4.3.11 Infestation and Invasive Species

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the infestation hazard in Gloucester County.

2021 HMP Changes

This is a new hazard of concern for Gloucester County.

1.4.1.1 Profile

Hazard Description

An infestation is defined as a state of being invaded or overrun by parasites that attack plants, animals and humans. Insect, fungi and parasitic infestations can result in destruction of various natural habitats and cropland, impact human health, and cause disease and death among native plant, wildlife and livestock. An infestation is the presence of a large number of pest organisms in an area or field, on the surface of a host, or in soil. They result from when an area is inhabited or overrun by these pest organisms, in numbers or quantities large enough to be harmful, threatening or obnoxious to native plants, animals and humans. Pests are any organism (insects, mammals, birds, parasite/pathogen, fungi, non-native species) that are a threat to other living species in its surrounding environment. Pests compete for natural resources or they can transmit diseases to humans, crops and livestock. Human populations are generally impacted by insect or animal infestations that can result in health impacts and can lead to potential epidemics or endemics.

For the purpose of this HMP Update, the infestation hazard profile will include the following: Emerald Ash Borer, Spotted Lanternfly, white-tailed deer, Canada Goose, and harmful algal bloom. For information on the spread of disease caused by mosquito infestations, refer to Section 5.4.3 (Disease Outbreak).

Emerald Ash Borer

Emerald Ash Borer (EAB) was first discovered in Somerset County in 2014 and first detected in Gloucester County in the Township of East Greenwich in 2019. This Asian beetle infests and kills North American ash tree species, including green, white, black and blue ash; making all native ash trees susceptible to this insect. The insect is typically present from late May through early September and is most common in June and July. Signs of infection include tree canopy dieback and yellowing and browning of leaves. Most trees die within two to four years of becoming infested (NJDA 2020).

Source: NJDA 2020

Spotted Lanternfly

The spotted lanternfly (*Lycorma deliculta*) is an Asian plant hopper. The adults are quite colorful with a black head, grayish black spotted forewings, and reddish black spotted hind wings. Adults are approximately 1" in length and a 1/2" in width and are present from mid-July through the fall. During this time, SLF adults are mating and laying eggs. Egg masses are laid on smooth surfaces and appear like a patch of mud.

Source: NJAES 2020

In the USA, spotted lanternfly is an invasive species that could be very devastating to some New Jersey crops and hardwood trees. This insect was accidentally introduced into Pennsylvania and was confirmed in September 2014. In 2018, spotted lanternfly populations were found in New Jersey and a state quarantine encompassing Gloucester, Hunterdon, and Warren counties has been established by the NJ Department of Agriculture (New Jersey Agricultural Experiment Station [NJAES] 2020).

The spotted lanternfly can feed on more than 70 plant species including cultivated grapes, fruit trees, and hardwood trees. One tree of particular importance is *Ailanthus altissima,* or the Tree of Heaven, which is abundant in New Jersey. Tree of Heaven typically grows in clumps in sunny areas along highways or disturbed habitats such as the edges of crop fields, open spaces, or parks. Other key tree hosts include black walnut; red maple; and agricultural crops such as grapes, hops, apples, and peaches.

As with all plant hoppers, the spotted lanternfly has sucking mouthparts that it inserts into plant tissues to remove the fluids it needs to survive. Adults and nymphs are phloem feeders that feed in large congregations on woody tissue. Although there are no numbers or estimates on the economic impact of the spotted lanternfly, this insect feeds in large numbers and thus can quickly cause damage. Feeding occurs on the trunk and limbs of plants, not on the fruit or leaf tissues. During feeding, the insect excretes significant amounts of sugar water, called honey dew. Honey dew deposits provide a food source for a sooty mold fungus that can grow on plant surfaces and fruit leading to reduced photosynthesis and plant vigor, leading to additional plant damage (NJAES 2020).

White-Tailed Deer

White-tailed deer can be found from southern Canada to South America. In summer months, they typically live in fields and meadows while during the winter, the deer generally keep to forests. White-tailed deer are herbivores and graze on most types of plants. There are not many natural predators to white-tailed deer which causes the deer population to grow too large for their environment and some areas may experience an overpopulation of deer (National Geographic 2015).

Source: NJDEP 2019

In New Jersey, white-tailed deer are a major component of the environment throughout the State, with the exception of the most urbanized areas. In the early 1900s, the deer population in New Jersey was minimal, but the population rebounded during the 20th century and is thriving today. White-tailed deer in New Jersey affect forests, farms, gardens, backyards and roadways. They can have negative impacts on humans, as they cause car accidents, depredation of agricultural and ornamental plantings, and the potential for harboring diseases that are transmissible to man or domestic animals (NJDEP 2020).

Deer populations have reached problematic numbers in numerous areas of the state. In an effort to help reduce these populations, the NJDEP Division of Fish and Wildlife has lengthened hunting seasons, increased limits on the number of deer that can be harvested (bag limit), increased the number of hunting permits issued, and offered incentives for hunters to harvest more does and fawns. However, in some areas, factors such as development patterns, properties where hunting is prohibited, regulations or ordinances that severely restrict or preclude hunting, and landowner decisions not to allow hunting, have reduced the effectiveness of hunting. Public open space with full hunter access typically has much lower deer densities than surrounding areas where hunting is not allowed or is restricted. Although New Jersey has some of the most liberal deer hunting regulations in the nation, the lack of or restricted hunter access results in undesirable deer densities in many areas of the state. In areas where sport hunting is not considered to be a practical management tool, the Division has permitted alternative methods of controlling deer populations under the Community-Based Deer Management Permit program. These alternative methods include controlled hunting, shooting by authorized agents, capture and euthanization, capture and removal, and fertility control. Farmers also get free permits to hunt on their property and free depredation permits to allow for taking deer during off-hunting season to mitigate agricultural damage (NJDEP 2019).

