Commonwealth of Massachusetts
STATE RECLAMATION AND MOSQUITO CONTROL BOARD

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2020 INTEGRATED PEST AND VECTOR MANAGEMENT PLAN

District Updates:

- ***Residential Pesticide Exemption**:* Residents who request their property be excluded from pesticide applications must comply with the legal process to exempt their property. Pursuant to 333 CMR 13.03, individuals may request exclusion from wide area applications of pesticides by the district for the 2020 calendar year starting January 1st 2020. Requests **must be made to the Department of Agricultural Resources** online, and **will go into effect 14 days** from the date the request is received. All exclusion requests expire on December 31st, 2020. The exclusion request can be accessed from either our District's website or directly from the Department of Agricultural website:

  https://www.mass.gov/how-to/exclusion-from-wide-area-pesticides-application

Establish good mosquito avoidance habits during the mosquito season until the first hard frost.

- **Pick and always use a repellant with an EPA/CDC approved active ingredient when outdoors**
- Remove standing water to help reduce mosquito populations
- Use long sleeves to cover up whenever possible
- Repair screens
- Avoid outdoor activity between the hours of dusk and dawn in elevated risk areas
- Contact NEMMC to report potential mosquito breeding areas

A hard, or killing frost, is defined meteorologically as two consecutive hours of temperatures below 28 degrees Fahrenheit or three hours below 32 degrees. This will occur at different times for different communities, and there may even be variation within communities based on local geography. Although mosquitoes are not killed until a hard frost occurs, they are extremely unlikely to be active when temperatures fall below 50 degrees in the evening (Page 11 of the 2019 MA Arbovirus Plan listed below).

Refer to the 2019 Massachusetts State Arbovirus Surveillance and Response Plan viewed online at:
https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data#response-plan-

Introduction

Mosquito-borne viruses such as Eastern Equine Encephalitis virus (EEE) and West Nile Virus (WNV) have been and continue to be the cause of disease outbreaks in humans and animals in Massachusetts. Community-level mosquito control can be a practical and meaningful method of protecting people especially when risk levels of virus become moderate, high or critical. Efforts to reduce risk of arbovirus transmission include but are not limited to public awareness and prevention, adult and larval surveillance, and standard mosquito control methods utilized by established Mosquito Control Projects or Districts (MCPs).

Northeast Massachusetts Mosquito Control and Wetlands Management District

Mosquito control districts serve as critical elements in the surveillance network, and in performing and facilitating intervention efforts to reduce the burden of mosquitoes and mosquito-borne diseases. Districts coordinate the placement of traps, collecting, identifying and submitting mosquitoes and associated data with the Massachusetts Department of Public Health (MDPH).

District personnel have greater knowledge of local habitats and proper equipment that may be rapidly deployed to reduce mosquito populations. Personnel also increase public outreach/educational efforts for mosquito control, disease prevention, personal protection and IPM strategies. Districts also provide weekly summaries on mosquito abundance, diversity and local conditions that may be conducive to mosquito development and survival.

The purpose of the 2020 Integrated Pest and Vector Management Plan (IPVMP) is to summarize the NEMMC mosquito and arbovirus surveillance and management strategies specific to northeastern Massachusetts communities. This plan also outlines specific responses to arboviruses and how our resources will be directed toward implementing these responses effectively and efficiently.

Massachusetts Department of Public Health (MDPH)

Main objectives:

- Monitor trends in EEE and WNV in Massachusetts
- Provide timely information on the distribution and intensity of WNV and EEE activity in the environment
- Perform laboratory diagnosis of WNV and EEE cases in humans, horses and other animals
- Testing mosquito batches for disease through the Public Health Laboratory
- Communicate effectively with officials and the public
- Provide guidelines, advice, and support on activities that effectively reduce risk for disease
- Provide information on the safety, anticipated benefits, and potential adverse effects of proposed prevention interventions
- Assign risk categories for municipalities in the event WNV and EEE is detected

Refer to the 2019 Massachusetts State Arbovirus Surveillance and Response Plan viewed online at https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data#response-plan-

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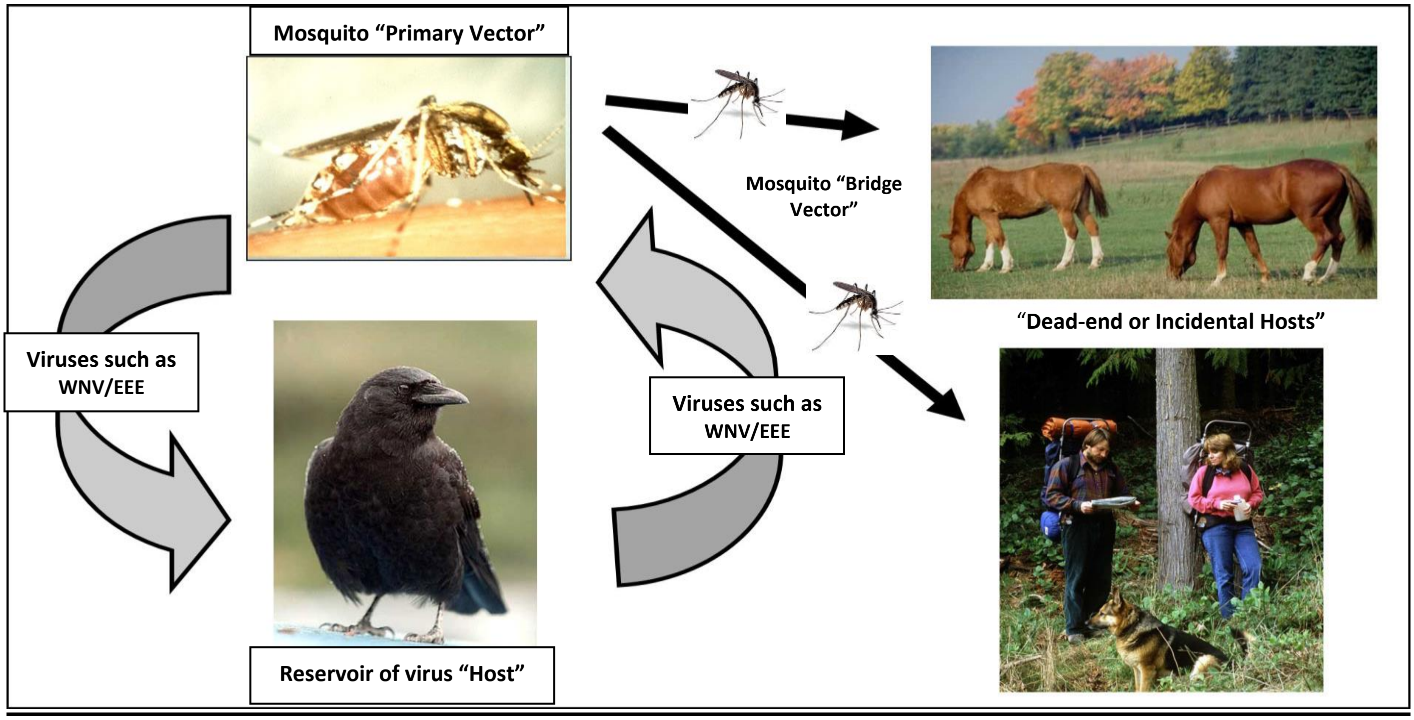
The Arbovirus Life Cycle

Arbovirus: A class of viruses transmitted to humans by arthropods such as mosquitoes and ticks.



Some mosquito species rarely bite humans; they feed on infected birds called "hosts". Newly infected mosquitoes then feed on non-infected birds causing an amplification of that virus in the local bird population. These mosquitoes are referred to as "primary vectors".

These infected birds become a blood-meal source for other mosquito species who themselves become infected. These other infected mosquito species may then bite humans. The species capable of infecting humans are known as "bridge vectors".

Humans and other mammals affected in this cycle are known as "dead end or incidental hosts". This means they do not develop the high levels of virus in their bloodstream needed to pass the virus to other biting mosquitoes.

Northeast District Mosquito Species of Concern

There are about 52 mosquito species present in Massachusetts. Approximately 12 species are associated with arboviral activity in Massachusetts and are targeted for control. Other species are listed as nuisance/pest species and can reduce the overall quality of life and recreation during a specific time of year. This list may expand over time.

Aedes vexans – Is a common nuisance mosquito. Temporary flooded areas such as woodland pools and natural depressions are the preferred larval habitat of this mosquito. It feeds on mammals and is an aggressive human biter. This species is typically collected from May to October. *Ae. vexans* is a bridge vector of EEE virus.

Anopheles punctipennis - Is found occasionally in the spring and summer. This pest of humans has a mildly annoying bite. The larvae are found in a wide variety of wetlands including permanent swamps and along the edges of ponds and slow moving streams. *An. punctipennis* has been implicated as a bridge vector of WNV.

Anopheles quadrimaculatus - Is a common summer mosquito. This species is a pest of humans and other mammals that readily enters houses and has a mildly annoying bite. The population increases during the summer. The larvae are found in clear water amongst low vegetation or floating debris, in permanent swamps and along the edges of ponds and slow moving streams. *An. quadrimaculatus* has been implicated as a bridge vector of WNV.

Coquillettidia perturbans – Marshes containing cattails, *Phragmites* and other emergent vegetation types such as rushes and arrow root are the primary larval habitat of this mosquito. It feeds on both birds and mammals. It is a persistent human biter and one of the most common mosquitoes in Massachusetts. This species is typically collected from June to September. *Cq. perturbans* is a bridge vector of EEE and WNV.

Culex pipiens – Artificial containers, including catch basins, are the preferred larval habitat of this mosquito. It feeds mainly on birds and occasionally on mammals. It will bite humans, typically from dusk into the evening. This species is regularly collected from May to October but can be found year round as it readily overwinters as an adult in manmade structures. *Cx. pipiens* is the primary vector of WNV.

Culex restuans – Natural and artificial containers, including catch basins, are the preferred larval habitat of this mosquito. It feeds mainly on birds and occasionally on mammals. This species is typically collected from May to October but can be found year round as it readily overwinters as an adult in man-made structures. *Cx. restuans* has been implicated as a vector of WNV.

Culex salinarius – Brackish and freshwater wetlands are the preferred habitat of this mosquito. It feeds on birds, mammals, and amphibians and is well known for biting humans. This species is typically collected from May to October but can be found year round as it readily overwinters as an adult in natural and manmade structures. *Cx. salinarius* may be involved in the human transmission of both WNV and EEE.

