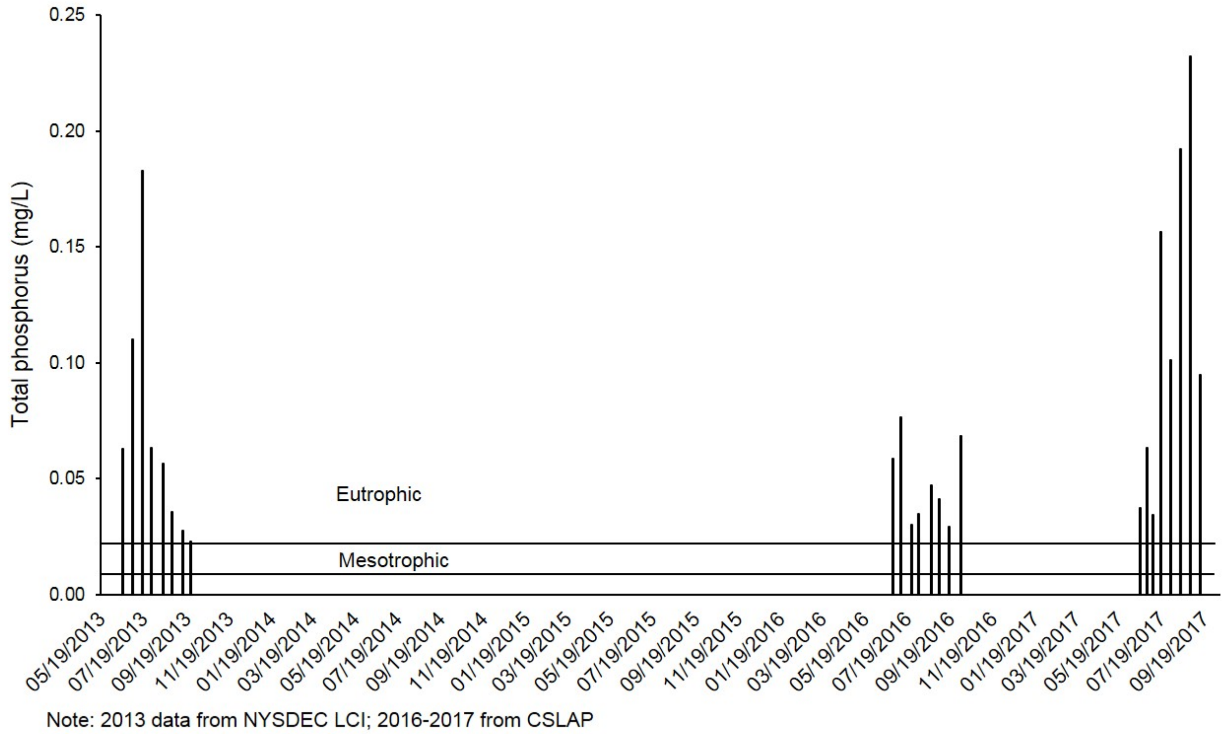

Figure 5. Total phosphorus (TP) concentrations (mg/L) in Palmer Lake from 2013 (LCI), and 2016 and 2017 (CSLAP).

Similar to phosphorus, annual average (± standard deviation) TN (**Figure 6**) concentrations in Palmer Lake are generally suggestive of eutrophic conditions (> 0.6 mg/L, Canfield et al. 1983) with concentrations ranging from 0.53 (±0.36) mg/L in 2016 to 0.86 (±0.36) mg/L in 2013.

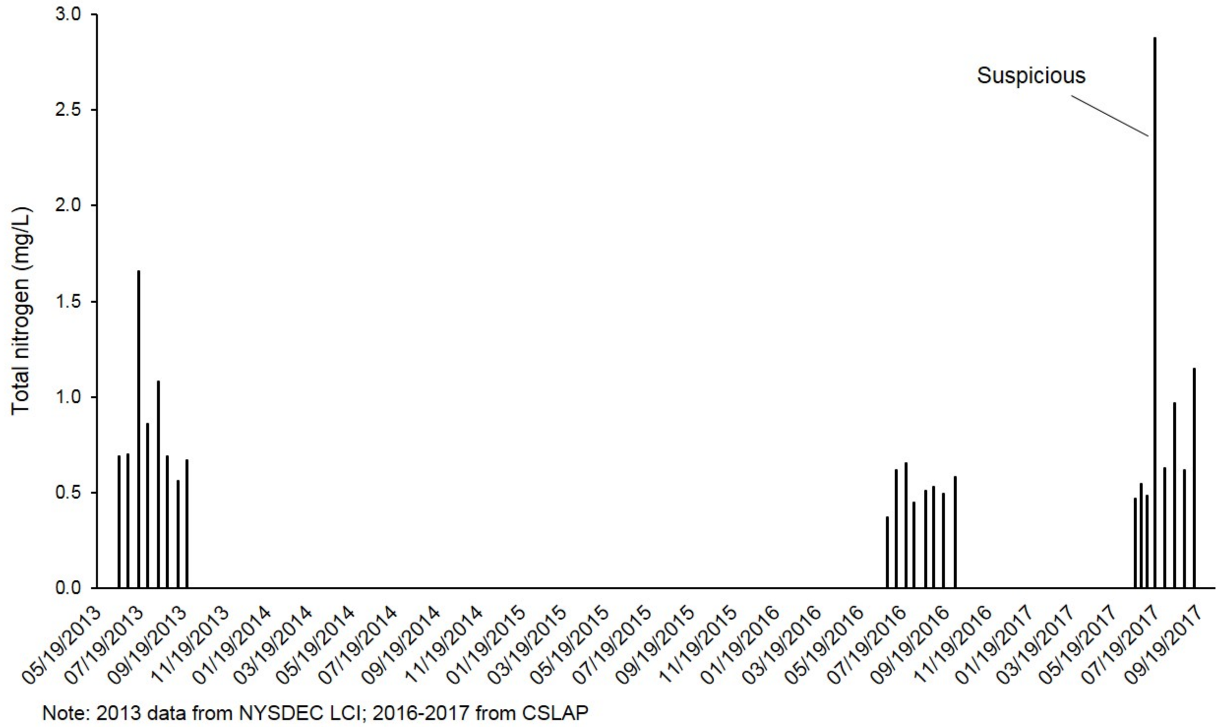

Figure 6. Total nitrogen (TN) concentrations (mg/L) in Palmer Lake from 2013 (LCI), and 2016 and 2017 (CSLAP).

The relative concentrations of nitrogen and phosphorus can influence algal community composition and the abundance of cyanobacteria. Ratios of TN: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 if HABs occur; cyanobacteria blooms are typically rare in lakes where mass based TN:TP ratios are greater than 29:1 (Smith 1983, Filstrup et al. 2016). Certain cyanobacteria taxa (e.g. *Aphanizomenon, Dolichospermum)* 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 (by mass) of TN to TP in Palmer Lake from 2013 to 2017 ranged between 2.7 and 29.3 and indicate that algal biomass (including cyanobacteria) is generally limited by nitrogen (TN:TP < 10) (**Figure 7**).