Canada Geese

The Canada Goose is a large, naturally occurring migratory waterfowl species. However, a portion of the population has adapted to become residential. These residential birds have overpopulated many urban and suburban areas that have expanses of short grass, abundant lakes and ponds, a lack of natural predators, limited hunting, and supplemental feeding. Resident geese are long-lived in suburban areas, living 20 or more years. A female goose may produce more than 50 young over her lifetime (NYSDEC 2007). The overpopulation of geese is a problem because their droppings and feathers accumulate on play areas and walkways, resulting in public health concerns at beaches and drinking water supplies, and environmental degradation in ponds due to increased nutrient loading. Furthermore, geese create a safety concern as nesting birds tend to be aggressive towards humans and create a safety hazard near roads and airports.

Harmful Algal Bloom

Algae blooms are caused by an excess of nutrients available in a waterbody, resulting in a rapid growth and reproduction of algae in what is commonly referred to as a "bloom." Waterbodies that are impacted by runoff of nutrients at high levels of both naturally occurring and manmade, algae can experience overloading of nutrients and become more vulnerable to algal blooms.

Algae, like plants, photosynthesize, forming the basis of many aquatic and marine food chains. However, unlike plants, algae do not have roots for nutrient intake. Some species of macroalgae appear to have roots because they are attached to the bottom by a structure known as a holdfast, but the holdfast does not absorb and transfer nutrients in the same way that roots do. Instead, algae are able to draw their nutrients directly from the environment that surrounds them. Due to this phenomenon, high nutrients, warm temperatures, and low turbulence at the water's surface all increase the risk of algal blooms.

As the base of the food chain in aquatic systems, phytoplankton populations are under constant threat of being eaten by herbivores. Phytoplankton species employ a variety of natural defenses to limit the amount of population destruction that unabated grazing by herbivores can cause. These may include regulation of population size and seasonal occurrence, growth of spiny exteriors, and the creation of toxins. More than 40 cyanobacterial species are confirmed or suspected to produce toxins (Graham and Wilcox 2000). When these populations of algae grow out of control and produce toxins or have harmful effects, it is typically referred to as a *Harmful Algal Bloom or HAB*. 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).

Traditional methods of in-home treatment systems such as boiling, disinfecting with chlorine/ultraviolet (UV), and water filtration units are not effective in removing HABs and their toxins. Public water is always the best option for drinking, preparing food, cooking, washing, and bathing, because water suppliers are required to treat, disinfect, and monitor their water supplies (NYSDOH 2017). Even after a HAB abates, toxins released by algae can remain in the water column for weeks. Water treatment plants with filtration systems can remove variable amounts of microcystin from drinking water; however, as much as 20 percent may escape the treatment process (Carmichael 1997), sometimes leading to plant and water system closures.

The presence of HABs will trigger official beach closures, drinking water restrictions, advisory signs, press releases, and notifications on websites such as the NJDEP Harmful Algal Blooms webpage (NJDEP 2019). Children and animals should be kept away from waters suspected of containing HABs, and fishing or eating fish should be prohibited. In Gloucester County, the primary threat from HABs is drinking water source contamination, followed by recreational precautions (and associated economic impacts) and the potential effects of the accumulation of toxins in fish for human consumption.

The appearance of HABs can vary greatly. According to the NJDEP, 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 Figure 4.3.13-1. Some blooms can also resemble spilled paint on the water's surface or change the appearance of water to that of pea soup (NJDEP 2019).

Figure 4.3.13-1. Examples of Harmful Algal Bloom Visual Appearance

HABs may look like parallel streaks, usually green, on the water surface.

HABs may look like green dots, clumps, or globs on the water surface.

HABs may look like blue, green, or white spilled paint on the water surface.

HABs may make the water look bright green or similar to pea soup.

Source: NJDEP 2019a

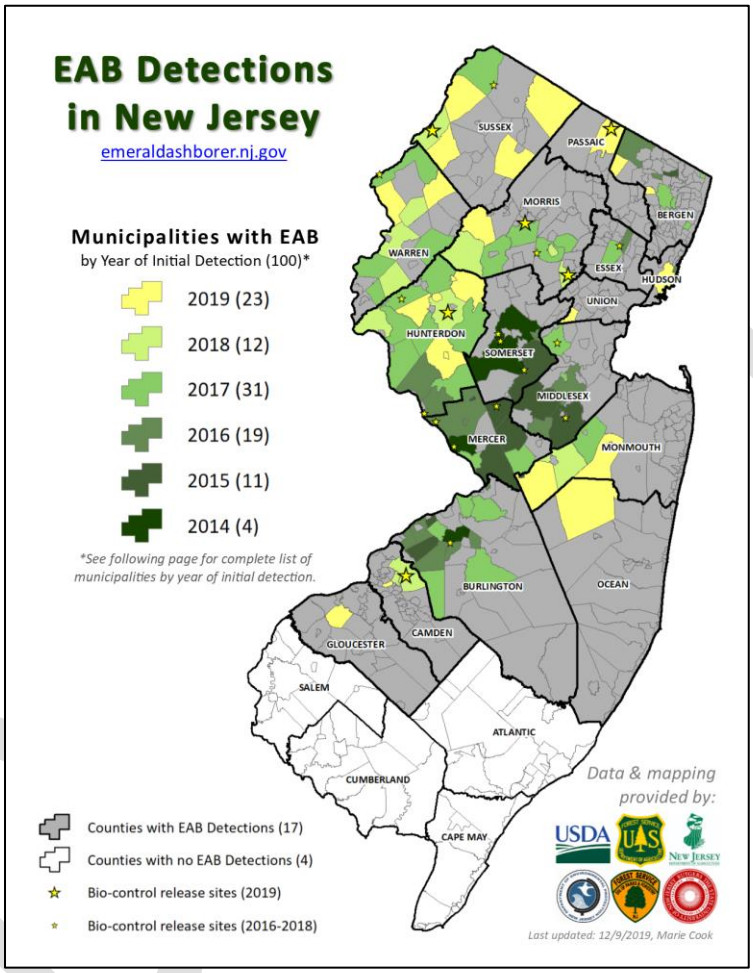
Location

Due to the diversity of landscape in Gloucester County, the entire County has the potential to be impacted by each of the species identified above.