Culiseta melanura and *Cs. morsitans* - Swamp mosquitoes that occur in Atlantic White Cedar and Red Maple swamps and sphagnum bogs characterized by low pH. The larvae often are found within subterranean crypts and root mats that are difficult to treat with conventional larvicide agents. *Cs. melanura* obtains most of its blood meals from birds but is known to feed on mammals. This species is our primary vector and responsible for the amplification of EEE in birds in our area. It has also been found to carry WNV.

Aedes abserratus and *Ae. punctor* - Are a very common early spring to early summer mosquito pest of humans and other mammals. Larvae are found in temporary spring pools and margins of permanent waters in April. Readily bites in shaded areas during the day.

Aedes canadensis – Shaded woodland pools are the preferred larval habitat of this mosquito. It feeds mainly on birds and mammals but is also known to take blood meals from amphibians and reptiles. This mosquito can be a fierce human biter near its larval habitat. This species is typically collected from May to October. *Ae. canadensis* is a bridge vector of eastern equine encephalitis EEE virus.

Aedes cantator - This salt-marsh mosquito is a fairly large mosquito that can be a serious pest along the immediate coast from late spring to mid-summer. It is active during both daytime and nighttime periods, and can fly great distances from its original source.

Aedes excrucians and *Ae. stimulans* - Are freshwater spring snowmelt mosquitoes. Larvae develop in temporary or semi-permanent woodland pools. The females will bite in the woods any time of day, but are most active in the evening. They are aggressive and long-lived pests.

Aedes sollicitans - The "brown salt-marsh mosquito" is a fairly large mosquito that can be a serious pest along the immediate coast from early summer into fall. It is active during both daytime and nighttime periods, and can fly great distances from its original source. It has been reported to carry EEE in the northeastern US.

Aedes japonicus – Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is an aggressive human biter. This species is typically collected from May to October. *Ae. japonicus* may be involved in the transmission of both WNV and EEE.

Aedes taeniorhynchus - The "black salt-marsh mosquito" is a nuisance mosquito species that is capable producing tremendous numbers of adults after coastal flooding events caused by rains or extreme high tides. *Ae. taeniorhynchus* may be involved in the transmission of both WNV and EEE.

Aedes triseriatus - Is also a pest of humans and other mammals. Most of these larvae are found in tire casings although some are found in other shaded artificial containers and in tree holes. When this mosquito is a pest its breeding source is usually close by. *Ae. triseriatus* may be involved in the transmission of both WNV and EEE.

Psorophora ferox – The "white footed woods mosquito" is also a pest of humans and other mammals. Most of these larvae are found in floodwater areas and temporary woodland pools during the summer. It is active during both daytime, near its breeding site, and nighttime periods. *Ps. ferox* may be involved in the transmission of both WNV and EEE.

Regional Adult Mosquito Surveillance

The District's surveillance program forms the basis for mosquito control operations. Surveillance of mosquito populations is based on protocols established by the Centers for Disease Control (CDC) and Massachusetts Department of Public Health (MDPH). To monitor adult populations, the District maintains 35 historical trapping stations set every year at the same locations for an entire season. There is at least one trapping station in each subscribing municipality. Each trapping station uses two types of traps to collect mosquitoes (Figures 1 and 2).

The stations are generally located at municipal-owned facilities which are secure, have access to electrical power and are within the general vicinity of major population centers. The traps operate from mid-May through mid-October, with one collection cycle per week, each cycle lasting 24-hours. Trap contents are collected at the end of each cycle and all adult female mosquitoes are identified and recorded with certain species sent for disease testing.

Figure 1. CDC CO2/Light Trap

Figure 2. Reiter-Cummings Gravid Trap

The first of the two traps is the Light/CO_2-baited CDC trap (Figure 1). To attract mosquitoes, a light is used along with carbon-dioxide gas released from a pressurized cylinder into a hose located at the top of the trap. As mosquitoes approach the gas released at the hose's opening, they are drawn inside by an internal fan, then blown into a container that hangs below. With this trap, nearly all mosquito species in a community are collected during that night. Because the traps are placed at the same locations every year, population trends can be predicted, studied and compared between years, as well as during the year.

To determine whether infected bridge vectors are present, portable CDC-CO_2 traps (Figure1) are often placed at locations when infected *Cs. melanura* and *Cx. pipiens/restuans* mosquitoes have been collected. These traps collect other species which upon identification, are tested. Knowing the "infection status" of bridge vectors in EEE-known habitats can result in more effective targeted adulticiding responses.

The second trap is the Reiter-Cummings Gravid Trap (Figure 2), our principal WNV detection tool. This trap is designed to attract container-breeding mosquitoes including *Culex pipiens* and *Cx. restuans* the key carriers of West Nile Virus (WNV) and these mosquitoes breed proficiently in heavily urbanized areas. The trap is baited with aged organic material-filled water, held below in a pan, to attract female mosquitoes for egg laying. These blood-fed females come to lay their eggs on the water's surface and when they approach the trap's underside opening, they are drawn into the collection container. The mosquitoes are later removed from the container. After identification of the mosquitoes, all WNV-vector species are separated and sent to the state lab to be tested for the presence of virus.

Our third surveillance trap is a Resting Box. Due to the behavior and habitats preferred by another disease carrying mosquito, resting boxes are not placed at the historical trapping stations. Instead, these traps are situated in the vicinity of cedar and red maple swamps where *Culiseta melanura* (Figure 4) resides. *Cs. melanura* is a primary vector of Eastern Equine Encephalitis (EEE). Resting boxes are designed to simulate the tree holes and cavities where these mosquitoes normally rest during the day after they feed on blood. Resting boxes (Figure 3) are visited once weekly from mid-May through the end of September; *Cs. melanura*, and the closely related *Cs. morsitans*, are gathered, identified, tallied, then separated to be later tested for the presence of viruses.

An "epicenter" of EEE activity developed in southeastern New Hampshire during 2005 and monitoring for EEE vectors became another component of the NEMMC surveillance program. Initially, nine resting box stations were placed at fixed locations along the southeastern New Hampshire border from Methuen through Salisbury. Additional resting box
stations were added gradually since 2006 in Boxford, Topsfield, Hamilton, Wenham, Newbury, Georgetown, Lynnfield, and Middleton. These additional stations were set in response to EEE infections in mosquitoes, horses, alpacas, or humans in these communities. Additional boxes are ready for deployment and stations have been selected in more communities if resting box surveillance must be expanded. Because *Cs. melanura* can also transmit WNV, resting box surveillance has enhanced our WNV monitoring.

Figure 3. Resting Boxes (left back view; right front view)

Figure 4. BG-Sentinel Trap

The BG-Sentinel Trap (Figure 4) mimics the motions and chemicals produced by a human host. The attractants are given off by various lures through a dispenser which releases a combination of lactic acid, octenol, ammonia, caproic acid and CO2; substances found on human skin or released through respiration. These traps were specifically developed for attracting *Aedes albopictus* (see exotic species below). The trap consists of an easy-to-transport, collapsible white cylinder with white mesh covering the top. In the middle of the mesh cover is a black funnel through which a down draft is created by a 12V DC fan that causes mosquitoes in the vicinity of the opening to be drawn into a catch bag. The catch bag is located above the suction fan to avoid damage to specimens passing through the fan. The air then exits the trap through the mesh top. We plan on using a few of these traps as well as oviposition traps near large tire collection facilities in 2019 to monitor potential movement of *Ae. albopictus* into this area. In 2018, we did collect 1 adult female *Ae. albopictus* from a gravid trap in Manchester-by-the-Sea. No additional collections of this species were made to confirm if a resident population exists in our district.

Virus Testing

After trapping, specimens of the principal WNV and EEE vectors are collected, counted and sorted into groups by species. At the William A. Hinton State Laboratory Institute (HSLI), MDPH tests these samples (up to 50 mosquitoes per sample) for WNV and EEE. These are frequently referred to as mosquito “pools” which indicates the batching of mosquitoes for testing purposes and is not a reference to any body of water.

Test results from routine mosquito collections are usually available within 48 hours after delivery of mosquitoes to HSLI. Routine collections from fixed and long-term trap sites provide the best available baseline information for detecting trends in mosquito abundance and virus prevalence, and for estimating the relative risk of human infection from EEE virus and WNV. On average, 50 samples (i.e., pools or batches) of mosquitoes are sent each week to the State Labs from this district.

Testing of adult female mosquito specimens starts on June 15th for primary vector species, August 1st for bridge vector species and ceases for all species on or around October 1st; unless there is an expressed need by the DPH to extend the testing season due to increased arboviral risk.

Mosquito virus testing criteria for 2020:

Phase I

- June 15th to August 1st
- Primary vectors (Bird biters): *Cs. melanura, Cs. morsitans, Cx. pipiens* and *Cx. restuans*
- Other mosquito species may be tested on a case by case basis.

Phase II

- August 1st to October 1st (or October 15th for DHP extended season)
- Primary vectors (species listed above) + Bridge vectors (bird/mammal biters): *Ae. cinereus, Ae. vexans, Cq. perturbans, Cx. salinarius, Ae. canadensis, Ae. japonicus, Ae. taeniorhynchus, Ps. ferox* and *Ae. sollicitans*
- Other mosquito species may be tested on a case by case basis.

Supplemental Trapping

To determine whether infected bridge vectors are present, portable CDC-CO_2 traps are often placed at locations when infected primary vector *Cs. melanura* and/or *Cx. pipiens/restuans* mosquitoes have been collected. These supplemental traps collect other species of mosquitoes that are attracted to and would bite humans/mammals. Knowing the infection status of bridge vectors in EEE/WNV known habitats can result in more effective targeted adulticiding responses. Supplemental traps may also be used to collect species not usually collected from historic trap locations to determine mosquito populations in a specific habitat.

After the 1st positive WNV/EEE primary vector species (bird biters) in any municipality, supplemental traps are set based on a number of factors including but not limited to:

- Radius of collection
- Distance from historic trap
- EEE/WNV historical foci
- Topography
- Human population density
- Bridge vector potential breeding sites
- Schools/parks/recreation areas
- Trap Security
- Wetland/wooded/shaded areas

Collections may be sent for additional MDPH arboviral testing. Test results can be found at the following DPH website: https://www.mass.gov/info-details/massachusetts-arbovirus-update

District Operations

Larviciding:

General Wetlands- Larviciding sites from the District's data base, including spring snowmelt areas, woodland pools, agricultural pastures, riverine floodplains, flooded lawns, shrub/cattail/*Phragmites* swamps, salt marshes, and other areas requested by the local Board of Health will be checked and treated for mosquito larvae as necessary, beginning in March or as snowmelt allows, to September 30th and beyond if circumstances warrant and conditions allow.

