



5.4.5 Harmful Algal Bloom

This section provides a profile and vulnerability assessment of the harmful algal bloom (HAB) hazard for Chenango County.

5.4.5.1 Hazard Profile

The profile contains a description of the HAB hazard, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences.

Hazard Description

Cyanobacteria were among the first life on the planet and were responsible for the oxygen-rich atmosphere. However, some cyanobacteria also produce toxins that threaten humans and animals. Because of their color, cyanobacteria are also referred to as blue-green algae, and when they form colonies, are called harmful algal blooms (HAB), though not all are harmful.

Algae are a diverse group of aquatic organisms that have the ability to photosynthesize. They can be found in a wide range of environments, include lakes, ponds, oceans, hot springs, and land (Live Science 2020). Most algae are harmless and are considered an important component of the food web. Certain types of algae can grow rapidly, forming blooms, and covering all or portions of a lake. There are some species of algae that produces toxins which can be harmful to humans and animals. Algae blooms that produce toxins are referred to as harmful algal blooms (HABs) (NYS DEC 2020). More than 40 cyanobacterial species are confirmed or suspected to produce toxins (Graham and Wilcox 2000).

Because of their incredible diversity and shared characteristics with plants, the taxonomy of algae has been much discussed. Originally classified as plants, algae are now found in the kingdom Protista. Algae are further broken down into groups commonly grouped by pigmentation. Most species of green algae are only found in fresh water while most species of red algae and brown algae are only found in salt water. Brown algae are among the most complex forms of algae while blue-green algae are one of the simplest forms of algae. Also referred to as cyanobacteria (a bacteria rather than a true algae), blue-green algae are either single celled or colonial. Blue-green algae are the most common form of algae to result in HABs in Chenango County, impacting the county's lakes, ponds, and reservoirs.

HABs are usually triggered by a combination of water and environmental conditions, including excess nutrients (phosphorus and nitrogen), excessive sunlight, low-water or low-flow conditions, still waters, and warm temperatures. The timeframe of HABs depends on weather conditions and characteristics of the lake. They can last for a few hours (short-lived) to several weeks or longer (long-lived) (NYS DEC 2020).

Identifying Harmful Algal Blooms

The appearance of HABs can vary greatly. According to the NYS DEC, colors can include shades of green, blue-green, yellow, brown, red, or white. The physical appearance of these blooms can include floating dots or clumps and streaks on the water's surface as illustrated in . Some blooms can also resemble spilled paint on the water's surface or change the appearance of water to that of pea soup (NYS DEC 2017b).