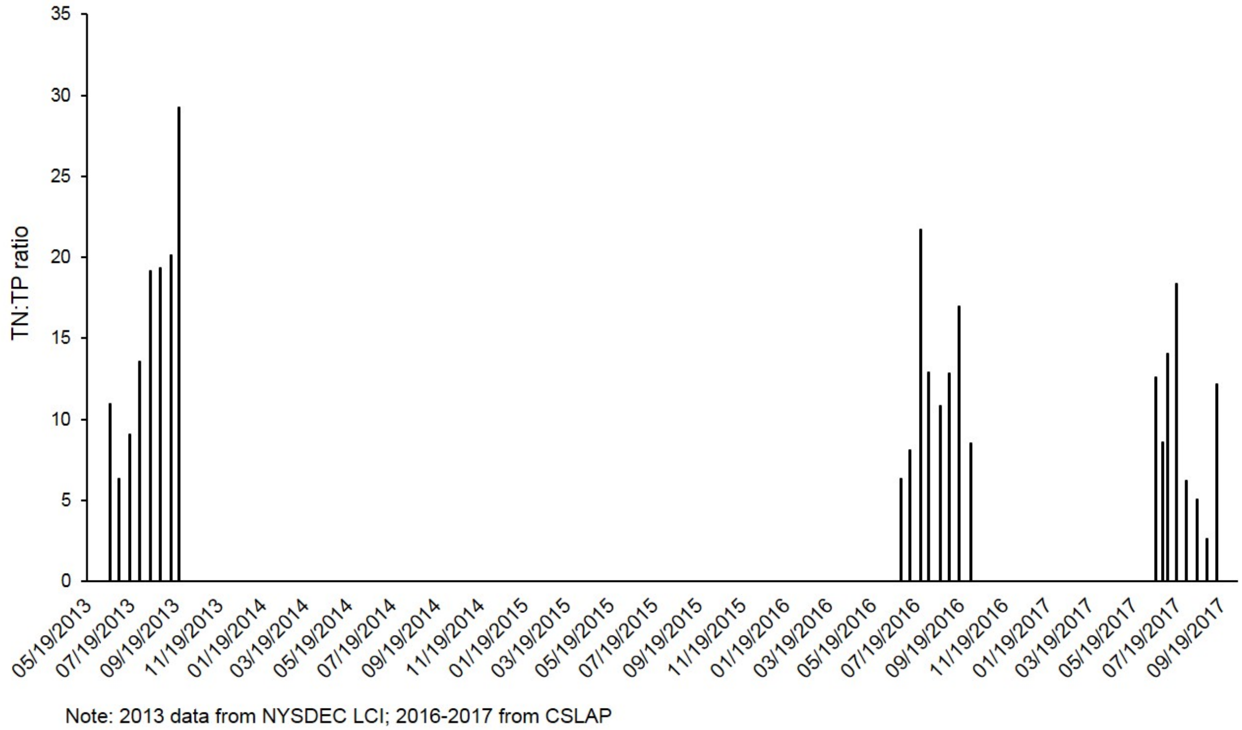

Figure 7. Total nitrogen (TN) to total phosphorus (TP) ratios in Palmer Lake from 2013 (LCI), and 2016 and 2017 (CSLAP).

Additionally, chloride levels in Palmer Lake are above the 75th percentile of New York State lakes (CSLAP 2017), and road salt operations are often associated with high lake chloride levels (Novotny et al. 2008). High concentrations of chloride could potentially impact aquatic life, however, the effect of chloride levels on the frequency and duration of HABs is less clear.

6.3 Biological Conditions

Palmer Lake's aquatic plant coverage is higher than in many other lakes within the Lower Hudson River region (CSLAP 2017). A survey conducted in August 2016 concluded that aquatic vegetation covers 88% of Palmer Lake (Aquatic Ecosystem Consultants Inc. 2017)

Two aquatic invasive plants, Eurasian watermilfoil (*Myriophyllum spicatum*) and brittle naiad (*Najas minor*), have been reported in Palmer Lake (CSLAP 2017). Both invasive plants are of major concern because they often grow in large dense beds and are known to outcompete and crowd out native aquatic vegetation. These dense beds are often less suitable habitat for fish and other aquatic species and can impede recreational activities such as boating, fishing, and swimming. The native aquatic plant coontail (*Ceratophyllum demersum*) is also considered to be a nuisance in Palmer Lake (Princeton Hydro LLC 2008a). Coontail, like the invasive aquatic plants mentioned above, form dense beds that decrease plant diversity by crowding out other native plants, limiting habitat suitability for aquatic life, and impeding recreation. 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 Palmer Lake.

Duckweed (Lemnoideae) is another nuisance native aquatic macrophyte in Palmer Lake, which was found to cover 70% of the lake in August 2016. (Aquatic Ecosystem Consultants Inc. 2017). Duckweed can also proliferate to nuisance levels in eutrophic conditions and cause impediments to recreational activities, such as swimming and fishing. Although considered a nuisance under certain environmental conditions, these native plants (coontail and duckweed) are more desirable than invasive aquatic plants. Duckweed, specifically, is a small floating aquatic plant and may compete with cyanobacteria for light and available nutrients.

Average summer concentrations of chlorophyll-a (photosynthetic pigment present in algae, including cyanobacteria) suggest that Palmer Lake is eutrophic (highly productive, 2013 data only) (**Figure 8**). Chlorophyll-a concentrations in 2013 generally increased during the early growing season (**Figure 8**), which followed a similar seasonal pattern as TP concentrations for that year. Additional monitoring of chlorophyll-a concentrations will supplement the limited water quality data for the lake and can be used to evaluate the effectiveness of recommended actions (see **Section 13**). Chlorophyll-a data from the 2016 and 2017 were determined to be suspect and unusable for this evaluation.

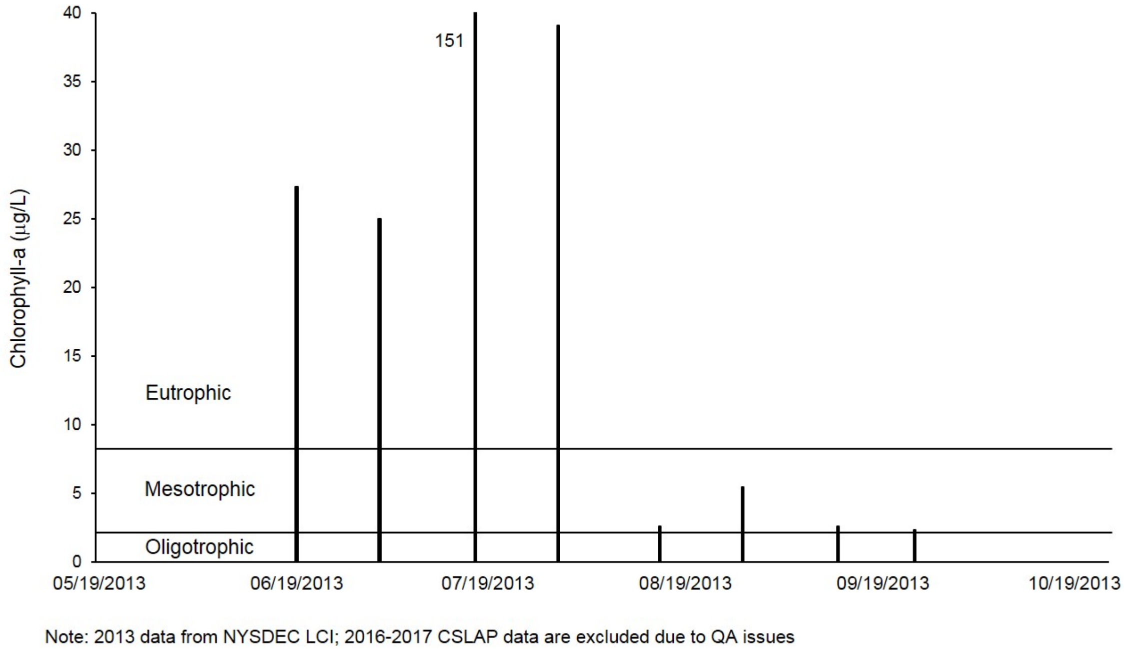

Figure 8. Chlorophyll-a concentrations (mg/L) from Palmer Lake in 2013 (LCI).

6.4 Other Conditions

Monitoring efforts conducted along the unnamed tributary to Palmer Lake in September of 2008 concluded that wetlands were a source of TP and SRP to the tributary during dry weather (**Table 3**) (Princeton Hydro LLC 2008b). Water quality data from the most upstream sampling location (upstream of Nichols Road and immediately downstream of a proposed WWTP discharge) had depleted dissolved oxygen concentrations (1.37 mg/L). TP and SRP concentrations at this location were 0.028 and 0.027 mg/L, respectively. TP and SRP concentrations increased as the stream flowed to Palmer Lake and was highest (TP = 0.118 mg/L, SRP = 0.076 mg/L) at the sampling location nearest to Palmer Lake. From upstream to downstream, dissolved oxygen increased to approximately 5.50 mg/L and then dropped to 1.60 mg/L at the site closest to Palmer Lake (Princeton Hydro LLC 2008b).