Aerial Salt Marsh- Coastal salt marshes in neighboring communities from Ipswich to the New Hampshire border will be aerially larvicided by helicopter to control salt marsh mosquitoes in accordance with the respective Best Management Practice Plans. Salt marsh mosquitoes are capable of flying up to 25 miles in search of a blood meal and then return to the salt marsh to lay eggs. Coastal communities as well as many inland cities and towns receive direct and immediate benefit from the control of salt marsh mosquitoes.

Catch Basins- The preferred long-term and more cost-effective vector control strategy is to eliminate larvae before they become adults. While *Culex* mosquitoes can develop in a variety of freshwater habitats, the greatest concentration of *Culex* breeding is in the estimated 80,000 catch basins found in the district

(Figure 5). The two principal urban *Culex* mosquitoes, *Cx. pipiens* and *Cx. restuans* breed in highly organic or polluted water that collect in catch basins, ditches, storm water structures including retention ponds (Figure 6), and discarded tires, clogged gutters, bird baths, and the like (Figures 7-8). Applications to schools must be in compliance with 333 CMR 14.00: PROTECTION OF CHILDREN AND FAMILIES FROM HARMFUL PESTICIDES.


Figure 5. Catch Basin


Figure 6. Retention pond.


Figure 7. Discarded tire yard


Figure 8. Clogged rain gutter filled with water

Treating catch basins consists of the application of either a bacterial agent or growth regulator. Short term surveillance data showed an 80% reduction in *Culex* species in communities where basins are treated as compared to communities with untreated basins. In a study conducted in Portsmouth, NH in 2007 by Municipal Pest Management Services Inc., there was a 75% reduction in mosquitoes breeding in treated catch basins compared to untreated basin (34). Long term surveillance data has shown that continual annual treatment of basins significantly decreases *Culex* populations throughout the district.

The order of catch basin larvicidal treatments for 2020 will be prioritized as follows. First to be treated will be the basins north of Boston and the basins in the municipalities bordering Lawrence. These cities are suspected

of being the prime WNV foci in northeast Massachusetts. Treatments of basins in these communities will begin in May through June as conditions allow, followed by the remaining municipalities in the District.
It is preferred that basins be treated in the late spring to early summer to maximize the effects of the larvicidal agents. However, applications of larvicides are often delayed in some communities until basins are cleaned of debris by the local DPW's. Basins filled with organic debris will reduce the effectiveness of the bacterial larvicides and other larvicide types must be used.

Municipal DPWs can further assist the district in efficient treatments of basins by scheduling annual cleanings before the end of May. Clean basins reduce organic material in the basins and allow for greater efficacy and interval of the bacterial larvicide treatments. If the basins cannot be cleaned early, then waiting until after August would suffice. This would allow the district to use a methoprene based larvicide in lieu of the bacterial product for the entire virus season.

Time, weather, DPW basin-cleaning schedules, and extent of other District operations will determine when basins will be treated and which product will be most efficient.

Source Reduction and Sanitation: The District has facilitated the removal and proper disposal of used tires and other potential container habitats from its service area for several years through petitioned wetland management projects, coordinated clean-ups and participation in Household Hazardous/Zero Waste Day Events. These practices are considered an important part of the District's integrated pest management (IPM) approach and have become a valuable vector mosquito habitat management tool. We ask that communities petition (request on letterhead) for tire removal through an assigned town department petitioning body such as the Board of Health, Conservation Commission and/or Public Works Department.

Waste Water Treatment Facilities Inspection: The District also inspects wastewater treatment facilities, when requested. This way, actual or potential *Culex* breeding can be reduced or eliminated. We wish to be a resource of information and technology to assist facility managers to prevent and/or abate mosquito breeding to the mutual benefit of the facility and the community.

Property Inspection: The District will represent the town's mosquito control concerns in an advisory capacity relative to proposed development and where prudent as requested by local health officials. District personnel are authorized, under the provisions of Chapter 252 Section 4 of the General Laws of the Commonwealth, to enter upon lands for the purpose of inspections for mosquito breeding.

Socioeconomics often plays an important role in mosquito control and associated public health risk. In a study conducted in California in 2007, there was a 276% increase in the number of human WNV cases in association with a 300% increase in home foreclosures. Within most foreclosed properties in Bakersfield (Kern County, CA) were neglected swimming pools (Figure 9) which led to increased breeding and population increases of *Cx. pipiens/restuans*.

Figure 9. Abandoned swimming pool.

Figure 10. Abandoned home property with containers of all types collecting water.

In recent years we have received requests from Boards of Health to inspect abandoned properties (Figure 10) and we will continue this practice in 2019. In the course of our routine activities, we will also inspect and report such properties to your Board. We will offer any support that may be appropriate to resolve mosquito problems related to such properties. With the support of the Boards of Health, we will implement the necessary control measures to mitigate any immediate mosquito problem associated with such properties.

The District will also consult with project developers to prevent/reduce mosquito breeding during and after phases of residential/commercial construction.

Selective truck-based ULV Adulticiding: As a final measure to reduce the risk of WNV/EEE infections, the District may recommend selective and targeted adulticiding applications when WNV-infected mosquitoes are discovered. The District uses "Ultra Low Volume" (ULV) truck-based adulticiding operations. One advantage of ULV applications is that only very minute amounts of pesticides are dispersed over a large area (Figure 11); between 0.41 and 1.23 fluid ounces per acre are applied, depending on truck speed, which ranges between 5 and 20 miles per hour. Due to the pesticides employed, adulticiding is done **only at night** (30 minutes after sunset to 30 minutes before sunrise).

Applications to schools must be in compliance with MGL Ch. 85 and **333 CMR 14.08** : PROTECTION OF CHILDREN AND FAMILIES FROM HARMFUL PESTICIDES. **Only the local Board of Health can authorize truck-based ULV adulticide operations.**

NEMMC will not conduct adulticide applications when temperatures are below 50 F and/or when wind speeds exceed 10 mph.

***Residential Pesticide Exemption**:* Residents who request their property be excluded from **all pesticide applications** must comply with the legal process to exempt their property. Pursuant to 333 CMR 13.03, individuals may request exclusion from wide area applications of pesticides by the district. Requests **must be made to the Department of Agricultural Resources** and **will go into effect fourteen (14) days** from the date the request is received. All exclusion requests expire on December 31st of the calendar year in which it was made. The exclusion request may be accessed from either our District's website or directly from the

Department of Agricultural website https://www.mass.gov/how-to/exclusion-from-wide-area-pesticides-application

Figure 11. Truck spray at night

Figure 12. Truck applying barrier treatment at dusk.

Barrier Treatment: While ULV is a cost-effective procedure on a large scale, it only affects those mosquitoes active at the time of the application; repeated applications are sometimes necessary to sustain population control. To reduce the need for repeated applications and provide more sustained relief from mosquitoes in high public use areas, the District may recommend a smaller scale "barrier spray treatment". This application would be made to public use areas such as schools (applications to schools must be in compliance with MGL Ch. 85 and **333 CMR 14.08**: PROTECTION OF CHILDREN AND FAMILIES FROM HARMFUL PESTICIDES.), playgrounds, parks and athletic fields (Figure 12). A barrier spray may reduce mosquito presence for up to 3 weeks. The District strongly recommends member municipalities take advantage of this service when necessary.

NEMMC will not conduct barrier applications when temperatures are below 50 F and/or when wind speeds exceed 10 mph and/or when precipitation is predicted within 24 hours of a barrier application.

Special Circumstance- Droughts: During intense drought seasons, normal development and distributions of *Cx. pipiens/restuans* can be increasingly unpredictable. Prolonged droughts together with periods of intense heat result in "explosions" of these species, as was seen in our district in 2010, 2013, 2015 and 2016. Patterns of heavy rainfall followed by stretches of intense heat lasting weeks will also result in greater than normal populations of these species, as exhibited in 2011. The availability of standing water diminishes during droughts and most mosquito species suffer significant population losses. The breeding habits of *Cx. pipiens/restuans* allow this species to take advantage of conditions provided by droughts. One type of artificial container filled with such water is the catch basin. Basins in urbanized areas can dry during severe drought conditions. However, people continue to water lawns and wash their cars during droughts. The excess runoff from these activities keeps catch basins filled. If basins have been treated with a larvicide, breeding should be kept in check. If the basins are property of a municipality, and we have records of their locations, they will be treated. However, we may not know of their existence on private properties and thus, they remain untreated and become a continual source of *Culex* mosquitoes throughout the season.

Normally, *Cx. pipiens/restuans* mosquitoes do not breed in great abundance in wetlands and definitely do not breed in moving water. However during a drought, large expanses of water become smaller, shallower, and more concentrated with more organic debris, presenting *Culex* mosquitoes with more breeding habitats to exploit. With more urbanization, *Culex* populations can move in and thrive. There are also fewer predators present (especially fish) as wetlands dry and the survivorship of the developing larvae is dramatically increased. Also during droughts, flowing waters such as rivers, streams, and brooks gradually slow and decrease in volume. Either in the very slow moving water or more likely, along the puddles and pools formed at the edges (usually filled with organic debris; see Figure 13), more breeding sites are available for *Culex* to utilize.

As any large body of water dries, containers and tires that were dumped into these bodies (when full of water) now become exposed (Figure 14). Being filled with polluted water, these also become ideal breeding sites for *Culex*. Debris-filled ground holes and depressions (either naturally-occurring or artificial) can become filled with water in a sudden downpour and also become instant breeding habitats for these species. Therefore, breeding areas for *Culex* mosquitoes are always in abundance, even in the middle of the worst drought.

Figure 13. Powow River (Amesbury) during June 2010 drought.

Figure 14. Drying pond in Newburyport in August 2010 exposing debris and containers originally found under water.

Beaver Impacted Waterway Protocol

Following the adoption of the Wildlife Protection Act in 1996, the beaver population in Massachusetts increased from 24,000 to nearly 70,000 in the first five years. Waterways subject to beaver activity are often altered from narrow, free flowing systems to large, slow or no flow systems. Additionally, many beaver impacted waterways contain multiple dams, further slowing water flow. As a result, many previously unaffected areas adjacent to waterways may become flooded, resulting in the appearance of potential for increased breeding habitat for mosquitoes.