Emerald Ash Borer

Three species of ash are native to Gloucester County an all are susceptible to EAB: white ash *(F. Americana),* green ash *(T. pennsylvanica*), and black ash (*F. nigra*). EAB was first detected in New Jersey in May 2014 and detected in Gloucester County (Township of East Greenwich) in 2019 (State of New Jersey Department of Agriculture 2021); refer to Figure 4.3.13-2.

Figure 4.3.13-2. Emerald Ash Borer Detections in New Jersey

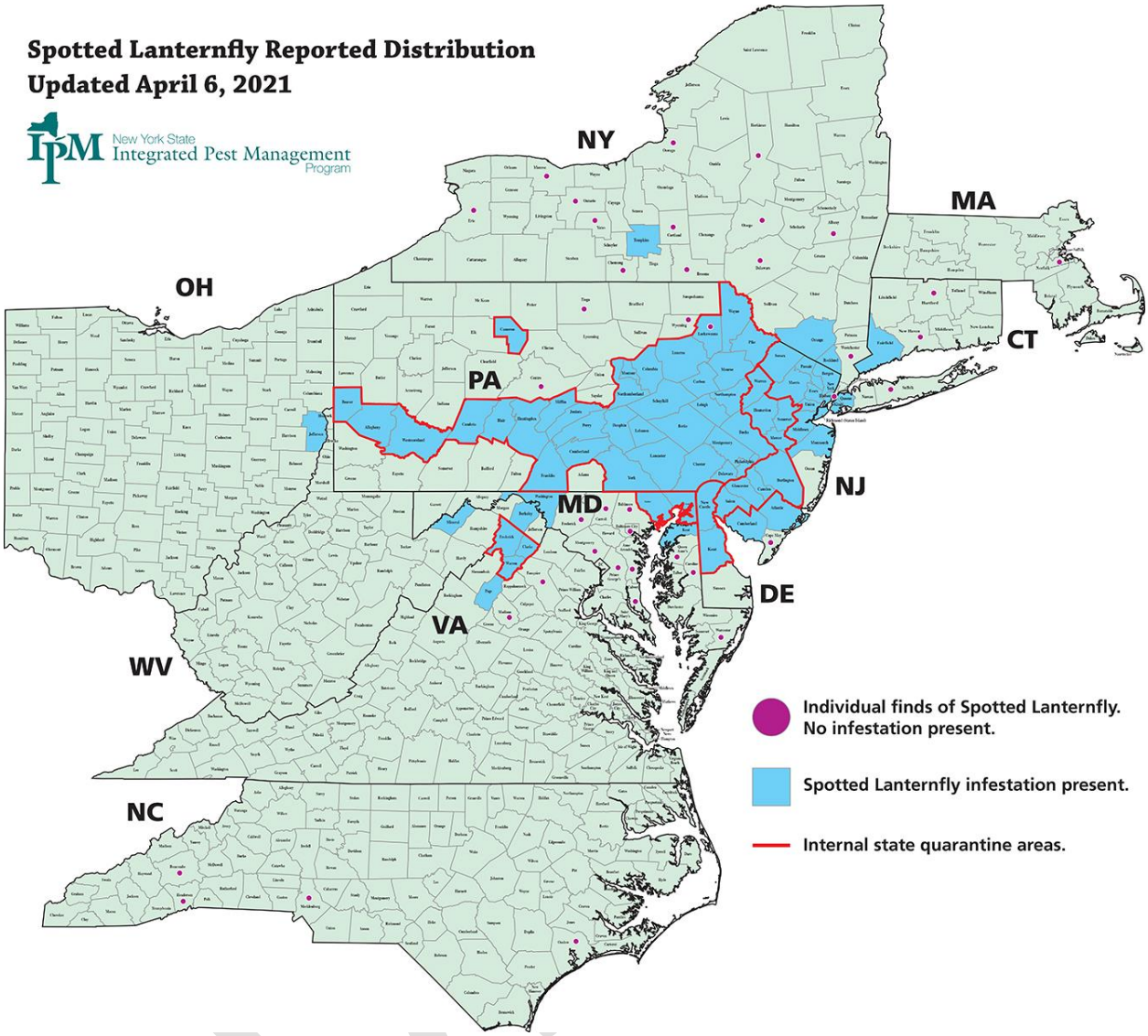


Source: State of New Jersey Department of Agriculture 2021

Spotted Lanternfly

According to NYSIPM, the spotted lanternfly infestation is present in Gloucester County as of April 2021. Gloucester County is included in the state quarantine area. The spotted lanternfly continues to spread across the mid-Atlantic region and increased occurrence within the County is likely in the near future unless successful mitigation occurs.