Table 3. Dissolved oxygen (mg/L) total phosphorus (mg/L) and soluble reactive phosphorus (mg/L) measurements from September 2008. Data are representative of cursory base flows prior to discharges from the Kent Manor WWTP (Princeton Hydro LLC 2008b).

Location (Distance from Burr Pond, m)	Dissolved Oxygen (mg/L)	Total Phosphorus (mg/L)	Soluble Reactive Phosphorus (mg/L)
Trib-2 (0 m)	1.37	0.028	0.028
Trib-3 (90 m)	4.75	0.039	0.027
Trib-4 (230 m)	5.63	0.031	0.023
Trib-5 (370 m)	5.46	0.080	0.053
Trib-6 (540 m)	1.60	0.118	0.076

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. As part of the HABs Program, the NYSDEC 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 bloom report indicates low likelihood that a cyanobacteria bloom (HAB) 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-a levels ≥ 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

Palmer Lake is a eutrophic, or highly productive, lake and had the first Confirmed Bloom documented by NYSDEC in 2017 based on data for samples collected by CSLAP. When lake observations of potential HABs are collected, they are compiled and assigned a bloom status, per NYSDEC's *Harmful Algal Blooms Program Guide* (NYSDEC 2017) and as described above. The 2017 Confirmed Bloom in Palmer Lake occurred along the shoreline in late June and was characterized as small localized in extent. The microscopic evaluation of the sample included the cyanobacteria genus *Microcystis* at a moderate density and the filamentous green alga *Mougeotia* at a high density. *Microcystis* is a common colonial, buoyancy regulating cyanobacteria that is occasionally associated with elevated toxins (see **Section 7.3**). The identification of dominant cyanobacteria taxa (i.e., those that are most often present) in Palmer Lake can help to target species management strategies at the key functional traits of those dominant taxa to limit their proliferation.

Two CSLAP reports of blooms occurred on July 9 and September 2 in 2016 but both were determined not to be cyanobacteria blooms. Both events were identified as shoreline blooms (CSLAP 2016). No cyanobacteria taxa were identified from water samples collected during these bloom events. The dinoflagellate *Ceratium*, identified during the July 9 event, may form blooms that result in oxygen-depleted conditions.

7.2 Drinking Water and Swimming Beach HABs History

Drinking water

Across New York, NYSDOH first sampled ambient water for toxin measurement in 2001, and raw and finished drinking water samples beginning in 2010. Two public water supplies were sampled in a 2012 pilot study that included both fixed interval and bloom based event criteria. While microcystin has been detected in pre-treatment water occasionally, rarely have any detects been found in finished water. To date, no samples of finished water have exceeded the 0.3 µg/L microcystin 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 Environmental Laboratory Approval Program (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.

Palmer Lake is not directly used as a drinking water source, but is located within the New York City watershed and is a tributary to reservoirs that supply potable water to New York City residents. As recommended by the NYSDOH, it is never advisable to drink water from a surface source unless it has been treated by a public drinking water system regardless of the presence HABs. Surface waters may contain other bacteria, parasites or viruses that can cause illness. If you choose to explore in-home treatment systems, you are living with some risk of exposure to blue-green algae and their toxins and other contaminants. Those who desire to use an intake for non-potable use, and treat their water for contaminants including HABS, should work with a water treatment professional who should evaluate for credible third-party certifications such as National Sanitation Foundation standards (NSF P477; NYSDOH 2017). Thus, HABs do not pose a direct threat to Palmer Lake residents through regulated drinking water sources.

Swimming

Palmer Lake has a community beach open for seasonal swimming by Hill and Dale Country Club members and guests. Neither the county health department nor the state health department are known to have closed the lake's community beach due to HABs in 2016 or 2017. 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 4 provides a summary of the guidance criteria that the NYSDEC and NYSDOH use to advise local beach operators.

Table 4. HABs guidance criteria.			
NYSDEC Bloom Categories			
Confirmed	**Confirmed w/ high toxins**		**Suspicious**
	Open water	**Shoreline**	
[BGA Chlorophyll-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) in 2017.	

7.3 Other Bloom Documentation

Cyanobacteria Chlorophyll-a

The BGA chlorophyll-a concentration reported from the 2017 Confirmed Bloom sample was 43.8 µg/L (sample from June). Water samples collected by CSLAP in 2016 did not have detectable concentrations of BGA chlorophyll-a (CSLAP 2016). HABs may have been observed at other times, but were not reported to the NYSDEC.

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 threshold, established based on WHO criteria. Microcystin was not detected in the Confirmed Bloom in 2017, but was detected by laboratory analysis during the September 2016 at a concentration of 15.7 µg/L (CSLAP 2016). This concentration approaches but is below the 20 µg/L shoreline threshold (**Table 4**). There was visual evidence of a green algae bloom at that time, suggesting that a cyanobacteria bloom had occurred at this location but had dissipated shortly before this sampling.

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

7.4 Use Impacts

Public bathing and other recreational uses of the lake were assessed as “stressed” and “impaired”, respectively, in the WI/PWL fact sheet for Palmer Lake due to elevated nutrients that lead to excessive algae and low water transparency (NYSDEC 2011). Accordingly, other related uses or lake conditions such as aesthetics can be considered impacted by the same pollutants or lake issues. The lake’s aesthetic conditions are perceived by the public as “poor” (CSLAP 2016), likely attributable to nuisance aquatic vegetation and excessive algal abundance.

8. Waterbody Assessment

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

The WI/PWL assessments reflect data and information drawn from numerous 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 Palmer Lake (**Appendix C**) reflects monitoring data collected in 2016 through 2017. Palmer Lake is required to support primary and secondary contact recreation and fishing use.

Palmer Lake is assessed as an impaired waterbody due to primary and secondary contact recreation uses that are known to be impaired by excessive nutrients and resulting in some algal growth and reduced water clarity. Known sources of nutrients include onsite septic systems and urban stormwater runoff.

Palmer Lake is included on the NYS Section 303(d) List of Impaired Waters Requiring a TMDL. However, a phosphorus Total Maximum Daily Load (TMDL) for Palmer Lake was completed in 2016 and Palmer Lake will be moved to USEPA IR Category 4a as an Impaired Waterbody for which a TMDL was completed. Phosphorus management strategies for septic systems and stormwater runoff are included in the TMDL.

Table 5. WI/PWL severity of use impact categorization (Source: NYSDEC 2011).	
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 (SWPP)

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. Palmer Lake is not utilized as a potable water source, so it has not been evaluated as part of the SWAP program.

8.3 CSLAP 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. According to the Palmer Lake 2017 CSLAP scorecard, algae levels impact swimming and recreational uses (**Figure 9**).