Figure 5.4.5-1. Examples of Harmful Algal Bloom Visual Appearance

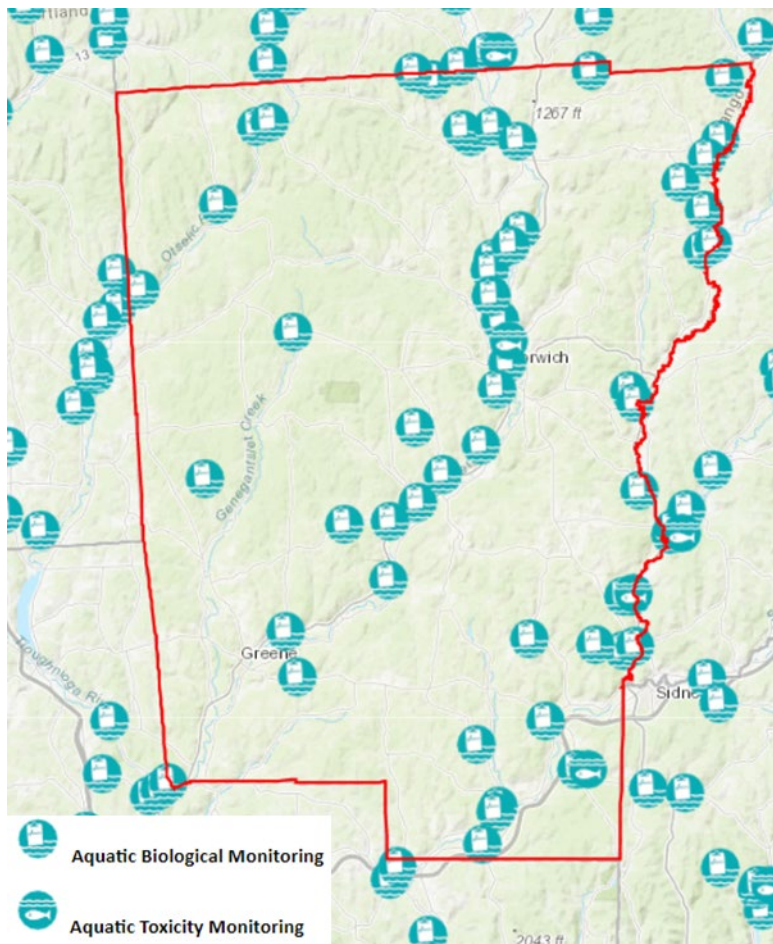


Source: NYS DEC 2016

The NYS DEC Lake Classification and Inventory Program, Citizen Statewide Lake Assessment Program volunteers and partnered HAB monitoring programs collect and report information about the status of waterbodies in New York that may be impacted by HABs (NYS DEC 2018). Figure 5.4.5-2 shows the location of waterbodies that are monitored in Chenango County or bordering Chenango County.



Figure 5.4.5-2. NYS DEC Lakes Monitoring Program Map



Source: NYS DEC Info Locator, 2020

Location

Chenango County has significant exposure and vulnerability to the HAB hazard, as described below.

- Shorelines of the Chenango County waterbodies with documented HABs are publicly accessible, which can increase the chance of exposure. Many of the county’s lakes are popular recreation lakes and have an abundance of lake users, tourism and shoreline development.
- HABs are generally limited to lakes and ponds but any surface water can experience harmful algal blooms as evinced by prior events in Thunder Lake and Plymouth Reservoir.
- The widespread use of septic systems in the County is a major contributing factor to HABs.
- Locations that rely on surface water intake for drinking water are most exposed to the impacts of HABs. However, most of the County relies on groundwater from deep wells.

NYS DEC records indicate 12 waterbodies in Chenango County had documented HABs in recent years (since 2012). In total, these waterbodies have a combined approximately 15.56 miles of shoreline, all of which are part of Chenango County. Table 5.4.5-1 breaks down the total shoreline miles per lake and the shoreline miles per lake in Chenango County. While most HAB contact occurs along shorelines, blooms can take place throughout surface waters. According to the 2010 Census, approximately 3.87 percent of Chenango County is made up of surface water.



Table 5.4.5-1. Shoreline of Major Waterbodies in Chenango County with Documented HABs

Lake	Shoreline Miles (total)	Shoreline Miles (in Chenango County)	Surface Area (Acres)
Bowman Lake	1	1	34
Chenango Lake*	2.1	2.1	133
Echo Lake	0.43	0.43	63.9
Genegantslet Lake	Approx. 2.4	2.4	108.6
Glenn Lake	Approx. 0.8	0.8	-
Guilford Lake	1.5	1.5	70
Lake Petonia	Approx. 0.79	0.79	26
Long Pond	3.5	3.5	114
Norwich Reservoir East*	-	-	-
Plymouth Reservoir	Approx. 1.37	1.37	77
Thunder Lake	Approx. 0.79	0.79	18
Warn Lake	Approx. 0.88	0.88	32
Total	15.56	15.56	676.5

Source: NYS GIS

Note: * Indicates major drinking water source.

- Undetermined

Extent

The NYS DEC uses visual observations, photographs, and laboratory sampling results to determine if blooms are comprised of cyanobacteria or other types of algae. Figure 5.4.5-3 is a photograph of a confirmed cyanobacteria bloom at Plymouth Reservoir. NYS DEC staff will set bloom statuses for waterbodies that are being investigated for harmful algal blooms:

- **Suspicious Bloom:** NYS DEC staff have determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs. Laboratory analysis has not been conducted to confirm whether this suspicious bloom is a HAB. It is not known if toxins are present in the water.
- **Confirmed Bloom:** Water sampling results have confirmed the presence of a cyanobacteria HAB, which may produce toxins or other harmful compounds.
- **Confirmed with High Toxins Bloom:** Water sampling results have confirmed that toxins are present in enough quantities to potentially cause health effects if people and animals come in contact with the water through swimming or drinking (NYS DEC 2018).

Suspicious blooms are reported to NYS DEC, local health departments, or the NYS Department of Health (NYSDOH 2017).



Figure 5.4.5-3. Cyanobacteria Bloom in Plymouth Reservoir, Chenango County



Source: NYS DEC, 2020

The extent of a harmful algal bloom is an estimate of the area of the waterbody that is impacted. The NYS DEC has four categories to classify extent within their monitoring program (NYS DEC 2018):

- **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. Special precautions should be taken in situations when a “Confirmed with High Toxins Bloom” is reported with an open water extent because toxins are likely to be even higher in shoreline areas.