Figure 4.3.13-3. Spotted Lanternfly Reported Distribution as of March 2021



Source: NYSIPM 2021

White-Tailed Deer

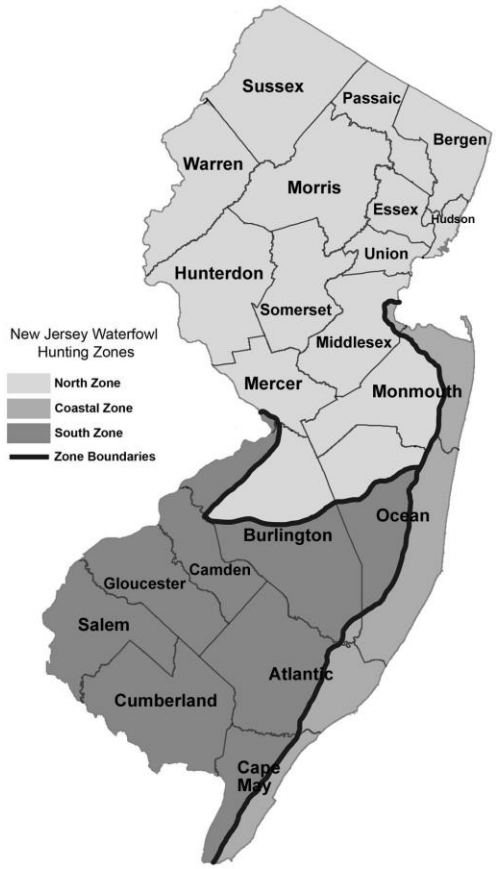
White-tailed deer populations vary throughout the state, based upon the habitat available. If deer were evenly distributed throughout the state, the 2017 population would average about 16.7 deer per square mile. However, urban areas typically have relatively few or no deer, and most suburban and rural areas with good deer habitat have more. Before recent culling efforts, Princeton Township had an estimated deer population of 114 per square mile and Hopewell Township estimated its deer population in 2010, prior to hunting season, as 54 per square mile (NJ DEP 2019).

Canada Geese

Within New Jersey there are three distinct populations of Canada geese: Atlantic Population, North Atlantic Population, and Resident Population. Atlantic Population Canada geese nest in the boreal forest and tundra of northern Quebec with the densest populations along the Ungava Bay and Hudson Bay coasts. North Atlantic Population geese nest further east in Newfoundland, Labrador, and Greenland. Collectively, Atlantic Population and North Atlantic Population geese are colloquially known as "migrant" geese since they breed in the sub-arctic and migrate south to spend winter. Resident Population geese breed in southern Canada and throughout the US and generally make no or relatively short migrations in winter. Although all three populations of geese readily mix in fall and winter, Resident Population geese are present in the states during spring and summer. Resident Population geese have readily adapted to human-dominated landscapes and are generally the goose population responsible for damage complaints regarding droppings and poor water quality (NJDEP 2018).

To manage and provide opportunity to hunt Resident Population geese, but avoid harvest of migratory geese, special seasons are designed to harvest Resident Population geese when and where possible. Gloucester County is included in the South Zone for hunting Canada Geese with the hunting season and bag limits set by the NJ DEP Division of Fish and Wildlife and the Fish and Game Council (NJDEP 2019).

Figure 4.3.13-4. New Jersey Waterfowl Hunting Zones

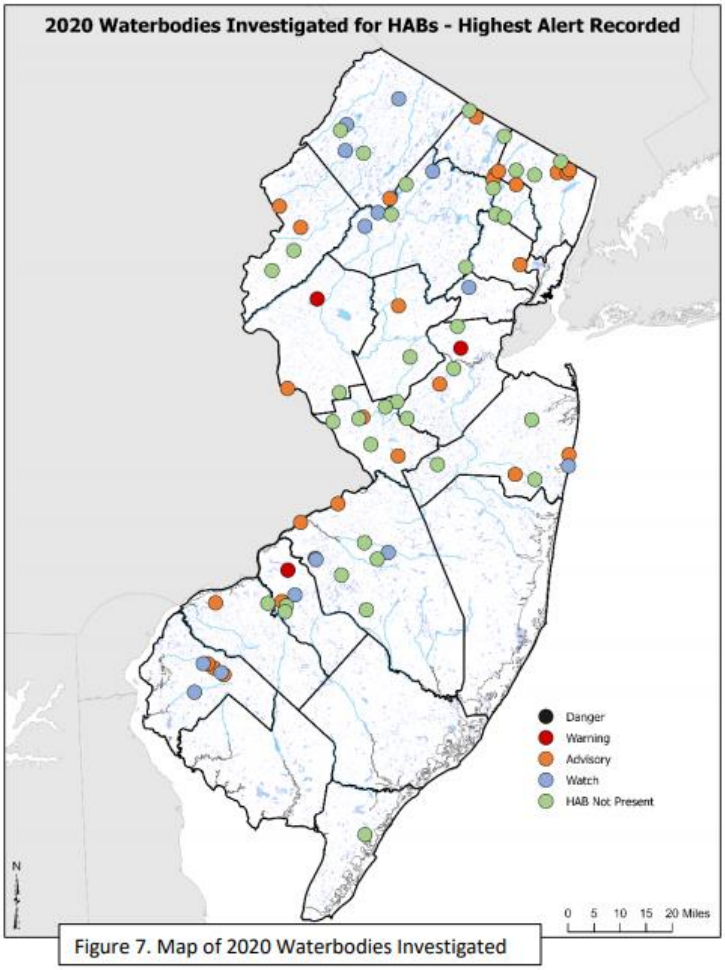


Source: NJ DEP 2019

Harmful Algal Bloom

HABs have the potential to impact waterbodies throughout Gloucester County and New Jersey. Waterbodies that are calm and have issues with eutrophication (overloading of nutrients), are the most susceptible to HABs. In Gloucester County, Greenwich Lake and Almonesson Lake are monitored for HAB's. In 2020, Greenwich Lake reached advisory levels for HAB's.

Figure 4.3.13-4. 2020 Waterbodies Investigated for HAB's, Highest Alert Recorded



Source: NJ DEP 2021

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.

Extent

The extent and location of infestations and invasive species depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. However, each of these threats can impact many areas of Gloucester County. The magnitude of infestations and invasive species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation.