The District's response to inquiries regarding beaver impacted waterways will take into consideration Best Management Practices. All beaver related projects must have a documented mosquito component. All efforts will be made to work with local, state, and federal agencies responsible for the management of wildlife within the municipality of the permitted or proposed project. Removal and/or alteration of beaver dams by the

District should be considered as a last resort. The following protocol is designed as a working document and guideline to address beaver concerns within the District's member municipalities.

1. All residential inquiries shall be advised to contact the Board of Health and/or Department of Public Works of the resident's municipality.
2. Municipalities may submit a petition to the Biologist to have beaver impacted waterways evaluated.
3. Petitioned beaver sites will be evaluated for mosquito activity and documented. The District should seek the guidance and cooperation of local, state, and federal agencies responsible for the management of wildlife.
4. All efforts shall be made to coordinate with local, state, and federal agencies responsible for the management of wildlife for the removal and/or alteration of beaver dams. District personnel may assist in the removal and/or alteration of beaver dams if needed, to the extent that such work is necessary to perform mosquito control activities authorized by M.G.L. c. 252.
5. All efforts shall be made to work with the local conservation commission and municipal authorities to ensure that all interested parties are aware work is performed only on an as-needed basis and in accordance with M.G.L. c. 252, or that work is performed by another authorized entity and all legally appropriate steps have been taken.

Invasive Plant Protocol

Phragmites australis (Phragmites)

Phragmites is an invasive wetland plant that provides habitat for a number of mosquito species, including those involved in various virus cycles (*Culiseta melanura, Culex salinarius, Coquillettidia perturbans)*, as well as opportunistic species (*Ochlerotatus spp, Anopheles spp, Aedes spp*) that may be involved in the virus cycle in addition to impacting quality of life near *Phragmites* stands. Mosquito control efforts may be inhibited by dense stands of *Phragmites*, either by preventing the spray from aerial larval applications from reaching the breeding pools or by inhibiting the ability of mosquito control personnel from accessing the breeding sites.

Phragmites control shall be at the discretion of District personnel and/or local municipality to provide effective mosquito control in these habitats. Use of control measures may include mowing, cutting, herbicide applications or a combination of methods.

The District's use of herbicides will be carefully considered for each proposed project. Invasive plants growing within the working area and along the path of access or egress of a proposed wetlands project will be surveyed during the initial site evaluation. Careful consideration of all Best Management Practices should be taken, with a timeline developed for the removal and disposal of invasive plants prior to the start of a permitted project.

All efforts should be made to coordinate with local, state, and federal agencies responsible for the management of invasive plants for the removal, disposal and management of invasive plant material associated with proposed wetlands projects. Removal of invasive plants by the District should be considered as a last resort in an effort to reduce the spread of invasive plants. District personnel may assist in the removal of invasive plants if needed, to the extent that such removal is necessary to perform mosquito control activities authorized by M.G.L. c. 252.

Emergency Response Aerial Adulticiding Plan

In the event that the risk of WNV/EEE infection escalates to a point that truck-based ULV adulticiding is insufficient to reduce that risk, an emergency aerial adulticiding application may be warranted. Fixed-winged aircraft would be employed to release adulticides over targeted areas. For this aerial application to proceed, a consensus must be reached by the District, State Reclamation and Mosquito Control Board, Massachusetts Department of Health and an independent advisory board. A declaration of a Public Health Emergency from the Governor is also required. Typically, once the decision is made, the need for action is immediate and the window of opportunity is short.

Please refer to pages 16 and 17 of the MA Department of Public Health's 2019 Arbovirus Surveillance Plan https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data#response-plan- for the Multi-Agency Response Flowchart on Aerial Adulticide Application in Response to Threat of EEE.

Follow this link for the MDAR Fact Sheet on Aerial Mosquito Control https://www.mass.gov/doc/short-fact-sheet-eee-and-mosquito-control-2019/download.

Risk Communications and Public Relations

Massachusetts DPH assesses arboviral risk levels based on many factors including but not limited to: mosquito isolations, locations of acquired veterinary and human infections, virus history locally and in bordering states, weather conditions present and predictions, and current mosquito populations and future trends.

Dissemination of mosquito and arbovirus information and risk is paramount to the success of any mosquito control operation. With the speed which information, as well as rumors and even disinformation, can be conveyed in all public informational media, it is crucial that Boards of Health and subscribing municipality residents are kept correctly informed. The District continues to improve its communication regarding mosquito species, potential arboviral threats, and details of larviciding and adulticiding operations.

At the end of the season, the District sends detailed Best Management Practice Plans (BMPs) to each participating municipality. Each BMP includes summaries of the previous year's mosquito and arbovirus activities, descriptions of suggested and agreed-upon control operations, as well as their costs. When necessary, the District conducts a Mosquito/Arbovirus Surveillance Workshop to inform/educate health agents and Boards of Health members of District communities. Potential mosquito and arboviral threats along with response options are discussed. When requested, lectures are presented to Boards of Health and other interested municipal organizations. These are often recorded for broadcast on public-access television as well as posted on the internet. District personnel are available to residents for site requests and answering questions about integrated pest management and homeowner risk reduction.

The District's Liaison communicates information between participating Boards of Health, school officials, and District personnel to facilitate operational requests in member municipalities. The Liaison will distribute and review the BMPs with all participating Board of Health directors, contact school IPM coordinators who have not updated their IPM plans to include mosquito control products, and will act as the single point of contact during the mosquito season.

Please visit our website for more information: www.nemassmosquito.org

District Phased Response to WNV/EEE Virus Isolations

NEMMC Phased Response to WNV Virus Isolations- 2020		
MDPH Risk Category	**Definition of Risk Category in a Focal Area[1]**	**NEMMC District Recommended Response[2]**
1. WNV-Low	All localities begin the year at low Current Year 1. No evidence of WNV activity in mosquitoes in the focal area. OR 1. **Sporadic** WNV activity in mosquitoes in the focal area. AND 2. No animal or human cases	1. Routine collection and testing of mosquitoes at historic trap sites 2. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans. 3. Continued assessments of adult and larval mosquito populations 4. Continued source reduction and routine larvicide efforts 5. Local BOH is notified immediately of WNV isolates 6. Supplemental trapping may be implemented for sporadic activity depending on mosquito populations, time of year and weather
2. WNV-Moderate	Current Year 1. **Sustained** or increasing WNV activity in mosquitoes in the focal area. OR 2. WNV activity in a mammal biting mosquito species (bridge vector) detected from a supplemental trapping event 3. One confirmed animal or human case	Response as in category 1, plus: 1. Increased larval control and source reduction measures. 2. Locally targeted "block target" ground-based ULV adulticiding operations should be considered. The decision to use ground-based adult mosquito control will depend on the time of year, mosquito populations and proximity of virus activity to human populations. 3. Consideration of barrier treatments at schools, parks and recreation areas. The decision will depend on School IPM plans, time of year, mosquito populations, human activity and vegetation surrounding the proposed treatment area.

3. WNV-High	<u>Current Year</u> 1. Multiple WNV isolations in vector and/or mammal biting (bridge vector) mosquitoes during the same week from the focal area. AND 2. At least one multiple meteorological or ecological condition (such as above average temperatures, dry conditions, or larval abundance) associated with increased abundance and increased risk of human disease. OR 3. Two or more confirmed animal or human cases of WNV occurring within the focal area (focal area based on exposure history of cases)	Response as in category 2, plus: 1. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. 2. Municipal wide, ground-based ULV applications of adulticide that may be repeated as necessary to achieve adequate mosquito control. 3. Communicate risk to neighboring communities if focal area is bordering those communities. 4. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests.
4. WNV-Critical	<u>Current year</u> An excessive number of human cases clustered in time and space. AND Evidence that the risk is likely to increase based on time of year, weather patterns, mosquito populations or other factors specific to the situation.	Response as in category 3, plus: 1. MDPH will confer with local boards of health, the SRMCB and Mosquito Control projects to discuss the need for additional intervention If additional mosquito control activities are indicated, the SRMCB will determine the appropriate pesticide and extent, route and means of treatment. 2. MDPH recommends reduction of outdoor activities, during peak mosquito activity hours, especially by the elderly and others at higher risk for severe WNV disease, in areas of intensive virus activity for high risk populations or individuals

<u>Sporadic</u> WNV activity- 1-2 mosquito isolates are detected during non-consecutive weeks within one focal area.

<u>Sustained</u> WNV activity-when mosquito isolates are detected for at least 2 consecutive weeks within one focal area.

[1] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in the assessment of human risk and the outlining of a particular focal area include: mosquito habitat, prior virus isolations in surveillance specimens from previous years, human population densities, type and timing of recent isolations of virus in mosquitoes, occurrence of human case(s) in the current or previous years, current and predicted weather patterns, and seasonality of conditions needed to present risk of human disease.

[2] Please refer to Table 1. Guidelines for Phased Response to WNV Surveillance Data in the 2017 Massachusetts State Arbovirus Surveillance and Response Plan for MDPH Primary Recommended Response.

NEMMC Phased Response to EEE Virus Isolations- 2020		
MDPH Risk Category	**Definition of Risk Category in a Focal Area[1]**	**NEMMC District Recommended Response[2]**
1. EEE-Remote	All of the following conditions must be met: Prior Year 1. No EEE activity detected in community or focal area in at least 10 years AND Current Year 1. No current surveillance findings indicating EEE activity in mosquitoes in the focal area AND 2. No confirmed animal or human EEE cases	1. Routine collection and testing of mosquitoes at historic trap sites 2. Continued assessments of adult density and larval mosquito populations 3. Continued source reduction and routine larvicide efforts 4. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans. 5. BOH notified by NE District and Public health alert sent out by MDPH in response to first EEE virus positive mosquito pool detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies.
2. EEE-Low	Prior Year Any EEE activity detected within the last 10 years OR Current Year 1. **Sporadic** EEE isolations in *Cs. melanura* mosquito in the community or focal area AND 2. No confirmed animal or human EEE cases	Response as in category 1, plus: 1. Increased larval control and source reduction measures. 2. Supplemental trapping for bridge vectors may be implemented for sporadic activity depending on mosquito populations, time of year and weather
3. EEE-Moderate	Prior year	Response as in category 2, plus:

	<u>Sustained</u> EEE activity in bird-biting mosquitoes; or EEE isolate from mammal-biting mosquitoes; or confirmation of one human or animal EEE case in the community or focal area OR <u>Current year</u> 1. **<u>Sustained</u>** EEE activity in *Cs. melanura* with minimum infection rates that are at or below mean levels for focal area trap sites OR 2. A single EEE isolate from mammal-biting mosquitoes (bridge vector species) OR 3. Sustained EEE activity plus at least one multiple meteorological or ecological condition (rainfall, temperature, seasonal conditions, or larval abundance) associated with elevated mosquito abundance thus likely to increase the risk of human disease AND 4. No confirmed animal or human EEE cases in current year	1. Supplemental mosquito trapping and testing in areas with positive EEE findings. Notify all boards of health of positive findings. 2. If not already in progress, standard**, locally targeted "block target"** ground-based ULV adulticiding operations should be considered where surveillance indicates human risk. The decision to use ground-based adult mosquito control will depend on the time of year, mosquito populations and proximity of virus activity to human populations. 3. Consideration of barrier treatments at schools, parks and recreation areas. The decision will depend on School IPM plans, time of year, mosquito populations, human activity and vegetation surrounding the proposed treatment area. 4. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests.
4. EEE-High	<u>Current Year</u> 1. **<u>Sustained</u>** or increasing EEE activity in *Cs. melanura* with weekly mosquito minimum infection rates above the mean OR 2**. 2 or more EEE isolates in mammal-biting mosquitoes from 2 different traps** AND/OR	Response as in category 3, plus: 1. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. 2. Municipal wide, ground-based ULV applications of adulticide that may be repeated as necessary to achieve adequate mosquito control. 3. Communicate risk to neighboring communities if focal area is bordering those communities.