Wind currents can play a large role in the concentrations of algae that float at or near the water surface. Consistent winds can accumulate algae at downwind shorelines. Shorelines containing coves or other features that could capture floating algae may be more susceptible to HABs. In instances where freshwater intakes are impacted by these blooms, the extent may also include the area that is serviced by the impacted water utility or the private/residential intake.



Previous Occurrences and Losses

For this HMP update, HAB events were researched from 1972 to September 2020. The NYS DEC began HAB testing and issuing notifications for New York waterbodies in 2012. The 2018 DEC Lake Monitoring Program includes the Lake Classification and Inventory Survey (LCI), the Citizens Statewide Lake Assessment Program (CSLAP) and several individual lake sampling programs. Table 5.4.5-2 lists events identified by the NYS DEC HAB Program between 2012 and 2020. This table includes events specific to Chenango County as well as events listed for neighboring counties but on a shared waterbody, keeping in mind that algal blooms can spread on connected waterways. Figure 5.4.5-4 shows the location of HAB reports throughout the County.

Table 5.4.5-2. Harmful Algal Bloom Events in Chenango County or Lakes Bordering Chenango County, 2012 to 2019

	2012	2013	2014	2015	2016	2017	2018	2019
Bowman Lake					S			
Chenango Lake		C			C			
Echo Lake		C						
Genegantslet Lake		C			S			
Glenn Lake					S			
Guilford Lake					C			
Lake Petonia			HT					
Long Pond					S			
Norwich Reservoir East					S			
Plymouth Reservoir					C	HT	HT	C
Thunder Lake				S		S		C
Warn Lake					C			

Source: NYS DEC 2020

Note:

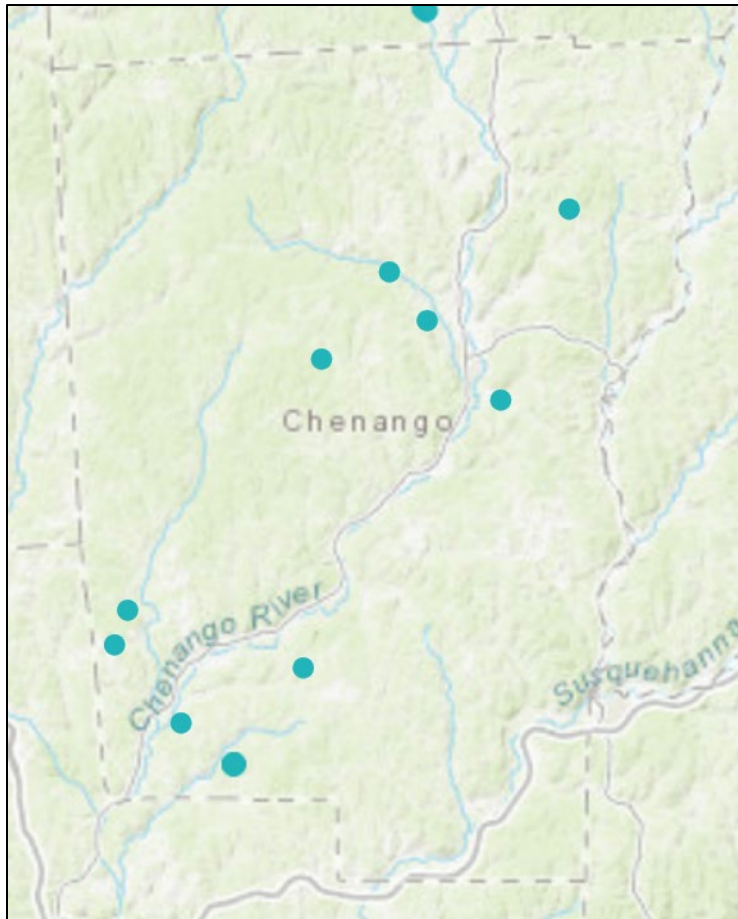
S (Suspicious Bloom) = DEC staff determined that conditions fit the description of a cyanobacteria HAB based on visual observations and/or digital photographs

C (Confirmed Bloom) = Water sampling results have confirmed the presence of a cyanobacteria HAB which may produce toxins or other harmful compounds

HT (Confirmed with High Toxins Bloom) = Water sampling results confirmed that there were toxins present in quantities to potentially cause health effects if people or animals came in contact with the water



Figure 5.4.5-4. Location of HAB reports, Chenango County, 2012 – 2020



Source: NYS DEC, 2020

Probability of Future Events

HABs appear to be a recent occurrence in Chenango County or have only recently been officially reported and recorded. Even with these blooms becoming increasingly common, season and year-to-year fluctuations make predicting their occurrence difficult (U.S. Environmental Protection Agency [EPA] 2017a). Despite this uncertainty, the impact of HABs on the environment, human health, and local economies cannot be discounted.