Emerald Ash Borer

The NJ Emerald Ash Borer Task Force and other experts predict a 99% mortality rate for untreated ash trees. Peak die off of trees is likely to occur 9 to 10 years after the initial infestation. This suggests that Gloucester County will be dealing with large volumes of tree deaths in the next 15 years. Management options for EAB include tree removal, treating with insecticides, and biological controls (the release of wasps which act as parasitoids for egg and larvae). The United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA, APHIS, PPQ), operates the biological control production facility in Michigan which was designed to produce EAB parasitoids for release. In order to be considered for inclusion in the parasitoid release program, release sites must meet a certain criteria to be eligible: the site must be forested at least 40 acres in size; the site must contain no less than 25% ash of varying age classes; ash trees must be relatively healthy; and EAB must be detected in close proximity to the release site and be in low to moderate densities. The New Jersey Department of Agriculture (NJDA) is coordinating New Jersey's EAB biocontrol program.

Spotted Lanternfly

The Spotted Lantern Fly damages plants through the extraction of plant sap. Infestations of Spotted Lanternfly can result in decimation of crops, forest habitat, and landscaping (NJDA 2019). Due to the County's quarantine status, residents of Gloucester County are encouraged to inspect their cars for Spotted Lanternfly before leaving the County.

Canada Geese

While most people find a few Canada Geese acceptable, problems develop as local flocks grow exponentially including:

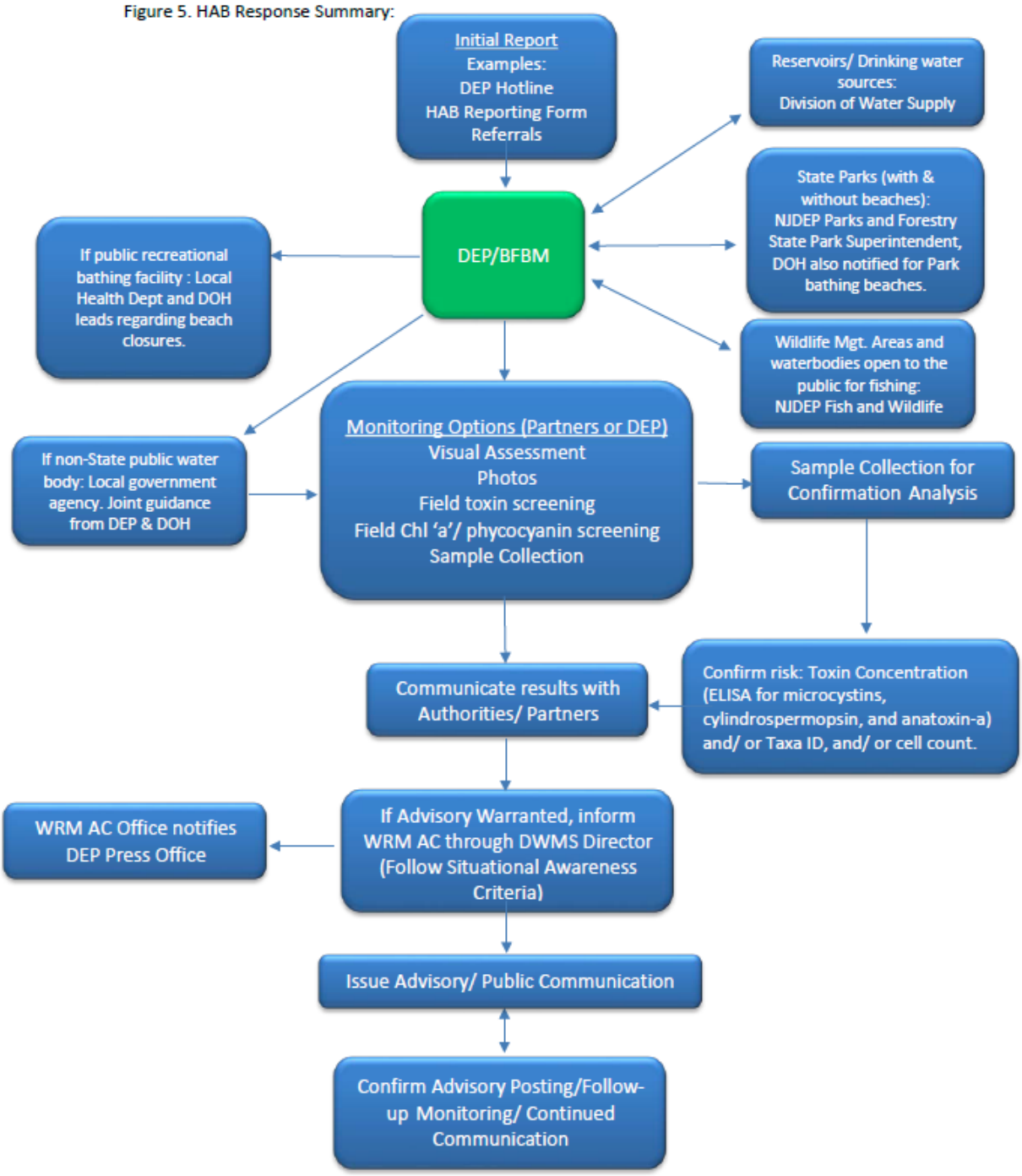
- over-grazed lawns
- accumulations of droppings and feathers on play areas and walkways
- nutrient loading to ponds
- public health concerns at beaches and drinking water supplies

- aggressive behavior by nesting birds
- safety hazards near roads and airports (NYSDEC 2021)

Harmful Algal Bloom

The NJDEP uses visual observations, photographs, and laboratory sampling results to determine if blooms are comprised of cyanobacteria or other types of algae. Suspicious blooms are reported to NJDEP or local health departments (NJDEP 2019). The NJDEP has a Cyanobacterial Harmful Algal Freshwater Recreational Response Strategy which includes the DEP Division of Water Supply and Geoscience's Emergency Response Plan. This response plan is outlined below in Figure 4.3.14-4.

Figure 4.3.13-4. NJDEP/BFBM HAB Response Plan



Source: NJDEP 2018

NJ DEP will declare alert levels depending on the results of testing. Figure 4.3.14-5 displays the HAB alert levels, criteria, and recommendations for actions to take with each level.