	3. **Sustained** or increasing EEE activity in mosquitoes plus multiple meteorological or ecological condition (such as above average temperatures, dry conditions, or larval abundance) associated with increased abundance and thus very likely to increase the risk of human disease AND 4. No confirmed animal or human EEE cases in current year	4. Urge towns and schools to consider reschedule outdoor, evening events † 5. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 6. MDPH will confer with local health officials, SRMCB and MCPs to determine if the risk of diseasetransmission warrants classification as level 5. 7. MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discussthe use of intensive mosquito control methods. Ifelevated risk is assessed in multiple jurisdictions and evidence exists that risk is likely to either increase (based on time of season, weather patterns, etc.) or remain persistently elevated, the interventions may include state-funded aerial application of mosquito adulticide which, if conditions warrant, may be repeated as necessary to interrupt the virus transmission cycle and protect public health
5. EEE-Critical	Current year 1. Multiple quantitative measures indicating critical risk of human infection (e.g. early season positive surveillance indicators, and sustained high mosquito infection rates, plus multiple meteorological or ecological conditions (rainfall, temperature, seasonal conditions, or larval abundance) indicating rapidly escalating epizootic activity) OR 2. A single confirmed EEE human or animal case	Response as in category 4, plus: 1. Continued highly intensified public outreach messages on personal protective measures. Frequent media updates and intensified community level education an outreach efforts. Strong recommendation for rescheduling of outdoor, evening events.† 2. MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine the measures needed to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide.

		Factors to be considered in making this decision include the seasonal and biological conditions needed to present a continuing high risk of EEE human disease and that those same conditions permit the effective use of an aerially applied pesticide. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by making recommendations on: A. Appropriate pesticide B. Extent, route and means of treatment C. Targeted treatment areas 3. MDPH Bureau of Environmental Health will initiate active surveillance for pesticide-related illness via emergency departments and with health care providers only if aerial spraying commences. 4. MDPH will designate high-risk areas where individual no spray requests may be preempted by local and state officials based on this risk level. If this becomes necessary, notification will be given to the public. 5. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 6. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt sample submission from all clinically suspect cases.

Sporadic WNV activity- 1-2 mosquito isolates are detected during non-consecutive weeks within one focal area.

Sustained WNV activity-when mosquito isolates are detected for at least 2 consecutive weeks within one focal area.

[1] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in the assessment of human risk and the outlining of a particular focal area include: mosquito habitat, prior virus isolations in surveillance specimens from previous years, human population densities, type and timing of recent isolations of virus in mosquitoes, occurrence of human case(s) in the current or previous years, current and predicted weather patterns, and seasonality of conditions needed to present risk of human disease.

[2] Please refer to Table 2. Guidelines for Phased Response to EEE Surveillance Data in the 2018 Massachusetts State Arbovirus Surveillance and Response Plan for MDPH Primary Recommended Response

† See Appendix 2 for schedule of recommended cancellation time for use in the 2018 Massachusetts State Arbovirus Surveillance and Response Plan

Emergent Exotic and Invasive Mosquito Species

Newly imported and exotic mosquito species becoming established in our area is a growing problem. Within the past ten years, we have seen the appearance and rapid spread of *Ochlerotatus japonicus*, the "Japanese Rock Pool Mosquito", throughout our district (Figure 15). While this species is a competent disease vector in other areas, there is little to suggest it is currently a major disease vector in the northeast. As we monitor our local mosquitoes, we are also conscious of the appearance of any new species.

Another exotic and geographically-expanding species is *Aedes albopictus*, the “Asian Tiger Mosquito” (Figure 16). It is a notorious daytime human-biting species and competent disease vector. We are currently monitoring the progression of this species as it potentially moves into the northeast. Originally from northeast Asia, it has spread rapidly throughout the temperate regions of the world assisted by the importation of used automobile tires and ship hulls. Water-filled discarded tires, flower pots, and other containers left outdoors is where this species tends to lay its eggs. Similar to salt marsh mosquitoes near coastal regions, this species will aggressively attack humans (usually around the lower extremities) during the daytime in urban areas.


Figure 15. Japanese Rock Pool Mosquito (***Ae. japonicus***) Figure 16. Asian tiger mosquito (***Ae. albopictus***)
Both Photographs copyright: Steve A. Marshall Published on *The Diptera Site* (http://diptera.myspecies.info)

Ae. albopictus was first found in the U.S. in Houston in 1985 and has spread nationwide as far northeast as southern and central Massachusetts; it has become the dominant mosquito species in New Jersey. Climate change predictions suggest *Ae. albopictus* will continue to be a successful invasive species that will spread beyond its current geographical boundaries. This mosquito is already showing signs of adaptation to colder climates which may result in disease transmission in new areas. *Ae. albopictus* is a great concern in public health because of its ability to transmit many arboviruses that cause serious disease in humans, including Chikungunya and Dengue (discussed below) and may be implicated in potential transmission of Zika virus. *Ae. albopictus* has been collected in Bristol County on repeated occasions since 2011 in used tire-collection facilities. In 2018, a single adult female *Ae. albopictus* was collected from a gravid trap at a DOT station in Manchester-by-the-Sea. Although ovitrap surveillance is ongoing, no other collections were made in our District for this species.

Mosquito-Borne Arboviruses Endemic to our Region:

West Nile Virus

West Nile Virus (WNV) was introduced to New York City in 1999 and within five years had spread to all 48 continental US states. Since its first appearance in North America, WNV has caused significant illness to over 39,000 persons in the United States. About 1 in 5 people who are infected develop a fever and other symptoms. About 1 out of 150 infected people develop a serious, sometimes fatal, illness.

These neurological diseases include acute febrile paralysis, encephalitis, and meningitis; resulting in death to about 10% of all neurological cases. Of the over 17,000 neuroinvasive cases since 1999, there have been almost 1,600 deaths. Persons older than 50 years of age have a higher risk of developing severe illness. There are no vaccines to prevent WNV.

It was thought that WNV associated neurological ailments were short-lived, affecting only a small percentage of those infected. However, recent studies suggest that neurological disorders may be more prolonged and serious, affecting more people than originally thought. According to an article published in November of 2016, the American Society of Tropical Medicine and Hygiene reported death rate rises from 'delayed' fatalities long after recovery. https://www.eurekalert.org/pub_releases/2016-11/b-nst110816.php

WNV was first isolated from birds and mosquitoes in Massachusetts during 2000, and the State's first human case was identified in 2001. It is now endemic throughout the state, particularly in and around large metropolitan areas. WNV circulates annually in mosquitoes in Massachusetts but can increase and cause an increase in human cases during drier years.

Between 2001 and 2019, 205 people were reported with WNV infection in Massachusetts. Ten of the total cases were fatal (Table 1). Because most people who are exposed to WNV have no symptoms, it is difficult to know exactly how many people have actually been infected. Usually people who develop severe illness with WNV are most often reported.

2018 was a historic year for WNV in Massachusetts with 579 positive mosquito batches and 49 human cases with 1 fatality.

Culex pipiens and Cx. restuans are primarily responsible for the transmission and amplification of WNV within the bird population. The larvae of both these species develop in the high-organic content water that accumulate in catch basins, containers, tires, pools and other man made water-holding structures that are in greater abundance in urbanized areas. Since some water-holding structures are permanent (catch basins) and the water contained cannot often be drained, the water itself must then be treated with larvicides to reduce the number of larvae breeding in these sites.

Table 1. Total Number of Human WNV Cases by Type and Number of Fatalities in Massachusetts 2000-2019.

Year	Neuroinvasive (1)	Non-Neuroinvasive (2)	Total	Fatalities
2000	0	0	0	0
2001	3	0	3	1
2002	19	4	23	3
2003	12	5	17	1
2004	0	0	0	0
2005	4	2	6	1
2006	2	1	3	0
2007	3	3	6	0
2008	1	0	1	0
2009	0	0	0	0
2010	6	1	7	0
2011	5	1	6	0
2012	25	8	33	1
2013	7	1	8	0
2014	5	1	6	0
2015	7	3	10	2
2016	10	6	16	0
2017	5	1	6	0
2018	44	5	49	1
2019	2	3	5	0
Totals	**160**	**45**	**205**	**10**

1) Neuroinvasive disease= Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND** Meningitis, encephalitis, acute flaccid paralysis, or other acute signs of central or peripheral neurologic dysfunction, as documented by a physician, **AND** Absence of a more likely clinical explanation.

2) Non-neuroinvasive disease= Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND** Absence of neuroinvasive disease **AND** Absence of a more likely clinical explanation.

The principal strategy used by our District to minimize WNV transmission and risk is by reducing and/or eliminating larval development in catch basin and other container-like habitats. Table 2 compares WNV positive mosquito pools and WNV positive human cases in the entire state of Massachusetts compared with WNV in our Northeast District.

Table 2. Total Number of WNV Mosquito Batches and WNV Human Cases in Massachusetts compared to NEMMC District from 2000 to 2019.