Table 5.4.5-3 lists probabilities of occurrences of HAB events. The information used to calculate probabilities of occurrences is based on NYS DEC database records that only date back to 2012. It is possible that HABs were present in waterbodies before 2012 but were not identified or monitored. It is also possible that events have taken place in waterbodies that went unreported.

Table 5.4.5-3. Probability of Occurrence of Harmful Algal Bloom-Related Events

Hazard Type	Number of Occurrences Between 2012 and 2020	Percent Chance of Occurrence in Any Given Year
Harmful Algal Bloom	24	100%

Sources: NYS DEC 2020

Note: Probabilities were calculated from years 2012 to 2020. NYS DEC data only included harmful algal bloom events beginning in 2012.

During the Risk Assessment Planning Partnership meeting, the occurrence of harmful algal blooms was discussed. The Steering Committee also provided documentation of the occurrence of HAB’s in the County. In



Section 5.3, the identified hazards of concern for Chenango County were ranked. Probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence of HAB in Chenango County is considered “frequent” (hazard event has 100% annual probability and may occur multiple times per year).

Climate Change Impacts

Increases in temperature may result in increased frequency of HABs. Most HABs take place during the summer months when water temperatures are warmest. Cyanobacteria in particular prefer warmer water. When lakes are at their warmest, mixing of the water column is less likely. When lakes are stagnant, algae are able to grow thicker and faster. In addition, the lower density of warm water allows algae to float to the surface faster. As algae grow and reproduce, they absorb more sunlight at the surface, further increasing the lake temperature and promoting more blooms (EPA 2017b).

Annual average precipitation is projected to increase by up to five by the 2050s and by up to 10 percent by the 2080s. During the winter months, additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Northern parts of New York State are expected to see the greatest increases in precipitation (NYSERDA 2014).

The projected increase in precipitation is expected to occur via heavy downpours and less in the form of light rains. Rising air temperatures intensify the water cycle by increasing evaporation and precipitation, which can cause an increase in rain totals during storm events, with longer dry periods between those events. Alternating periods of drought and heavy rainfall increase the likelihood of nutrient runoff into waterways, which can fuel algal blooms (EPA 2017b).

Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. In addition to warmer temperatures and heavy precipitation events, carbon dioxide levels are forecast to continue to increase. Higher levels of carbon dioxide in the atmosphere and water can lead to increased algal growth, particularly for cyanobacteria that float at the surface (EPA 2017b).

5.4.5.2 Vulnerability Assessment

To understand risk, a community must evaluate assets that are exposed and vulnerable to the identified hazard. All assets surrounding and relying on the waterways and water in the county are exposed to the HAB hazard. The following text evaluates and estimates the potential impact of the HABs hazard on the county.

Impact on Life, Health, and Safety

Impacts of HABs on life, health, and safety depend on several factors, including the severity of the event and whether or not citizens and tourists have become exposed to waters suspected of containing a HAB. Routes of exposure include consumption, inhalation, and dermal exposure. The population living near or visiting waterbodies is at risk for exposure as well as those that use those waterbodies for recreation, fishing, and water supply. Contact with water containing HABs can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (NYSDOH 2017).

Cyanobacteria blooms are one of the most common freshwater HABs and have been identified by NYS DEC as being present in Chenango County blooms. Cyanobacteria are known to produce toxins from the following classes and have impacts on human health.

- **Endotoxins:** Endotoxins associated with cyanobacteria have been tied to fever and inflammation in humans that have come in contact with water that contains cyanobacterial blooms.



- **Hepatotoxins:** Hepatotoxins are commonly tied to animal poisonings that are associated with cyanobacterial blooms. Animals may exhibit weakness, heavy breathing, paleness, cold extremities, vomiting, diarrhea, and bleeding in the liver. In humans, hepatotoxins have been indicated to promote tumors and may lead to increases in liver cancer. Some types of hepatotoxins, such as microcystin, can persist in fresh water for up to 2 weeks before being naturally broken down (algae).
- **Neurotoxins:** Neurotoxins act to block transfers between neurons. Extreme cases can result in paralysis.