Figure 4.3.14-5. 2020 HAB Alert Levels

HAB ALERT LEVEL	CRITERIA	RECOMMENDATIONS
NONE	HAB report investigated and no HAB found	None
WATCH *Suspected or confirmed HAB with potential for allergenic and irritative health effects*	Suspected HAB based on visual assessment or screening test **OR** Lab confirmed cell counts between 20k – 40k cells/mL **AND** No known toxins above public health thresholds	Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) Waterbody Accessible: • Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ALERT *Confirmed HAB that requires greater observation due to increasing potential for toxin production* **PUBLIC BATHING BEACHES INCREASE MONITORING**	Lab confirmed cell counts between 40k – 80k cells/mL **AND** No known toxins above public health threshold	**WATCH remains in effect.** **Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) and should observe and report changing bloom conditions** Waterbody Accessible: • Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with **moderate risk of adverse health effects** and increased potential for toxins above public health thresholds*	Lab testing for toxins exceeds public health thresholds **OR** Lab confirmed cell counts above 80K cells/mL **OR** Field measurement evidence indicating HAB present and above guidance thresholds (e.g. phycocyanin readings)	Public Bathing Beaches Closed Waterbody Remains Accessible: • Avoid primary contact recreation (e.g. swimming) • Use caution for secondary contact recreation (e.g. boating without water contact) Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with **high risk of adverse health effects** due to high toxin levels*	Toxin (microcystin) 20 - 2000 µg/l **AND/OR** Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Public Bathing Beaches Closed Waterbody Remains Accessible: • Avoid primary contact recreation (e.g. swimming) • May recommend against secondary contact recreation (e.g. boating without water contact) with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish
DANGER *Confirmed HAB with **very high risk of adverse health effects** due to very high toxin levels*	Toxin (microcystin) > 2000 µg/l **AND/OR** Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Closure of Public Bathing Beaches Possible closure of all or portions of waterbody and possible restrictions access to shoreline. Avoid primary contact recreation (e.g. swimming) May recommend against secondary contact recreation with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish

Source: NJ DEP 2021

Previous Occurrences and Losses

Many sources provided information regarding infestations in Gloucester County; however, specific events and/or losses pertaining to the species discussed above were not identified. Testing for HAB's was limited prior to 2017. Invasive species may have occurred in Gloucester County prior to being officially identified and confirmed.

Federal Disaster Declarations

Between 1954 and 2021, FEMA included the State of New Jersey in one infestation-related emergency (EM) classified as a virus threat (EM-3156 in November 2000). Gloucester County was included in this declaration (FEMA 2021). For details regarding West Nile Virus in Gloucester County, refer to Section 5.4.3 (Disease Outbreak).

USDA Disaster Declarations

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Gloucester County was not included in declarations related to infestation or invasive species from 2015 to 2021 (USDA 2021).

Infestation and Invasive Species Events

Infestation and invasive species events that have impacted Gloucester County between 2011 and 2021 are identified in Table Error**! No text of specified style in document.**-1. With documentation of infestations and invasive species for New Jersey and Gloucester County being so extensive, not all sources have been identified or researched. Therefore, Table Error**! No text of specified style in document.**-1 may not include all events that have occurred in the County and focuses primarily on the species of concern identified for this HMP. Testing and identification is limited prior to 2017 for HAB and 2014 for other species. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

*Table **Error! No text of specified style in document.**-1. Infestation and Invasive Species Events in Gloucester County, 2011 to 2021*

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Gloucester County Designated?	Location	Description
2011	Canada Geese	N/A	N/A	Gloucester County	Municipal lakes in Gloucester County were reported to be closed, due in part to high bacteria counts attributed to Canada Geese overpopulation.
2019	Spotted Lanternfly	N/A	N/A	National Park	Spotted Lanternfly was first detected in Gloucester County at Red Bank Battlefield Park in National Park.
2019	Emerald Ash Borer	N/A	N/A	Township of East Greenwich	EAB was first detected in Gloucester County (Township of East Greenwich) in 2019
2020	Harmful Algal Bloom	N/A	N/A	Township of Greenwich	In 2020, Greenwich Lake in the Township of Greenwich reached advisory levels for HAB's.
2020	Spotted Lanternfly	N/A	N/A	Gloucester County	Gloucester County was included in the list of counties under quarantine for Spotted Lanternfly infestation.

Source: FEMA 2021; NJ DEP 2021, NYSIPM 2021, NJOEM 2019, Patch.com 2019, NJ.com 2011
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
N/A Not Applicable

Probability of Future Occurrences

Based on historical documentation, increased incidences of infestation throughout the State of New Jersey and the overall impact of changing climate trends, it is estimated that Gloucester County and its jurisdictions will continue to experience infestation events that may induce secondary hazards and health threats to the County population if infestations are not prevented, controlled or eradicated effectively. Based on these historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for infestation and invasive species in Gloucester County is considered "frequent". Refer to Section 4.4. (Hazard Ranking) for more information.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater

potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

The following provides information on the different infestations impacted Gloucester County and how they may be affected by climate change.

Emerald Ash Borer and Spotted Lanternfly

A warmer climate would extend the active insect season and allow for species that are not as cold tolerant to move north and expand their range. This increases the impact of the emerald ash borer and spotted lanternfly and their related impacts.

White-Tailed Deer

It is difficult to predict the impacts of climate change on the white-tailed deer population. A warmer climate with more mild winters could result in a population increase, as severe winters can cause female mortality (PSU 2015). However, an increase in extreme weather and disease are potential climate-driven stressors on white-tailed deer. Warmer temperatures will likely increase the midge population, which transmits hemorrhagic disease to white-tailed deer resulting in fatalities, as midges are killed by cold temperatures. Additionally, white-tailed deer serve as hosts for many tick species which may similarly increase in population due to warmer temperatures.