	Total number of positive WNV mosquito batches to (WNV human cases)	
Year	MA Statewide	NEMMC District
2000	4 (0)	0 (0)
2001	25 (3)	4 (0)
2002	68 (23)	14 (3)
2003	48 (17)	2 (0)
2004	15 (0)	4 (0)
2005	99 (6)	11 (0)
2006	43 (3)	5 (0)
2007	65 (6)	15 (0)
2008	135 (1)	10 (0)
2009	26 (0)	2 (0)
2010	121 (7)	21 (1)
2011	275 (6)	58 (1)
2012	307 (33)	48 (0)
2013	335 (8)	77 (2)
2014	56 (6)	7 (1)
2015	164 (10)	8 (1)
2016	189 (16)	39 (1)
2017	290 (6)	28 (0)
2018	579 (49)	18 (9)
2019	**87 (5)**	**5 (0)**
Totals	**2,931 (205)**	**376 (19)**

For more information on WNV please visit: https://www.cdc.gov/westnile/index.html and https://www.mass.gov/service-details/west-nile-virus-wnv

Eastern Equine Encephalitis Virus

Eastern Equine Encephalitis (EEE) human infections manifest symptoms similar to West Nile encephalitis and while the human infection rate is lower; the fatality rates are much higher with EEE infections, about 33%. Also, the recovery rates from EEE virus are longer and most often incomplete. EEE seems to attack the young as readily as the elderly; unlike WNV which the elderly are far more susceptible.

EEE was first discovered in horses hence, the basis for the name "Equine Encephalitis". The name "equine" stuck even after the virus was later identified to cause the same encephalitis in humans. Humans and horses are "dead-end hosts", meaning that the virus cannot be transmitted from infected horses or humans. Like WNV, EEE is an avian virus, transmitted bird-to-bird principally by the mosquito species *Culiseta melanura*. There are no vaccines to prevent EEE.

Prior to 2004 there were never serious concerns about EEE in Essex County. EEE seemed to be restricted to southeast Massachusetts and its vector, *Cs. melanura*, seemed to thrive in the expansive habitat of the great cedar swamps found there. Historically, clusters of human cases have occurred over a period of two to three years (Table 3), with about 10 to 13 years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur (1938-39, 1955-56, 1972-74, 1982-84, 1990-92, 2004-06, 2010-2012). EEE mostly occurs during wetter years.

2019 was an unprecedented year for EEE in Massachusetts and may continue, however, decreasing over the next few years.

Table 3. Total Number of EEE Virus isolations/cases in Massachusetts compared to NEMMC District from 2003 to 2019.

YEAR	Eastern Equine Encephalitis Virus (EEEV)					
	Massachusetts Statewide (including NEMMC)			Northeast Mosquito Control District (NEMMC)		
	Mosquito Batch Isolations	Veterinary Cases	Human Cases	Mosquito Batch Isolations	Veterinary Cases	Human Cases
2003	9	5	-	-	-	-
2004	39	7	4	-	1	-
2005	45	4	4	2	2	-
2006	157	6	5	11	-	-
2007	31	-	-	-	-	-
2008	13	1	-	-	-	-
2009	54	1	-	13	1	-
2010	65	4	1	-	-	-
2011	80	1	1	-	-	-
2012	267	5	7	14	2	2
2013	61	4	1	4	-	-
2014	33	2	-	2	-	-
2015	1	-	-	-	-	-
2016	4	-	-	-	-	-
2017	1	-	-	-	-	-
2018	2	2	-	-	-	-
2019	428	9	12	11	1	1
Totals	**1,290**	**51**	**35**	**57**	**7**	**3**

While *Cs. melanura* mosquitoes are primarily responsible for the amplification of virus in bird populations, they typically do not bite humans if adequate bird populations are present. It is usually other mosquito species known as "bridge vectors" with wider host preferences that can transmit EEE to humans. Bridge vectors such as *Ae. vexans, Cx. salinarius, Cq. perturbans* and *Ae. canadensis* will feed on birds and pick up the virus but are notorious mammal-biting mosquitoes and may effectively transmit EEE to humans.

While risks to humans directly from infected *Cs. melanura* are extremely low (about 5% of feeding can occur from mammals), we will continue to take preemptive protective operations directly against *Cs. melanura* even if infected mosquitoes are not detected.

Early intervention through spring larviciding can reduce *Cs. melanura* populations, thus limiting amplification of EEE in the bird population. Summer larviciding can further reduce other mosquito species that are known bridge vectors of these arboviruses. Continual larviciding of these bridge vector mosquito species through the season can help reduce the risk of transmission of EEE and WNV from mosquitoes to humans.

Detections of West Nile (WNV) and Eastern Equine Encephalitis (EEE) viruses in mosquitoes in the Northeast Massachusetts Mosquito Control District from 2002 through 2019.

Year	Number of pools Submitted for DPH Testing	WNV		EEE	
		# Positive WNV Pools- NEMMC	%	# Positive EEE Pools-NEMMC	%
2002	740	14	1.9	0	0
2003	646	2	0.3	0	0
2004	604	4	0.7	0	0
2005	870	11	1.3	2	0.3
2006	1,181	5	0.4	11	0.9
2007	850	15	1.9	0	0
2008	774	10	1.3	0	0
2009	567	2	0.4	13	2.3
2010	714	21	2.9	0	0
2011	1,009	58	5.7	0	0
2012	1,039	48	4.6	14	1.3
2013	1,315	77	5.9	4	0.3
2014	804	7	0.9	2	0.2
2015	541	8	1.7	0	0
2016	1.324	39	2.9	0	0
2017	596	28	4.7	0	0
2018	547	18	3.3	0	0
2019	793	5	0.6	11	2.02

Red highlighted years reflect human cases of virus in the Northeast District (NEMMC) during those years

***Cs. melanura* habitat surveillance:** Monitoring *Cs. melanura* population trends can help to predict future EEE activity. *Cs. melanura* is one of only a few mosquitoes that survive the winter in the larval stage. Instead of open water, they develop inside flooded root mats, holes and tunnels (crypts) under trunks of trees and in tree hummocks in acidic Atlantic White Cedar, Red Maple swamps and sphagnum bogs (Figure 17 & 18).

Figure 17. Red Maple/sphagnum and peat bog
http://www.co.oswego.ny.us/info/news/2012/061112-1.html

Figure 18. "Inside the Atlantic White Cedar Swamp Trail"
http://www.paulscharffphotography.com/occ-insidetheatlanticwhiteceda.htm

These habitats are in relative abundance in northeast MA, although they exist more as isolated pockets and are difficult to access. During the winters, we will continue to narrow our search for Cs. melanura breeding to areas in the District. Our focus is to reduce the risk of EEE transmission in communities bordering NH, areas with historic EEE mosquito isolations and areas where *Cs. melanura* habitat is relatively abundant. The expectation is to make projections of what may happen in the following seasons and prepare for intervention.

For more information on EEE please visit: https://www.mass.gov/service-details/eee-eastern-equine-encephalitis and https://www.cdc.gov/easternequineencephalitis/index.html

Jamestown Canyon Virus (JCV)

Jamestown Canyon virus (JCV) was first isolated in 1961 from a mosquito in Colorado and was first recognized to cause human disease in 1980. JCV persists among white-tailed deer and 22 different species of mosquitoes including *Aedes* and *Anopheles*. The infection occurs in June through September with a peak in mid-June to mid-July. Although rare, this disease has potentially severe and even fatal consequences for those who contract them. Clinical features include mild febrile illness with acute central nervous system infection including meningitis and encephalitis and frequently respiratory system involvement in patients more than 18 years old. There are no vaccines to prevent JCV.

In 2013, of 10 states reporting cases, 8 states (Georgia, Idaho, Massachusetts, Minnesota, New Hampshire, Oregon, Pennsylvania, and Rhode Island) reported their first JCV cases. In Connecticut, human cases have been rare, but mosquitoes in 8 towns, including Stamford and Norwalk, have tested positive for the virus in 2014. In August 2015, the Iowa Department of Public Health announced that one case of JCV has been confirmed.

In 2017, 2 Maine residents from Kennebec and Franklin Counties were diagnosed with JCV. Both had onset dates in June. Also, 2 New Hampshire residents were diagnosed with JCV in 2017 and 1 resident in 2018. Although the 2017 cases were not travel related the single 2018 infection in NH was most likely acquired out of state.

In 2019, 2 New Hampshire residents were diagnosed with JCV; one in August from Kingston and another in October from Laconia. No out-of-state travel history was reported for either case. New Hampshire has had eight cases since the state's first report of the disease in 2013.

Also in 2019, Massachusetts reported 4 human cases of JCV from Essex, Worcester, Middlesex and Barnstable Counties. Massachusetts has also had eight human cases since the state's first report of the disease in 2013.

For more information on JCV please visit: https://www.cdc.gov/jamestown-canyon/

La Crosse Encephalitis (LACV)

La Crosse encephalitis is a viral disease spread to people by the bite of an infected mosquito. Most cases occur in the upper Midwestern, mid-Atlantic, and southeastern states. Many people infected have no apparent symptoms. Some of those who become ill develop severe neuroinvasive disease. Severe disease often involves encephalitis and can include seizures, coma, and paralysis. Severe disease occurs most often in children under the age of 16. There are no vaccines to prevent LACV.

LACV is transmitted by the bite of an infected mosquito, Aedes triseriatus "the tree-hole mosquito". Anyone bitten by a mosquito in an area where the virus is circulating can get infected with LACV. The risk is highest for people who live, work or recreate in woodland habitats, because of greater exposure to potentially infected mosquitoes. LACV is not transmitted directly from person to person.

To date, there have been no reported cases of La Crosse Encephalitis in Massachusetts. In 2019, Newport County in Rhode Island, which borders southern MA, reported the first human case of LACV for the state.

For more information on LACV please visit: https://www.cdc.gov/lac/tech/epi.html

Saint Louis Encephalitis Virus (SLEV)

Saint Louis encephalitis virus (SLEV) is transmitted to humans by the bite of an infected mosquito. Most cases of SLEV disease have occurred in eastern and central states. *Culex pipiens* are one of the primary mosquito vectors for this bird disease. Most persons infected with SLEV have no apparent illness. Initial symptoms of those who become ill include fever, headache, nausea, vomiting, and tiredness. Severe neuroinvasive disease (often involving encephalitis, an inflammation of the brain) occurs more commonly in older adults. In rare cases, long-term disability or death can result. There is no specific treatment for SLEV infection; care is based on symptoms. There are no vaccines to prevent SLEV.

The majority of cases have occurred in eastern and central states, where episodic urban-centered outbreaks have recurred since the 1930s. New Hampshire reported one human case in 2006.

To date, there have been no reported cases of Saint Louis Encephalitis in Massachusetts.