Populations in Chenango County that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Chenango Lake, Ransford Creek, and the Upper and Lower Reservoirs are the primary source of surface drinking water for the City of Norwich and Town of Norwich (combined population of 10,342) and is accessed using an unfiltered system (City of Norwich 2016). Some recreational lakes, such as Plymouth Reservoir, Echo Lake, Geneganslet Lake, and Guilford Lake, have shoreline housing and campsites with many residents and visitors drawing directly from surface waters without filtration systems in place.

Impact on Critical Facilities

The typical impact of HABs on critical facilities is due to shut down of water intakes from surface waters that are impacted by blooms and their toxins. Water treatment plants can remove variable amounts of microcystin from drinking water, but as much as 20 percent of these toxins may escape the treatment process (Carmichael 1997), sometimes leading to plant closures. The City of Norwich and Village of Afton supplement their public water wells with a filtered surface water supply (Chenango County 2016).

Public Water systems within Chenango County are monitored regularly by the NYSDOH, Chenango County Environmental Health Staff, and certified municipal employees. The EPA has also established an incident checklist for harmful algal bloom incidents impacting water utilities (EPA 2017c).

Impact on the Economy

Economic impacts from HAB events are difficult to quantify in Chenango County. Nationally, these events have caused significant economic loss. For example, a 1976 red tide event in New Jersey was estimated to have caused losses near \$1 billion (in 2000 dollars) and a 1997 outbreak of *Pfiesteria* in Chesapeake Bay is estimated to have resulted in \$46 million in lost sales of seafood (PCM HAB Research Plan). The costs of these events were largely estimated to be the result of closed fisheries or impact on consumer choices to purchase seafood.

Economic impacts on Chenango County would largely focus on the water recreation and tourism sector, and public drinking water infrastructure. News of a closure of a body of water or beach can result in tourists avoiding the area. Even after closures are lifted, negative public reaction can persist and continue to impact tourism revenue and property values.

Recreational fishing is popular along the Chenango, Susquehanna, and Unadilla Rivers, as well as on Lakes and Ponds throughout the County, with several species stocked by the NYS DEC to enhance fishing opportunities and restore native species (Chenango County 2016). Other recreational activities in the area include hunting, hiking, boating, bird watching, snowmobiling, canoeing, and camping (Chenango County 2016). Property values, as residences are concentrated around the County's waterbodies could also be impacted.

More traditional economic impacts can be associated with the costs of operating monitoring programs, shutdowns of water supplies and associated backup water source costs, and the costs of advanced drinking water treatment (NYS DEC 2017b).



Impact on the Environment

Harmful algal blooms can release toxins that lead to fish and invertebrate kills. Animals that prey on fish and invertebrates in surface waters, such as birds and mammals, may be affected if they ingest impacted prey. Both harmful and non-harmful algal blooms can have drastic impacts on oxygen levels in surface waters. When algae begin to die off following a bloom, bacteria begin to decompose the organic material. This decomposition consumes dissolved oxygen and releases carbon dioxide. If the bloom and die off is large enough, dissolved oxygen levels in aquatic systems can rapidly crash. Anoxic conditions connected to algal blooms have resulted in large fish and invertebrate kills (Graham and Wilcox 2000).

Cascading Impacts on Other Hazards

Harmful algal blooms can exacerbate the impacts of disease outbreak. Species and persons that are exposed to cyanobacteria may become poisoned, experience gene alterations, or disease (EPA 2020). More information about disease outbreaks can be found in Section 5.4.1 (Disease Outbreak).

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the county. HABs could impact any areas of growth located near waterbodies that are vulnerable to harmful algal blooms. As increased development is often associated with stormwater and runoff issues, harmful algal blooms may become more likely in areas of increased development. The specific areas of development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Projected Changes in Population

According to population projections from the Cornell Program on Applied Demographics, Chenango County will experience a slight population decrease through 2040 (more than 7,500 people in total by 2040). Population change is not expected to have a measurable effect on the overall vulnerability of the county's population over time.

Climate Change

Chenango County will see an increase in both temperature and precipitation amounts as a result of climate change. As discussed above, a warming climate will allow for an extended growing period for algal blooms. Additionally, increases in precipitation will generate more stormwater runoff, which can lead to increased nutrient loads entering waterways from leached nutrients in the soil or fertilizers on agricultural lands. Warmer temperatures and increased nutrient loads will allow for algal blooms to grow and spread more rapidly. These changes will increase the county's overall vulnerability to HABs.



Change of Vulnerability since the 2015 HMP

The 2015 version of this HMP did not identify HABs as a hazard. Chenango County and its municipalities have only recently been impacted by these blooms and it is possible that HAB events had taken place previously but were undetected. It appears likely that these blooms will continue to pose a hazard in the future.

DRAFT