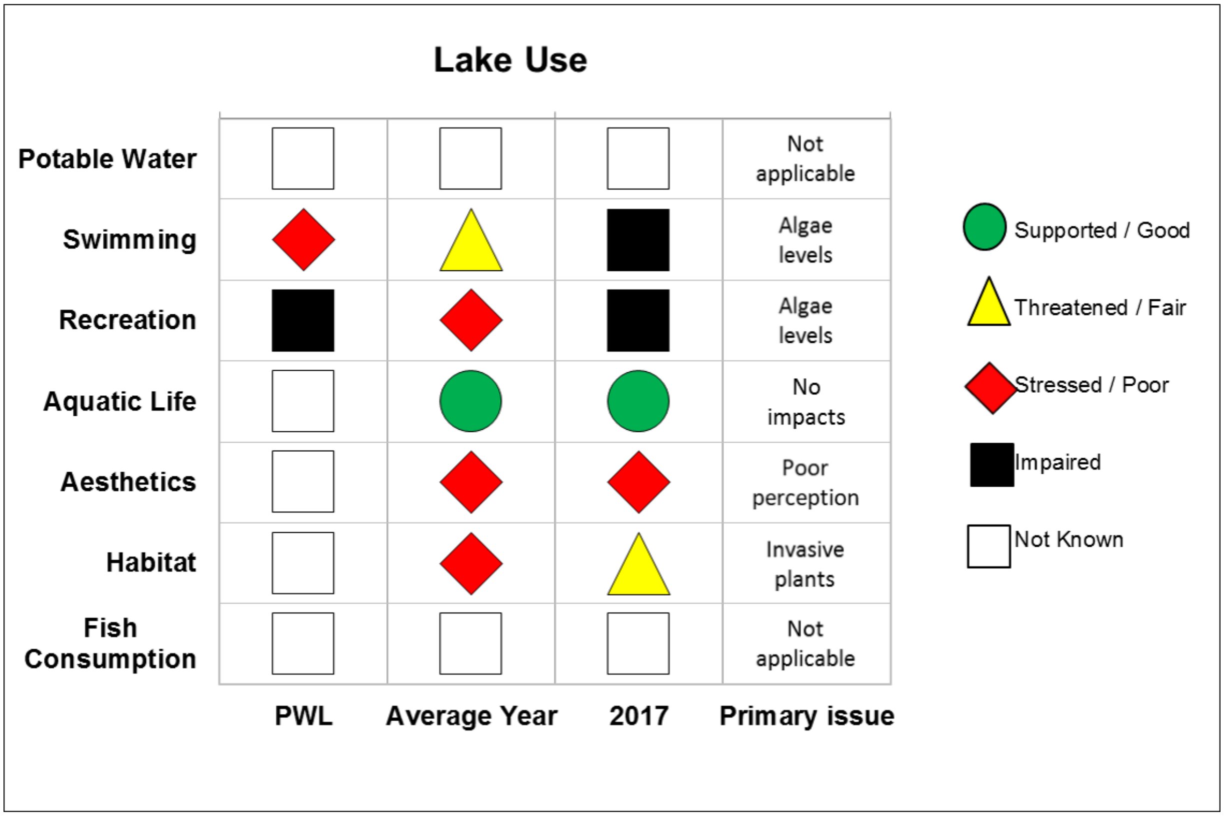

Figure 9. Palmer Lake 2017 CSLAP scorecard.

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

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

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

There is continuing interest in the possible role of nitrogen in the occurrence and toxicity of HABs (e.g., Conley et al. 2009), and preliminary analysis of this statewide data set suggests that elevated total N and total P concentrations are both statistically significant associates with the occurrence of toxic blooms. When total N and total P concentrations are not included in the statistical model, elevated inorganic nitrogen (NH4 and NOx) 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.

To fully understand the likely triggers of HABs in Palmer Lake, continued water quality monitoring and associated HAB observation recording should be conducted. Nutrient and water chemistry data that are aligned with HAB observations, collected during both bloom and no-bloom conditions, and coupled with concurrent meteorological information (wind, waves) will yield a higher confidence in the identification of HABs triggers and greater power for predictions of HAB formations. However, Palmer Lake appears to be susceptible to HABs due to factors such as elevated levels of phosphorus and nitrogen and shallow depth, common in other lakes with a high frequency of HABs.

10. Sources of Pollutants triggering HABs

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

10.1 Land Uses

Based on the TMDL analysis in 2015, the watershed comprises the following land use types (**Figure 10**):

- Forested = 53%
- Developed land = 39%
- Open space = 8%

As depicted in **Figure 11a**, much of the forested land use within the Palmer Lake watershed is found in the northern extent, while developed land surrounds much of the lake and extends to the northwest portion of the watershed.

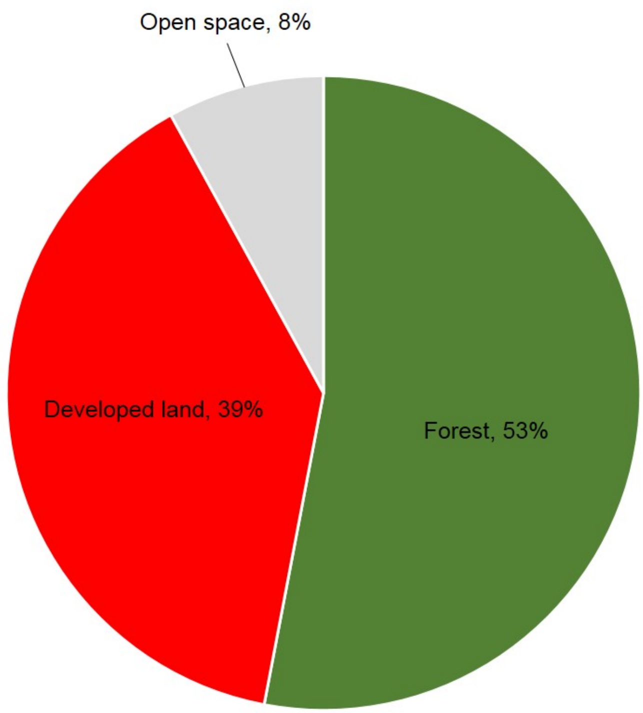

Figure 10. Land uses and percentages in the Palmer Lake watershed.

(a) Watershed land use (b) Septic system density

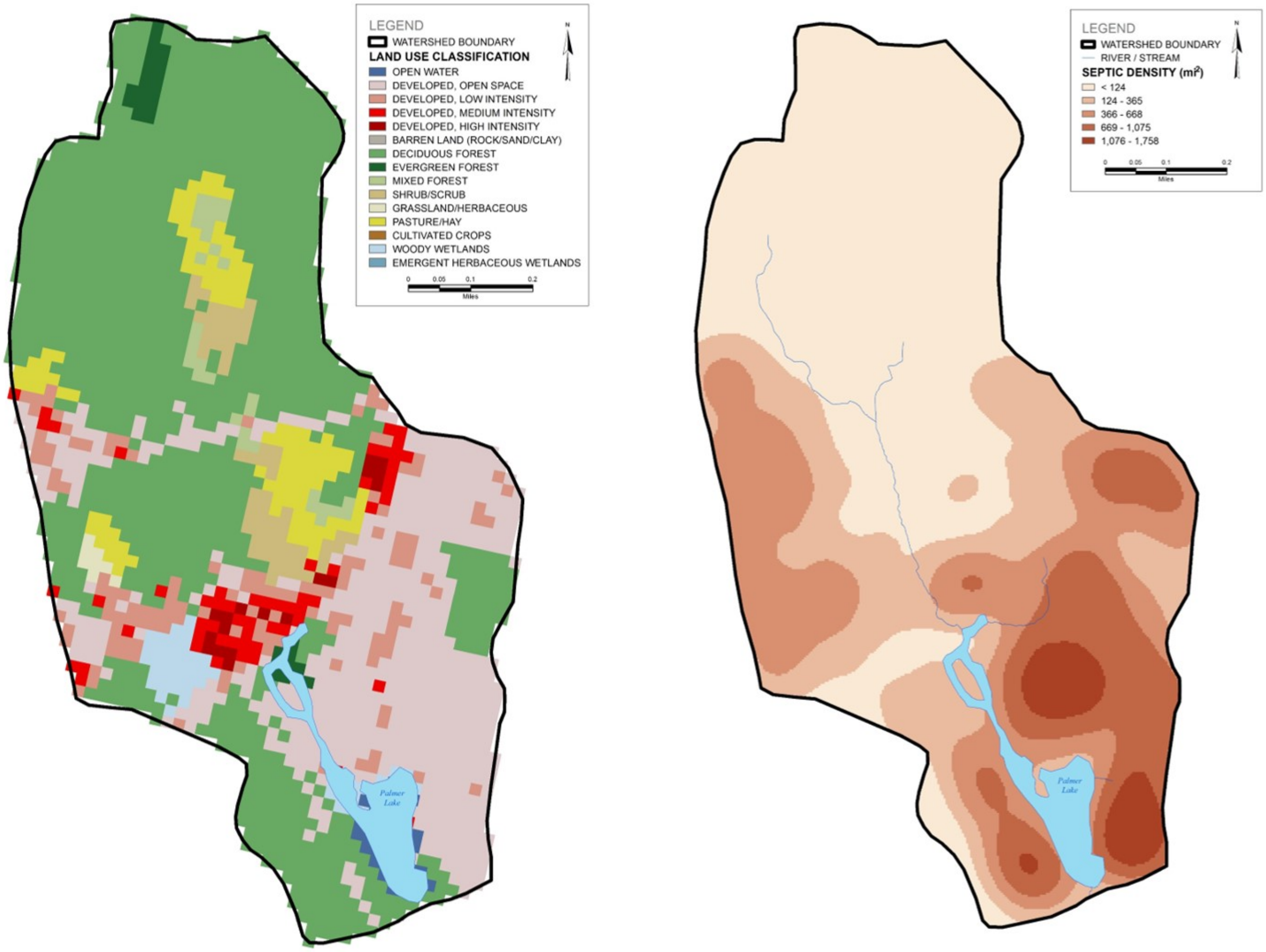

Figure 11. (a) Watershed land use and (b) septic system density for Palmer Lake.