Harmful Algal Bloom

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 2017a).

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 2017a).

1.4.1.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the infestation and invasive species hazard, the entire County is exposed. The following discusses Gloucester County's vulnerability, in a qualitative nature, to the infestation and invasive species hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County is vulnerable to infestations and invasive species. According to the 2019 American Community Survey (ACS) 5-year Estimate, Gloucester County had a population of 291,165. Of that total population, the elderly population and people with suppressed immune systems are most susceptible to the effects of infestations such as Harmful Algal Blooms. The ACS has identified that there are 35,699 persons over the age of 65 in Gloucester County.

As discussed earlier, infestations can have an impact on agricultural commodities. The NJDA has indicated that New Jersey farmers lose $290 million annually in direct crop loss or damage caused by agricultural pests (New Jersey Department of Agriculture n.d.). This destruction of crop may include consumable resources that are sold to persons in the County. Section 5.4.4 (Drought) discusses the number of farms that are operating in the County (i.e., 580 farms). Based on the Department of Agriculture's study, it is reasonable to assume that the farms in Gloucester County also experience losses in crops. This not only impacts the livelihood of the farmers; it also affects the community that relies on these crops for food or other commodities.

Additionally, the impacts of harmful algal blooms on life, health, and safety depend on several factors, including the severity of the event and whether citizens and tourists have become exposed to waters suspected of containing toxins associated with cyanobacteria. 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 harmful algal blooms can cause various health effects including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (CDC 2020).

Further, the population living near waterbodies is at risk for exposure to HABs as well as those that use those waterbodies for recreation, fishing, and water supply. Therefore, exposure should not be limited to only those who reside in a defined hazard zone, but visitors to Gloucester County waterbodies as well. 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 (NJDEP 2020).

Cyanobacteria blooms are one of the most common freshwater HABs and have been identified by NJ DEP as being present in Gloucester County blooms. Cyanobacteria are known to produce toxins from the following classes:

- **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 (EPA 2014).

The EPA has established an incident checklist for HAB incidents impacting water utilities (EPA 2017). This tool is available to help utilities detect, identify, and monitor a bloom. Locations in Gloucester County that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Purchasing water may make some users more vulnerable if the utility has less control over the quality of the source. Coordinating with the supplier to ensure that the water is clear of harmful algae, thus maintaining the safety of users of the purchased water, is recommended.

Impact on General Building Stock

Structures are not anticipated to be directly affected by infestation or invasive species; however, EAB may cause a catastrophic loss of ash trees throughout the County, which could result in stream bank instability, erosion, and increased sedimentation, impacting ground stabilization and possibly cause foundation issues for nearby structures. Additionally, with an increased number of dead trees, there is an increased risk of trees falling on roadways, power lines, and buildings.

Some invasive plants have been shown to destabilize soil due to high densities and shallow root systems, negatively impacting nearby buildings and septic systems. Other invasive plant species have been known to clog culverts and streams, increasing flooding risk.

Impact on Critical Facilities

Water treatment plants could be impacted by infestation and invasive species because of similar issues that the general building stock may experience. Water that becomes polluted due to increased sedimentation and erosion will require additional treatment. If the system becomes clogged with these pollutants, the ability of water treatment plants to operate may become impaired. Additionally, soil that becomes unstable due to decaying vegetation can impact critical facilities that are built on or around these soils.

The typical impact harmful algal blooms have on critical facilities are shutdowns of water intakes from the surface waters that are impacted by blooms and their toxins. Water treatment plants can remove variable amounts of microcystin from drinking water depending on the active removal process used by the water treatment plant (EPA 2020). However, applying the wrong treatment process at a specific state in treatment could damage the facility and release cyanotoxins rather than remove them. The EPA has summarized the effectiveness of treatment options for harmful algal blooms (refer to Table Error**! No text of specified style in document.**-2).

*Table **Error! No text of specified style in document.**-2. Assessment of Treatment Options for HABs*

Treatment Process	Relative Effectiveness
Intracellular Cyanotoxins Removal (Intact Cells)	
Pre-treatment oxidation	Oxidation often stresses or lyses cyanobacteria cells releasing the cyanotoxin to the water. If oxidation is required to meet other treatment objectives, consider using lower doses of an oxidant less likely to lyse cells. If oxidation at higher doses must be used, sufficiently high doses should be used to not only lyse cells but also destroy total toxins present (see extracellular cyanotoxin removal).
Coagulation/ Sedimentation/ Filtration	Effective for the removal of intracellular toxins (cyanobacteria cells). Ensure that captured cells accumulated in sludge are removed frequently to release toxins. Ensure that sludge supernatant is not returned to the supply after sludge separation.
Membranes	Effective for removal of intracellular cyanotoxins (cyanobacteria cells). Microfiltration and ultrafiltration are effective when cells are not allowed to accumulate on membranes for long periods of time. More frequent cleaning may be required during a bloom event.
Flotation	Flotation processes, such as Dissolved Air Flotation (DAF), are effective for removal of intracellular cyanotoxins since many of the toxin-forming cyanobacteria are buoyant.
Extracellular (Dissolved) Cyanotoxins Removal	
Membranes	Depends on the type of cyanotoxin, membrane material, membrane pore size distribution, and influent water quality. Nanofiltration is generally effective in removing extracellular microcystins. Reverse osmosis filtration is generally applicable for removal of microcystins and cylindrospermopsin. Cell lysis is highly likely. Further research is needed to characterize performance.
Potassium Permanganate	Effective for oxidizing microcystins and anatoxins. Further research is needed for cylindrospermopsin. Not effective for oxidizing saxitoxin.
Ozone	Very effective for oxidizing microcystins, anatoxin-a, and cylindrospermopsin. Not effective for oxidizing saxitoxin.
Chloramines	Not effective.
Chlorine dioxide	Not effective at doses typically used in drinking water treatment.
Free Chlorine	Effective for oxidizing microcystins as long as the pH is below 8. Effective for oxidizing cylindrospermopsin and saxitoxin. Not effective for oxidizing anatoxin-a.
UV Radiation	UV radiation alone is not effective at oxidizing microcystins and cylindrospermopsin at doses typically used in drinking water treatment. When UV radiation is coupled with ozone or hydrogen peroxide (called