For more information on SLEV please visit: https://www.cdc.gov/sle/index.html

Emergent and Travel Related Mosquito-Borne Viruses:

Mosquito-borne disease is continually on the rise world-wide. The potential for invasion, transmission, and establishment of new arboviruses in the United States is on the increase. After the introduction and establishment of West Nile Virus in 1999 and continuous introduction of new invasive tropical mosquito species, potential arboviral threats in Massachusetts are considered and even anticipated.

Zika Virus

Zika virus is transmitted to people primarily through the bite of an infected *Aedes* species mosquito (*Ae. aegypti* and *Ae. albopictus*). These mosquitoes become infected when they feed on a person already infected with the virus. Infected mosquitoes can then spread the virus to other people. The virus can also be spread from mother to child, sex, blood transfusions and in the laboratory/healthcare exposure setting. The most common symptoms of Zika are fever, rash, joint pain, and red eye. The illness is usually mild with symptoms lasting from several days to a week. Severe disease requiring hospitalization is uncommon. There is no vaccine to prevent or medicine to treat Zika.

The first locally acquired US case of Zika was reported in Florida in 2016 and Texas in 2017. Local transmission means that mosquitoes in the area have been infected with the virus and are spreading it to people.

Zika virus continues to be spread in Africa, Asia, the Caribbean, Central and South America, India, and Mexico. The mosquitoes that spread this disease are active during the day. Travelers who are pregnant or part of a couple planning on becoming pregnant soon are advised not to travel to areas with ongoing Zika virus transmission. If residents choose to travel, prevent mosquito exposure by: using EPA registered mosquito repellents, cover exposed skin by wearing long-sleeved shirts and pants, stay in places with screens and air-conditioning, or sleep under mosquito netting.

In order to avoid sexual transmission of Zika virus from a partner who has recently traveled to an area where Zika transmission is occurring, abstain from sexual contact or use condoms consistently and correctly during all sexual activity. Talk to your healthcare provider for more information.

For more information on Zika, please visit: https://www.cdc.gov/zika/index.html

Chikungunya Virus (CHIKV)

Chikungunya virus is transmitted to people by mosquitoes. The most common symptoms of Chikungunya virus infection are fever and joint pain. Other symptoms may include headache, muscle pain, joint swelling, or rash. There is no vaccine to prevent or medicine to treat Chikungunya virus infection. Travelers can protect themselves by preventing mosquito bites. When traveling to countries with Chikungunya virus, use insect repellent, wear long sleeves and pants, and stay in places with air conditioning or that use window and door screens.

Prior to 2006, Chikungunya virus disease was rarely identified in U.S. travelers. From 2006–2013, studies identified an average of 28 people per year in the United States with positive tests for recent chikungunya virus infection (Range 5–65 per year). All were travelers visiting or returning to the United States from affected areas in Asia, Africa, or the Indian Ocean. In late 2013, the first local transmission of Chikungunya virus in the Americas was identified in Caribbean countries and territories.

Beginning in 2014, Chikungunya virus disease cases were reported among U.S. travelers returning from affected areas in the Americas and local transmission was identified in Florida, Puerto Rico, and the U.S. Virgin Islands. During 2016, there have been 139 travel-associated but no locally acquired cases reported in the US and 159 locally acquired cases in Puerto Rico. By the end of 2017, there have been 97 travel-associated but no locally acquired cases reported in the US and only 8 locally acquired cases in Puerto Rico.

There were 3 probable and confirmed Chikungunya Virus travel acquired cases in Massachusetts during 2019.

For more information on Chikungunya Virus please visit: http://www.cdc.gov/chikungunya/index.html

Dengue Virus (DENV)

A continuing arboviral concern in the continental United States is Dengue virus (DENV), also known as "Break bone fever". It was thought that, except for occasional imported cases, Dengue had vanished from the U.S. There were localized outbreaks near the Texas-Mexican border in the late 1990's and in Hawaii in 2000. However, the threat level was raised considerably beginning in 2009 when a New York resident visiting Key West, Florida contracted Dengue. In December 2010, there were 55 confirmed cases of locally-acquired Dengue in Key West. Six cases of locally-acquired Dengue were confirmed in Florida for 2011, four more in 2012 and 20 in 2013. And last November, it was announced that a Long Island (NY) man, who had not traveled in the previous months, contracted Dengue. The suspected vector was *Ae. albopictus*, recently becoming established on Long Island.

Containment of DENV transmission is not easily accomplished when at the same time there are concurrent imported cases of Dengue (infections of patients when traveling outside the US and returning ill); there were 133 imported Dengue cases in the US in 2011, 100 more in 2012, and 519 in 36 states in 2013.

DENV is the greatest mosquito-borne virus circulating in the world today, affecting anywhere from 50 to 100 million people annually in about 100 countries. If *Ae*. *albopictus* becomes established in Massachusetts, it can acquire DENV from an infected returning traveler, and transmit the virus locally, causing a public health havoc. Symptoms of Dengue include high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, and mild bleeding. A more dangerous manifestation, frequently when there have been multiple dengue episodes in an individual, is Dengue hemorrhagic fever. After the fever declines, there is persistent vomiting, severe abdominal pain, and difficulty in breathing. This can be followed by excessive bleeding into the body cavities leading to circulatory failure and shock, followed by death. There is no medication for the prevention or treatment of Dengue.

There were 9 probable and confirmed Dengue Fever travel acquired cases in Massachusetts during 2019.For more information on Dengue Virus please visit: https://www.cdc.gov/dengue/index.html

2019 Massachusetts State Arbovirus Summary

WNV and EEE MA State Virus Surveillance Summary Results contained in this report reflect data inclusive of MMWR Week 41, December 10, 2019 and are subject to change

Mosquito Surveillance – Cumulative 2019	
Number of Mosquito Samples Tested	8275
Number of WNV Positive Samples	87
Number of EEE Positive Samples	428
Equine/Mammal Surveillance – Cumulative 2019	
Number of Mammal Specimens Tested	33
Number of WNV Positive Horses	0
Number of EEE Positive Horses	8
Number of other EEE Positive Animals (goat)	1
Human Surveillance - Cumulative 2019	
Number of Human Specimens Tested	532
Number of Human WNV Cases	5
Number of Human EEE Cases	12

Figure 19. Massachusetts EEE Risk Level Map as of October 21st, 2019.

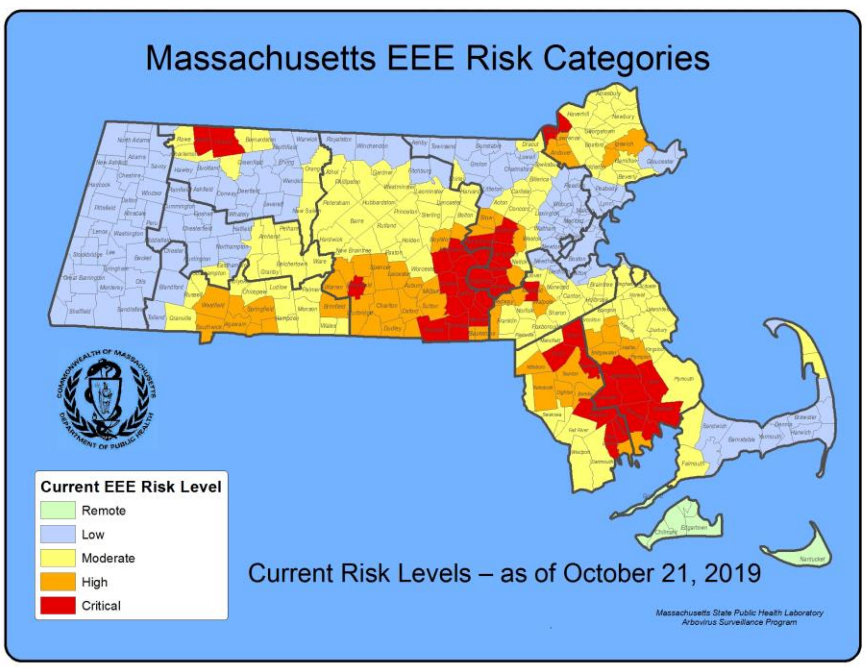
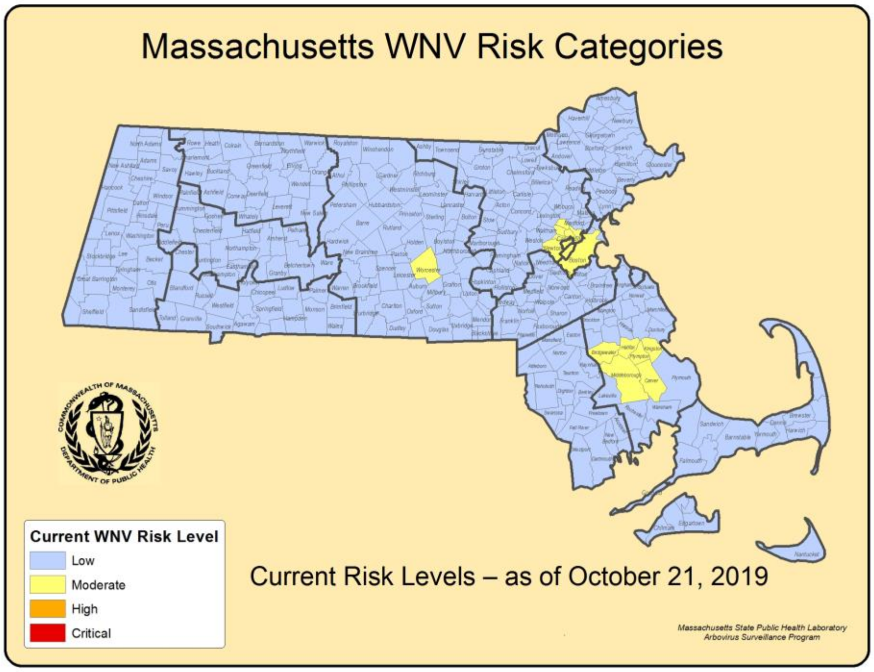


Figure 20. Massachusetts WNV Risk Level Map as of October 21st, 2019.