10.2 External Pollutant Sources

Pollutant loads were estimated using MapShed (Penn State University Institute of Energy and the Environment's watershed model). This model is based on the Generalized Watershed Loading Function (GWLF), which is capable of simulating runoff, sediment, and nutrient (N and P) loads from a watershed given different sources. The model can also calculate septic system loads and accommodates point source discharge data (Evans and Corradini 2012). The Palmer Lake TMDL is based on limited data (2010 and 2013) and therefore is meant only to be used to guide management.

Phosphorus load sources within the watershed, estimated using MapShed, can be broken down by contributor type as follows:

- Forested = 1.5%
- Developed land = 9.6%

- Open Spaces= 2%
- Stream Bank Erosion = 3.8%
- Septic Systems = 62.4%
- Groundwater = 20.8%
    - Groundwater load from natural sources = 60%
    - Groundwater load from developed land = 40%

Approximately 80% of the phosphorus load to Palmer Lake is attributable to development activities within the Palmer Lake watershed. Septic density surrounding Palmer Lake is relatively high, and the septic infrastructure is immediately adjacent to the lake shoreline (**Figure 11b**). It is important to note that phosphorus attributable to sources such as streambank erosion is generally in the form of particulate-bound phosphorus that is less biologically available than dissolved phosphorus that is associated with septic system effluent. **Figure 11b** illustrates how the concentrated development around the perimeter of Palmer Lake corresponds with the higher density of septic systems.

The loading percentages are based upon data collected as part of the TMDL analysis, but does not take into consideration existing BMPs and other nutrient reduction measures implemented by the agricultural community and other potential contributors of nutrients to the lake. Consequently, the land use percentages and loading estimates presented above for Palmer Lake should be interpreted with caution.

10.3 Internal Pollutant Sources

A possible data gap in the understanding of nutrient dynamics in Palmer Lake is the potential for the seasonal mobilization of phosphorus found within the sediments (i.e., internal loading of legacy phosphorus). This internal load can be an important source of phosphorus in lakes with small hypolimnetic volumes that become anoxic during the summer. Current estimates of annual phosphorus loads do not account for internal loading. Deeper areas of the shallow lake may be more prone to internal loading due to localized anoxic conditions and the release of legacy phosphorus.

10.4 Summary of Priority Land Uses and Land Areas

As discussed in **Sections 10.2** and **10.3**, loading occurs predominately through nonpoint sources. Of the nonpoint sources, the majority is estimated to be from septic systems (62.4%), followed by groundwater (20.8%) and developed (9.6%) land uses.

11. Lake Management / Water Quality Goals

The primary lake management/water quality goal for Palmer Lake is to achieve consistency with WI/PWL guidelines by maintaining the summer average total phosphorus concentration below 0.02 mg/L (20 μg/L). The available data suggest that total phosphorus concentrations of < 0.02 mg/L would reduce the frequency and severity of HABs in Palmer Lake. However, even lower phosphorus concentrations may be required to safeguard from potential events stemming from acute loadings of phosphorus (e.g., runoff events) and from the potential exacerbating effects from other contributory sources of HABs (e.g., elevated water temperatures).

The Palmer Lake TMDL reports that a 46% reduction in phosphorus loads from all sources is required to meet the TMDL target of 0.02 mg/L. The majority of the reduction (90%) in phosphorus loading comes from the TMDL recommendation of a 100% reduction of septic system phosphorus loading.

12. Summary of Management Actions to Date

12.1 Local Management Actions

The 2015 TMDL for Palmer Lake (discussed in detail in **Section 12.5** below) presents several recommended management actions for control of phosphorus inputs to the lake. Effective implementation of these management actions for reducing phosphorus loading and, accordingly, the potential for HABs, requires broad participation of both lake watershed residents and local governments, preferably in collaboration. Citizen involvement is key to implementing effective management actions and can range from traditional conservation practices for mitigating erosion and stormwater runoff to more comprehensive programs that focus on water storage enhancements and/or increased control of point source discharges.

The Town of Kent has installed stormwater filtration systems designed to trap sediment prior to its discharge to the lake. Some Croton watershed towns, including the Town of Kent, have installed stormwater retrofits designed to intercept sediment from reaching the lake, resulting in reduced sedimentation and phosphorus loading. Town of Kent ordinances are in place governing sewage disposal systems, on-site sanitary systems, stormwater management, and wetlands protection, all of which are designed to promote enhanced water quality in the lake and its tributaries (Town of Kent 2018b). Collectively, these efforts are expected to result in a lower probability of HABs occurrences.

The Town of Kent has implemented town wide ordinances to address sources of phosphorus and sediment that could potentially impact the water quality within the town. These ordinances include:

- Sewage Disposal System, Separate – which focuses on septic system maintenance and includes a mandatory pumping of septic systems every 5 years.
- Freshwater Wetland Protection and Drainage Law of the Town of Kent
- Steep Slope Protection and Stormwater Management
- Illicit Discharge to Storm Sewers

12.2 Funded Projects

Limited information exists on projects funded to improve water quality in Palmer Lake or its watershed. The State's Agricultural Environmental Management (AEM) and Agricultural Nonpoint Source Abatement and Control (ANSACP) programs provide resources for the planning and implementation of best management practices (BMPs) on farms to protect water quality. There are 23 farms in Putnam County that have implemented nearly 40 types of best management practice associated with agricultural operations, however, none of these farms are within the boundaries of the Palmer Lake watershed.

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 through the issuing of permits for discharges to waterbodies.

NYSDEC provides on-line information for the SPDES Permit Program for all nine regions in the state. Based on the SPDES Individual Permit records available for Putnam County, NYSDEC has issued a total of 22 SPDES Individual Permits within the Town of Kent. Of the 22 permits, three are available for viewing; only one, issued to the Kent Manor Sewer Corporation, was determined to be associated with direct discharges of waters or materials to Palmer Lake (NYSDEC 2018c).

The Towns of Carmel and Kent are both permitted by the NYSDEC under the NYSDEC SPDES General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (MS4s) (Permit No. GP-0-15-003) and are required to implement programs to reduce nutrient and pollutant loadings carried by stormwater to the extent practicable. Elements of the Towns' MS4 programs include:

- Public Education and Outreach
- Public Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Runoff Control
- Post-Construction Stormwater Management
- Pollution Prevention/Good Housekeeping for Municipal Operations

Both Towns are also subject to several enhanced requirements under Permit No. GP-0-15-003 due to their location within the East of Hudson River Watershed. These include:

- Install permanent stormwater management facilities that incorporate enhanced phosphorus removal design standards in accordance with the New York State Stormwater Design Manual for both new and redevelopment projects.
- Develop and maintain a map of the entire stormwater conveyance system.

- Inspect on-site sanitary systems at a minimum of once every five years; maintain and rehabilitate where necessary.
- Develop erosion and sediment control plans for any disturbance greater than or equal to 5,000 square feet.
- Implement BMPs to reduce nutrient contribution from turf management practices (e.g., fertilizer application, disposal of grass clippings).