Treatment Process	Relative Effectiveness
	"advanced oxidation"), the process is effective at oxidizing anatoxin-a, cylindrospermopsin, and with high UV doses, microcystins.
Activated Carbon Adsorption	Powdered activated carbon (PAC): Effectiveness of PAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as natural organic matter (NOM) concentration. Wood-based activated carbons are generally the most effective at microcystins adsorption. More research is needed to evaluate PAC's effectiveness at adsorbing cylindrospermopsin, anatoxin-a, and saxitoxin, however the limited research has demonstrated promising results. Doses in excess of 20mg/L may be needed for complete toxin removal, especially if NOM concentrations are high. Granular activated carbon (GAC): Effectiveness of GAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as NOM concentration. GAC is effective for microcystins, and likely effective for cylindrospermopsin, anatoxin-a and saxitoxin. The condition of the carbon is an important factor in determining GAC's effectiveness for cyanotoxin removal. GAC may need to be regenerated more frequently to ensure adequate adsorption capacity for HAB season.

Source: EPA 2020

Impact on Economy

Impacts of infestation and invasive species and infestations on the economy and estimated dollar losses are difficult to measure and quantify. Costs associated with activities and programs implemented to conduct surveillance and address invasive species and infestations have not been quantified in available documentation. However, as indicated by the NJDA, farmers across the State may collectively revenue because of crop losses from invasive species and infestations (New Jersey Department of Agriculture n.d.). In 2017, there were 35,554 acres of cropland in Gloucester County with $94,853,000 in crops sold (USDA 2017). Therefore, it is reasonable to believe that Gloucester County farmers have experienced monetary losses from infestations.

The New Jersey Forest Service has indicated that 9-percent of New Jersey forests are susceptible to EAB attacks (NJDEP 2016). The emerald ash borer can infect nursery stock and mature trees, which could reduce the timber value of hardwood exports (CFIA 2014). In 2010, the USDA Northern Research Station conducted computer simulations of EAB spread to estimate the cost of ash tree treatment, removal, and replacement (re-planting of new trees) between 2009 and 2019. The simulations predicted an EAB infestation covering 25 states, and assumed treatment, removal, and replacement of more than 17 million ash trees on developed land within established communities. The total costs were estimated at $10.7 billion. This figure doubled when the model was reset to include developed land outside, as well as inside, human communities (USDA 2013).

HAB-related economic impacts on Gloucester County would largely focus on the agricultural and recreation sector. News of a closure of a body of water can result in visitors avoiding the area. Even after closures are lifted, negative public reaction can persist and continue to impact local revenue and property values. As mentioned, there is a price tied to programs that protect water bodies from harmful algal blooms. The cost to operate and monitor these programs will vary depending on the extent of the blooms. Additional costs may include money spent on nutrient reduction programs for agricultural commodities, purchasing backup water sources, and costs to implement advanced drinking water treatment. Agricultural producers may need to develop better strategies to reduce the nutrient runoff that cause harmful algal blooms, which may increase production costs for their commodities and overall costs for their buyers.

Impact on the Environment

As previously discussed, Gloucester County's parks, forests, landscaping, and agricultural areas are vulnerable to spotted lanternfly and EAB. Species that cause eventual destabilization of soil, such as invasive insects that destroy plants or invasive plants that outcompete native vegetation but have less effective root systems, can increase runoff into waterbodies. This can lead to increased harmful algal blooms and negative impact on drinking water supplies. Soil destabilization can also increase the likelihood of mudslides in areas with a steep slope.

The New Jersey Forest Service has indicated that the EAB will first infest the top of the tree's crown. This leads to the crown dying, bark splitting, and exit holes are created on lower parts of the tree. Trees that are infested only live on average of 3 to 4 years (NJDEP 2016).

Harmful algal blooms can release toxins that can kill fish and invertebrate (EPA 2019). 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.

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 and Change in Population

As discussed in Sections 4 (County Profile) and 9 (Jurisdictional Annexes), areas targeted for future growth and development have been identified across Gloucester County. Changes in land use have the potential to render some habitats more susceptible to invasive species, as clearing the land provides opportunities for invasive species to inhabit the area. Clearing the land may also reduce the habitat for predator species that could manage the spread of invasive species naturally. 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.

Infestation to cropland and nurseries can have a wider impact on persons outside of Gloucester County if the farmers within the County supply resources to neighboring communities. Being aware of trends occurring around the County may reveal that infestations within agricultural commodities provided by the County impacts a greater number of persons.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency, and intensity of weather events. Changing weather patterns could create a change in the migration patterns for when these species move into and out of Gloucester County. If the species have a more prolonged existence in the County, there may also be a greater number of infestation events or a higher value of loss tied to infestation. Warmer temperatures could lead to an increase of the length of the algal growing season and increase the likelihood of algal blooms. Increased alternation of drought and heavy precipitation could result in additional nutrient runoff into local waterbodies, providing more fuel for algal blooms. Higher carbon dioxide levels in the atmosphere and surface waters could create a more favorable growing environment for HABs (EPA 2017a).

Vulnerability Change Since the 2016 HMP

Infestations and invasive species is a new hazard section added to the County's HMP. More frequent events of infestations and blooms have made this hazard an area of interest that will be monitored more frequently in municipalities throughout the County, particularly those that contain major bodies of water that are used for drinking water, recreation, and economic purposes.