NYSDEC also issues Multi-Sector General Permits (MSGPs) under the SPDES Program for stormwater discharges related to certain industrial activities. MSGPs have been issued for 12 active facilities in Putnam County (NYSDEC 2018c). None of these facilities are within the Town of Kent, and therefore, are not likely to strongly influence water quality conditions in Palmer Lake. In addition, two Municipal Separate Storm Sewer Systems (MS4s) discharge into the Palmer Lake watershed. These MS4s are operated by the towns of Carmel and Kent and potentially contribute phosphorus to Palmer Lake through collection and subsequent contribution of stormwater from roadways and other impervious surfaces that discharge to tributaries and then to the lake.

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

12.4 Research Activities

Water quality assessments have been conducted by Princeton Hydro LLC in 2008 and 2014 during the month of September (see **Section 5**) (Princeton Hydro LLC 2008a 2008b, 2014). Assessments included stream (2008 only) and lake sampling (2008a and 2014). In addition to these assessment efforts, Aquatic Ecosystems Consultants, Inc. (2017) assessed the water quality, macrophyte community composition, and macrophyte coverage in Palmer Lake in 2016 and 2017. Reports for the 2016/2017 assessments are not currently available.

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

Clean water plans are a watershed-based approach to outline a strategy to improve or protect water quality. Total maximum daily load (TMDL) and 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 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 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

As discussed in Section 8.1, the NYSDEC issued a TMDL for Palmer Lake in March 2015 to address the recreational use impairment attributable to phosphorus-induced eutrophication. NYSDEC's summer average guidance value for surface (i.e., epilimnetic) waters in ponds, lakes, and reservoirs of 0.02 mg/L was applied as the TMDL target for Palmer Lake.

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 E**.

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 Palmer Lake.

Steering committee members:

- Mario Riccobon, Hill & Dale Property Owners, Inc.
- Lori Emery, NYCDEP
- Jennifer Clifford, NYSDAM
- Bob Capowski, NYSDEC
- Shohreh Karimipour, NYSDEC
- Tom Snow, NYSDEC
- Lauri Taylor, Putnam County Department of Planning
- Michael Nesheiwat, Putnam County Health Department
- Lauri Taylor, Putnam County Soil and Water Conservation District (SWCD)
- William Wegner, Riverkeeper
- Ken Schmitt, Town of Carmel
- Bruce Barber, Town of Kent

- Maureen Fleming, Town of Kent
- Paul Heisig, United States Geological Survey (USGS)
- Gibson Dunford, Watershed Agricultural Council (East of Hudson)

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 Palmer 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 Palmer Lake include:

- Phosphorus inputs associated with septic system discharge.
- Nonpoint source nutrient inputs from the contributing watershed.

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

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

Funding Programs

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

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

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

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

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

Wastewater Infrastructure Engineering Planning Grant is available to municipalities with median household income equal to or less than $65,000 according to the United States Census 2015 American Community Survey or equal to or less than $85,000 for Long Island, NYC and Mid-Hudson Regional Economic Development Councils (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 Palmer Lake Priority Projects

13.3.1 Priority 1 Projects

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

Mid-term (3 to 5 years)

1. Construct a wastewater treatment plant (WWTP) and install infrastructure required to connect 300 houses or a subset of residences within the watershed, thereby removing up to 60,000 gallons/day of sanitary effluent from Palmer Lake.
    a. Prior to implementation, the following will need to be completed:
        i. Prepare an Engineering Report (expected in June 2018).
        ii. Receive project approval from the Town of Kent and/or approval of a referendum for long-term funding.
        iii. Apply for and receive regulatory approvals from the NYCDEP, NYSDEC, and other agencies.

2. Dredge bottom sediment to reduce re-sedimentation and introduction of legacy, sediment-bound phosphorus into the water column. Dredged sediment should be disposed of in an upland location.
    a. Complete the following before implementation:
        i. Prepare an Engineering Report.
        ii. Apply for and receive regulatory approvals from the NYCDEP, NYSDEC, USACE, and other agencies.

Long-term (5 to 10 years)

1. Continue to improve stormwater management within the watershed through the existing MS4 program to reduce sediment and nutrient loading into Palmer Lake, including:
    a. Acquire land and/or establish conservation easements on lands within the watershed.
    b. Preserve 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.
    c. Implement roadside ditch improvement projects that are likely to contribute to the greatest reduction in erosion. Best management practices could include:
        1. Timing of cleanout to minimize vegetative loss.
        2. Properly sizing culverts and channels to avoid headcuts and other erosion.
        3. Hydroseeding disturbed areas to assist in ditch bank stabilization.
    d. Install stormwater management basins or wetlands, or enhance existing wetlands at lake inlets or along the tributaries if streams within the Palmer Lake watershed are contributing to high nutrient loads, installation.
        i. **Figure 12** depicts locations in the Palmer 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.
    e. Install infrastructure retrofits to replace existing stormwater management facilities that were installed prior to the promulgation of Article 17, Titles 7

and 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, water and sediment control basins (WASCoBs), and urban treescapes in developed areas.

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. Purchase a backhoe to utilize in ditch clearing and reshaping to minimize conveyance of erosive material to the lake.
2. Continue the educational outreach program to inform landowners of stewardship actions that could improve lake quality. Topics could include how the use of fertilizers and the discharge from septic systems influences water quality. Demonstration projects should be completed to illustrate actions that homeowners can duplicate on their property (e.g. raingardens).
3. Purchase a street sweeping vacuum truck to prevent sediment and organic debris from entering storm drains, ditches, tributaries, and Palmer Lake. A joint application request by multiple municipalities or Putnam County itself is recommended so equipment can be used through a shared services agreement.
4. Implement an inspection and maintenance program for near-shore septic systems, including:
    a. Inspection, pump-out, and repair of septic systems located within 250-feet of the lakeshore.
    b. Replace failing systems with a 50% cost-share with individual property owners.

13.4 Additional Watershed Management Actions

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

1. Mandate strict adherence to the requirements of MS4 permit requirements by the five towns within the lake. Requirements for the towns include a 10% reduction in phosphorus loading in MS4 developed land (NYSDEC). Management actions to comply with MS4 requirements include public education to promote sensible lawn care, cleanup of pet waste, and limiting large flocks of waterfowl that could contribute nutrients to watershed lakes and streams.

2. Implement stormwater control measures during construction projects that are consistent with the stormwater management procedures and erosion control measures that the Town of Kent has incorporated into its by-laws.
3. Continue to identify and mitigate locations where animal wastes are concentrated (e.g., pet stores and animal care/boarding facilities) for illicit connections and exposure to stormwater, and provide them with tailored education and outreach materials.
4. Continue to identify and mitigate locations where yard or food wastes are stored (e.g., “dumpsters” serving restaurants and grocery stores, yard waste composting and disposal areas) for illicit connections and exposure to stormwater and provide them with tailored education and outreach materials.
5. Update and enhance the volume and treatment capabilities of the Kent Manor WWTP in order to handle additional capacity associated with the extension of the sanitary sewer system.

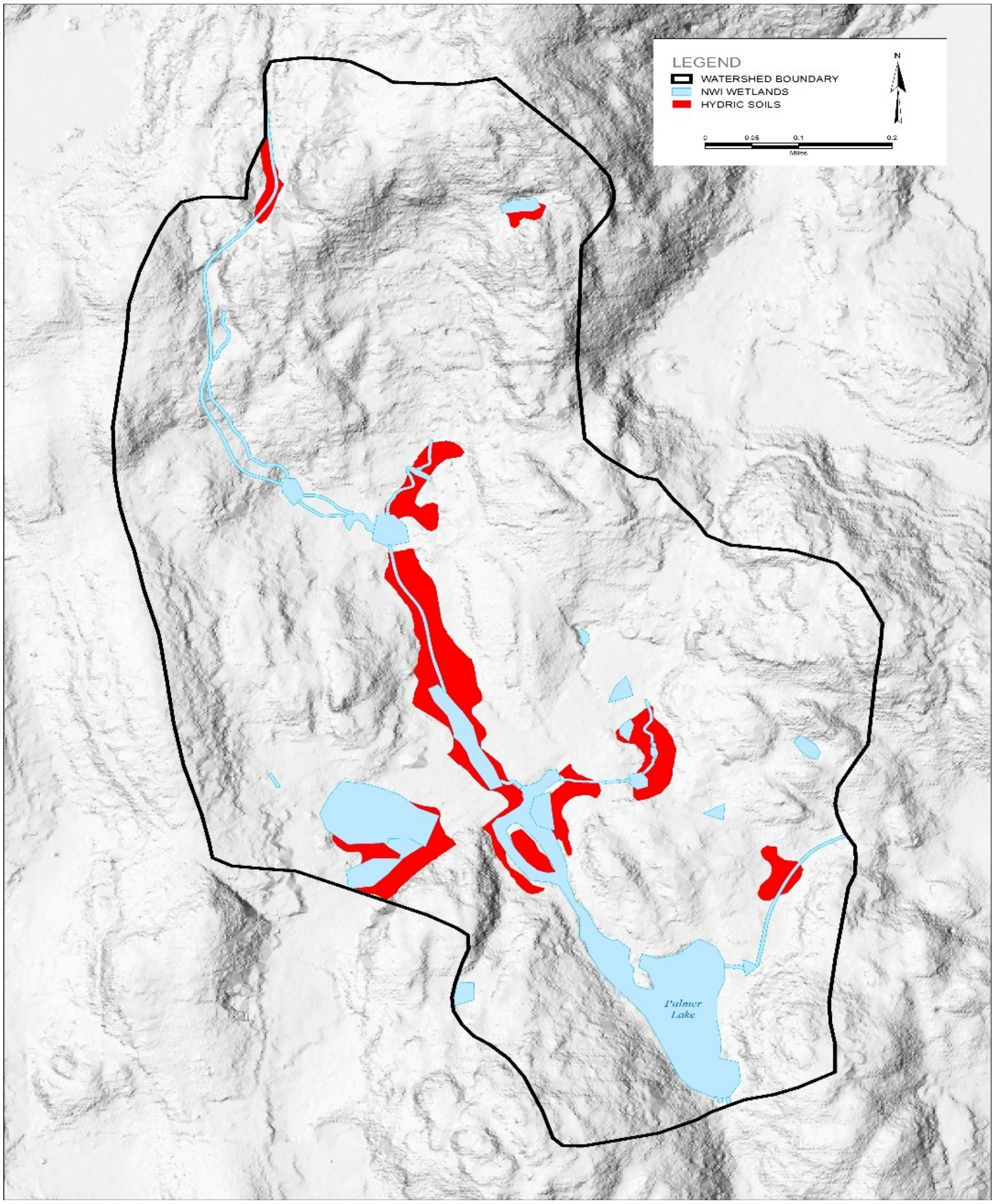

Figure 12. Locations (depicted in red) of either hydric, very poor, or poorly drained soils in the Palmer Lake watershed. Note the hydric soil locations presented are non-overlapping with National Wetland Inventory (NWI) mapped wetlands.

13.5 In-Lake Management Actions

In-lake management actions can be used to minimize the recycling of phosphorus from within the lake, minimizing concentrations that are likely leading to HABs. However, reductions in external loading should be prioritized to reduce the amount of phosphorus entering the lake. While not an action to reduce phosphorus release, continued, controlled use of an algaecide to reduce HABs could be continued until these other actions become more effective.

13.6 Monitoring Actions

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

Short-term

1. Continue annual CSLAP sampling to evaluate long-term trends in nutrient loading and occurrences of HABs. In addition, collect seasonal temperature and dissolved oxygen profiles to further understanding of mixing dynamics and to refine estimates of internal loading in Palmer Lake.
2. Analyze water quality samples for soluble forms of phosphorus to better understand how much is available to algae for growth, relative to total phosphorus concentrations.
3. Collect water quality data at nearshore sampling location(s) to determine spatial variability in water quality within Palmer Lake (relative to the open water sampling location). Evaluate the primary origin of HABs in Palmer Lake; that is, nearshore areas or in open water areas where the algae are then driven by wind and wave action into shoreline areas.
4. Continue to collect toxin concentration data during HAB events, particularly when large or lakewide blooms occur. This information will be critical to protect public health, issue advisories, and in conjunction with water quality measurements, provide insight into conditions that lead to blooms with undesirable toxin concentrations. Note that toxin analysis should be accompanied by continued surveillance, documentation, and reporting of the blooms themselves, either through CSLAP or through an independent system within the lake community that looks for and reports blooms to a local outreach coordinator.
5. Collect data regarding the taxa of BGA and toxin concentrations within Palmer Lake during early summer months (i.e., prior to bloom season) to better understand the lake dynamics.
6. Collect additional data during HABs to document the extent, duration, intensity, and location of the blooms throughout the shoreline.
7. Collect additional thermal and dissolved oxygen profiles to evaluate lake stratification to fully characterize the potential for internal nutrient loading and the role of stratification.

13.7 Research Actions

To help minimize the stresses that lead to the potential formation of HABs in Palmer Lake, the following research actions may be considered:

Short-term

1. Evaluate the impact of traditional copper algaecides on:
   a. toxin liberation, thereby subjecting recreational users to toxins after treatments outside of bathing beaches
   b. zooplankton populations
   c. other lake biota
2. Evaluate the use of alternatives to Cutrine, including other chelated copper formulations and hydrogen peroxide.
3. Evaluate upstream sources of nutrients, and measure nutrient levels in tributaries where they enter Palmer Lake to characterize watershed inputs. Empirically quantifying the watershed nonpoint source loadings through tributary water quality analyses will inform the effectiveness and benefit of stream stabilization projects relative to septic systems and in-lake management actions.
4. Evaluate the feasibility of deploying buoyed sampling system(s) in strategic location(s) that could provide remote, high temporal resolution data and alert stakeholders when HABs are occurring or likely to occur (proactive versus reactive).
5. Evaluate the potential to utilize functional traits of dominant cyanobacteria in Palmer Lake to implement strategies aimed at successfully controlling and managing their abundance. Minimal information is available on the dominant cyanobacteria in Palmer Lake to date.
6. Evaluate the potential effectiveness and cost of implementing Multi-Chambered Nutrient Separating Baffling Box(s) to reduce phosphorus and sediment loading associated with stormwater runoff.

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 Palmer 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.

13.8 Coordination Actions

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

Short-term

1. Promote BMPs for lakefront and near-lake septic systems.
2. Encourage Hill and Dale community residents to implement management practices for reducing lake eutrophication through education, periodic town hall meetings, and funding opportunities as they become available.
3. 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.
4. Improve coordination between NYSDEC and owners of highway infrastructure (state, county, municipal) to address road ditch management; including, identify practices, areas of collaboration with other stakeholder groups, and evaluation of current maintenance practices.
5. Continue to support and provide targeted training (e.g., ditch management, emergency stream intervention, sediment and erosion controls, prescribed grazing, conservation skills, etc.) to municipal decision makers, SWCDs, and personnel in order to underscore the importance of water quality protection as well as associated tools and strategies.

Mid-term

1. Adopt Erosion and Sediment Control Laws in the Towns of Carmel and Kent, where activities that significantly disturb lands (areas greater than 500 ft^2) are required to have effective erosion and sediment control measures in place.
2. Evaluate current and update zoning regulations for shoreline properties in the Towns of Kent and Carmel.

    a. Minimum lot size
    b. Maximum building coverage
    c. Setback requirements
3. Update the Towns of Carmel and Kent Comprehensive Plans to incorporate phosphorus reduction practices. A Comprehensive Plan is an advisory document that sets forth policies to guide future growth and development of communities.

Long-term

1. Identify opportunities to encourage best management practice implementation through financial incentives and alternative cost-sharing options.
2. Coordinate with Department of Health to support the local health departments to implement onsite septic replacement and inspection activities.
3. 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.
4. Support evaluation of watershed rules and regulations.

13.9 Long-term Use of Action Plan

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

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

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

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

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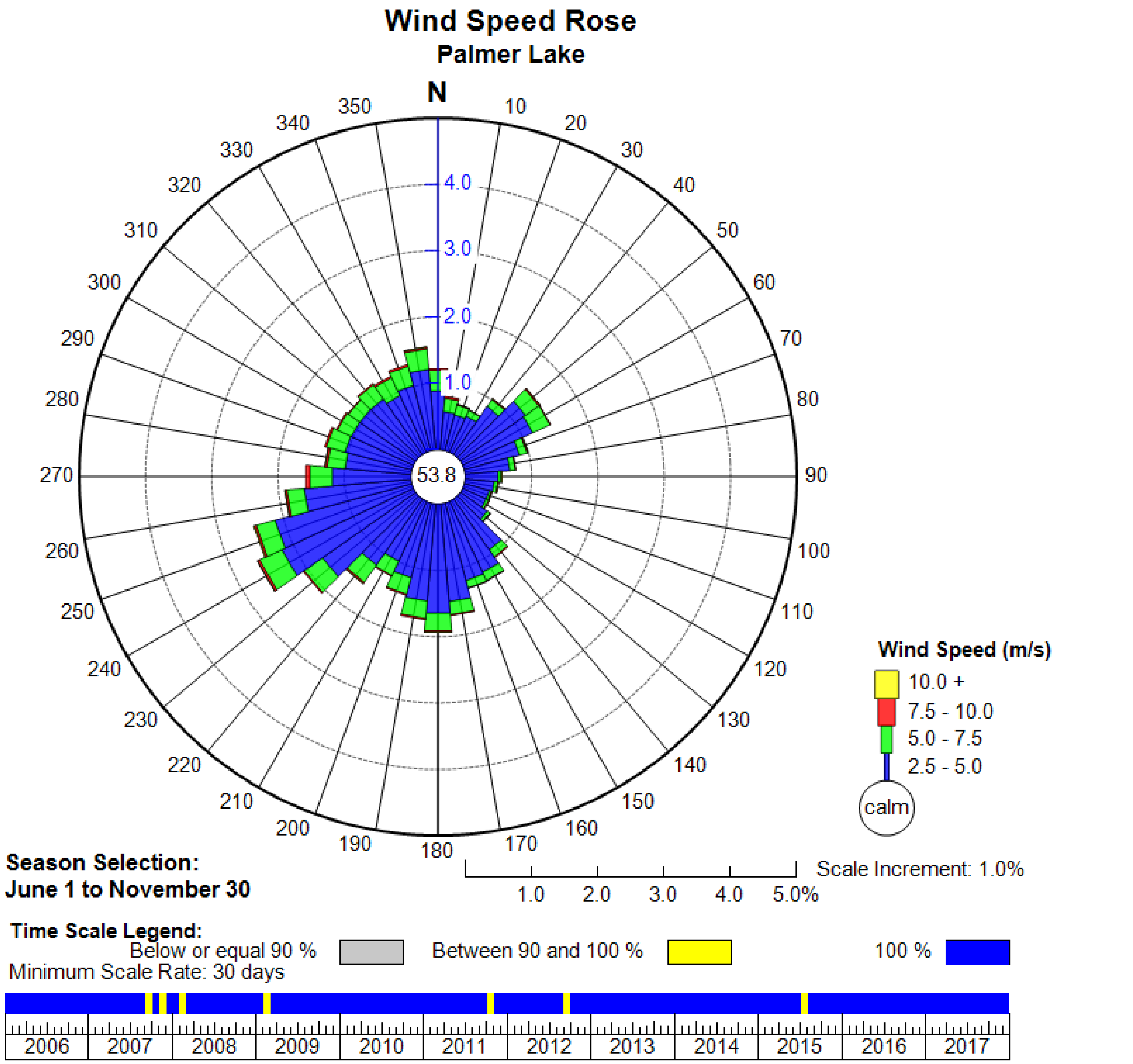
Appendix A. Wind Patterns



Selected Data: 01 Jan 2006 01AM to 31 Dec 2017 07AM
Calm Wind Conditions: Wind speed < 2.50 m/s
Source File: P:\12932.101 NY State HAB Action Plan\03_Data\02_Physical\Met data\Putnam, Carmel & Palmer Lakes \Putnam hindcast\DANBURY MUNICIPAL AIRPORT-wind.bts
Entire Range: 01 Jan 2006 01AM to 31 Dec 2017 07AM

The wind speed patterns for Palmer Lake from 2006 to 2017 during the growing season (June to November) indicate stronger winds were generally out of the south-southwest and northeast.

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. WI/PWL Summary

Palmer Lake (1302-0103) — Impaired

Waterbody Location Information

Revised: 05/01/2018

Water Index No:	H- 31-P44-23-P59- 5-P61a	**Water Class:**	B
Hydro Unit Code:	East Branch Croton River (0203010102)	**Drainage Basin:**	Lower Hudson River
Water Type/Size:	Lake/Reservoir 14 Acres	**Reg/County:**	3/Putnam (40)
Description:	entire lake		

Water Quality Problem/Issue Information

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

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

Known: NUTRIENTS (PHOSPHORUS), Algal/Plant Growth
Suspected: ---
Unconfirmed: ---

Source(s) of Pollutant(s)

Known: ON-SITE SEPTIC SYST, URBAN/STORM RUNOFF
Suspected: ---
Unconfirmed: ---

Management Information

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

Further Details

Overview
Palmer Lake is assessed as an impaired waterbody due to primary and secondary contact recreation uses that are known to be impaired by excessive nutrients resulting in some algal growth d reduced water clarity.

Use Assessment
Palmer Lake is a Class B waterbody required to support and protect primary and secondary contact recreation use as well as fishing use.

Primary contact recreation use is suspected to be impaired due to water clarity readings that regularly fall below levels needed to support swimming use. Secondary contact recreational use is impaired due to elevated nutrient loadings resulting in algal growth and reduced water clarity. Onsite septic systems and stormwater runoff are the primary sources of pollutants.

Fishing use is assessed as fully supporting. There are no fish/biological impacts documented for Palmer Lake, and dissolved oxygen and pH readings meet the water quality standards for support of aquatic life. However, aesthetics are poor in response to unfavorable water quality assessments, and habitat is impacted by the presence of invasive plants (Eurasian watermilfoil and brittle naiad).

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 Palmer Lake was conducted through NYSDEC Citizens Statwide Lake Assessment Program (CSLAP) in 2016 and 2017, and as part of the NYSDEC Lake Classification and Inventory (LCI) in 2013. Results of this sampling indicate the lake is best characterized as eutrophic, or highly productive. Chlorophyll algal levels frequently exceed criteria corresponding to impaired secondary contact recreation uses, while phosphorus concentrations are ocassionally above the NYSDEC guidance value of 0.020 mg/l. Lake clarity measurements indicate water transparency occasionally fail to meet the recomended minimum criteria for swimming beaches. Readings of pH typically fall within the range established in state water quality standards for fishing use and the protection of aquatic life.

The NYSDEC HABs Notification program confirmed the presence of HABs in Palmer Lake during the recreational season of 2017. The lake was on the HABs Notification List for 2 weeks. One confirmed, small localized HAB was reported in June 2017.

Source Assessment
It is estimated that roughly 60 percent of the phosphorus loading in Palmer Lake comes from residential on-site septic systems, 10 percent from stormwater runoff, and 25 percent is transported to the lake from groundwater. The remainder comes from other sources such as open land runoff and wildlife.

Management Actions
On December 21, 2017, New York State Governor Andrew Cuomo announced a $65 million initiative to combat harmful algal blooms in Upstate New York. Palmer Lake was identified for inclusion in this initiative as it is vulnerable to HABs.

A TMDL was completed for Palmer Lake in 2016. Recommended phosphorus management strategies for septic systems and stormwater runoff were identified in the TMDL. Grant and funding opportunities are listed in the TDML for phosphorus in Palmer Lake.

Section 303(d) Listing
Palmer Lake is listed on the current (2016) NYS Section 303(d) List of Impaired Waters Requiring a TMDL. However the completion of the TMDL makes the waterbody appropriate for delisting for phosphorus as a Category 4a water during the next update of the List. (DEC/DOW, BWAM/WQAS, April 2018).

Segment Description:
This segment includes the total area of the entire lake. Palmer Lake is a 12 acre, Class B lake found in the town of Kent and Carmel in Putnam County.

Appendix D. NYSDEC Water Quality Monitoring Programs

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

Appendix E. 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 Palmer 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.