2019 District Mosquito & Arbovirus Surveillance Summary

<u>16 EEE positive mosquito batches identified in the Northeast District during 2019</u>

- 6 municipalities had EEE positive mosquito isolates (Andover, Boxford, Methuen, West Newbury, Manchester, Amesbury)
- 793 total mosquito batches were sent to the MDPH Lab, 16 mosquito batches were EEE positive (2.02%)
- 4 EEE positives were in primary vector bird feeder species (*Cs. melanura*)
- 10 EEE positives were in bridge vector bird/mammal feeder species (*Ae. vexans, Cq. perturbans*)
- 47 supplemental traps were placed in the district following EEE mosquito isolations in historic traps
- 1 EEE human case and 1 EEE horse case was identified in the Northeast District during 2019

- First EEE mosquito isolation in the Northeast District: Andover- August 13th
- Greatest number of adult female mosquito collections occurred during the 1st week of July
- Last EEE mosquito isolation in the Northeast District: Amesbury- September 24th

<u>5 WNV positive mosquito batches identified in the Northeast District during 2019</u>

- 4 municipalities had WNV positive mosquito isolates (Lynn, Nahant, Revere, Haverhill)
- 793 total mosquito batches were sent to the MDPH Lab, 5 mosquito batches were WNV positive (0.6%)
- 3 WNV positives were in primary vector bird feeder species (*Cx. pipiens*)

- 2 WNV positives were in bridge vector bird/mammal feeder species (*Cx. salinarius*)

- First positive WNV mosquito in the Northeast District: Lynn- August 19th
- Last positive WNV mosquito in the Northeast District: Haverhill- September 17th

- No WNV human/animal cases in the district for 2019

Total Mosquito Collected by NE Mosquito Control District	**2018**	**2019**
Supplemental Traps	1,528	9,359
Resting Boxes	1,608	961
CDC CO2/Light traps	44,162	75,423
Gravid Traps	2,408	3,138
Total	**49,706**	**88,881**
Pest and Medically Important Mosquito Species (habitat)*	**2018**	**2019**
Culiseta melanura (red maple /acid bog/sphagnum swamp)	1,072	2,401
Culex pipiens (container/catch basins)	1,365	1,279
Culex restuans (container/catch basins)	374	637
Culex salinarius (brackish water/*Phragmites*/roadside ditches)	2,527	13,063
Coquillettidia perturbans (cattail/*Phragmites*)	27,474	45,233
Aedes vexans (rainwater/fresh floodwater)	813	968
Aedes japonicus (tree hole/container breeder)	501	835
Aedes sollicitans (salt marsh)	932	207
Aedes cantator (salt marsh)	5,848	8,566
Aedes canadensis (spring/summer woodland pool)	1,109	1,419

*Combined total of mosquitoes collected in historic Resting boxes, CDC/CO2 Light traps and Gravid traps only, supplemental traps are not included in this total.

WNV/EEE bridge vectors/human biters

- Due to frequent and heavy summer rain events there was a slight rise in the fresh floodwater species *Ae. vexans* of 19%. *Cq. perturbans* has made some recovery from consecutive years of drought with a population increase from 2018 of 65% primarily due to the late season rainfall in 2017 and increase in 2018 winter snow pack. *Cx. salinarius*, a brackish water mosquito, increased dramatically by 417%, coinciding with converging heavy summer rains and higher tidal events at the fresh marsh/salt marsh interface and can also breed in roadside ditches that are bordering roads treated in winter with de-icing salts or runoff areas near salt storage sheds. These mosquito species had EEE and WNV isolates in 2019.

WNV primary vectors/bird biters (*Cx. pipiens/restuans*)

- There was a 10% increase in collections of WNV primary vectors from 2018 to 2019. Early catch basin cleaning and treatments helped keep *Culex* mosquito populations in check despite frequent rain events that filled man-made containers and left stagnant water in more locations. Our District did have several WNV isolations from mosquitoes in 2019, but no human cases.

EEE primary vectors/bird biters (*Cs. melanura*)

- 2019 saw a 124% increase in *Cs. melanura*. There was a 4% decrease in 2017 due to long-term drought conditions and a rebounding increase of 99% during 2018 from mid to late summer precipitation. Any increases of *Cs. melanura* populations for 2020 will depend on future precipitation and groundwater conditions through the winter in the species hummock/crypt habitat.

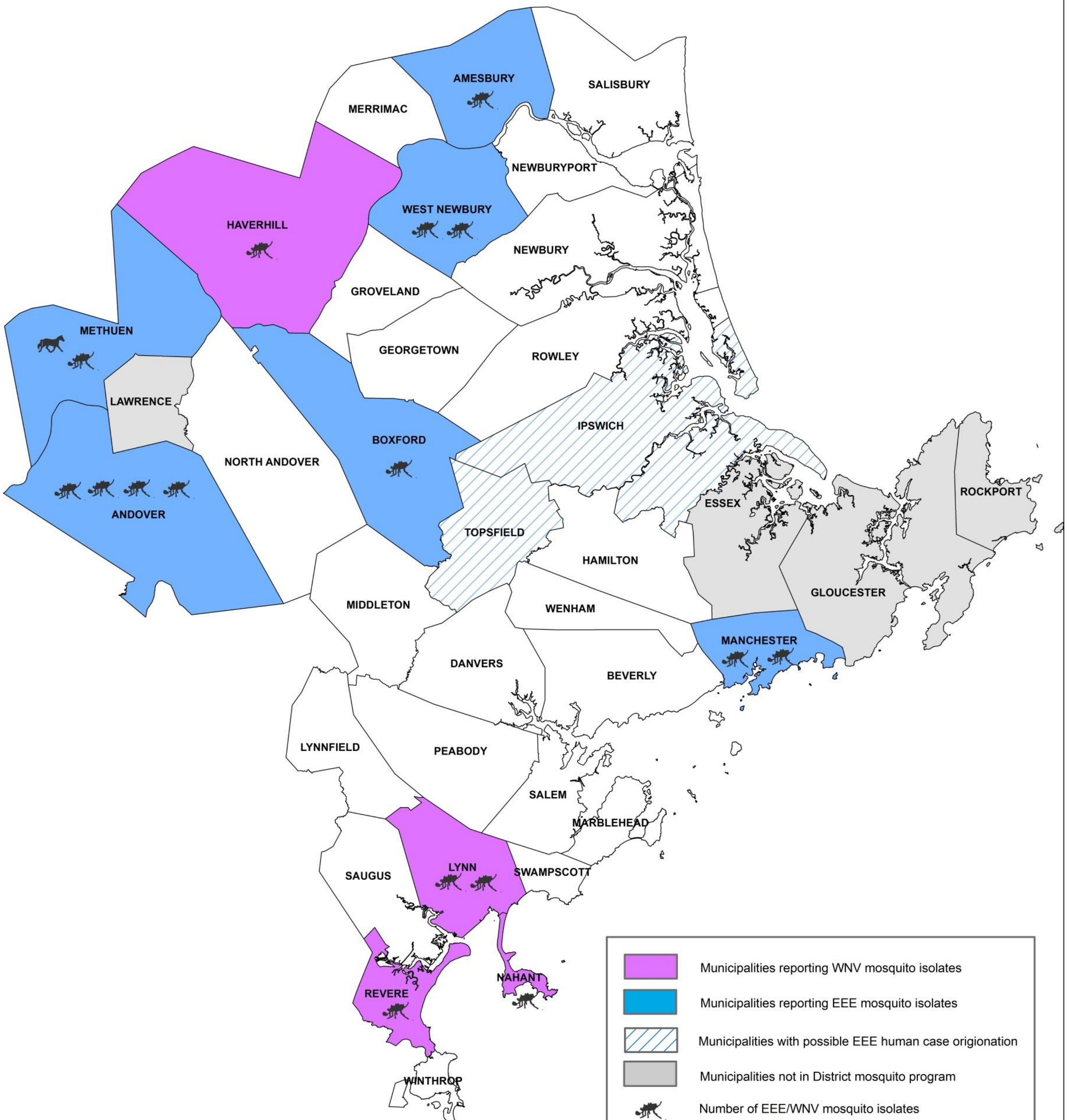
Pest Status salt marsh mosquitoes (*Ae. sollicitans*)

- *Ae. sollicitans,* a summer-fall species*,* declined due to high tidal events as upper salt mash areas flooded from high tides that carried many larvae away. Future habitat of this species may change due to more frequent, abnormal high tides.

Chronological EEE and WNV Isolations/Cases in the NE Massachusetts District - 2019

Test Result/Onset Date	Municipality		County	Virus Isolation
8/13/2019	Andover	*Aedes vexans*	Essex	EEE
8/13/2019	Andover	*Coquillettidia perturbans*	Essex	EEE
8/19/2019	Andover	*Coquillettidia perturbans*	Essex	EEE
8/19/2019	Andover	*Coquillettidia perturbans*	Essex	EEE
8/19/2019	Boxford	*Culiseta melanura*	Essex	EEE
8/19/2019	Lynn	*Culex pipiens*	Essex	WNV
8/22/2019	Methuen	Horse	Essex	EEE
8/27/2019	Methuen	*Coquillettidia perturbans*	Essex	EEE
9/3/2019	West Newbury	*Coquillettidia perturbans*	Essex	EEE
9/3/2019	West Newbury	*Aedes vexans*	Essex	EEE
9/4/2019	Lynn	*Culex pipiens*	Essex	WNV
9/9/2019	Nahant	*Culex pipiens*	Essex	WNV
9/9/2019	Revere	*Culex salinarius*	Suffolk	WNV
9/9/2019		Human	Essex	EEE
9/17/2019	Haverhill	*Culex salinarius*	Essex	WNV
9/23/2019	Manchester-by-the-Sea	*Culiseta melanura*	Essex	EEE
9/23/2019	Manchester-by-the-Sea	*Culiseta melanura*	Essex	EEE
9/24/2019	Amesbury	*Culiseta melanura*	Essex	EEE

Figure 21. NEMMC Municipalities Reporting WNV/EEE Isolations in 2019



DHP Risk level changes in NEMMC for 2019 (See DPH risk maps on Page 36):

EEE: CRITICAL RISK-
Methuen on 8/26/2019

EEE: HIGH RISK-
Andover and Lawrence on 8/26/2019
Ipswich and Topsfield on 9/18/2019

EEE: MODERATE RISK-
Andover on 8/19/2019
North Andover, Haverhill on 8/26/2019
Salisbury, Amesbury, Merrimac, West Newbury, Groveland, Georgetown, Rowley, Boxford on 8/29/2019
Beverly, Danvers, Hamilton, Manchester-by-the-Sea, Middleton, Newbury, Newburyport, Wenham on 9/18/2019

WNV: LOW- NEMMC had no risk level changes for WNV during 2019

Resources

Andreadis, T. 2011. The contributions of *Culex pipiens* complex mosquitoes to transmission and persistence of West Nile virus in North America. Presented at the 57th Annual Meeting of the Northeastern Mosquito Control Association. Plymouth MA. 5 December 2011.

Añez, German & Rios, Maria. 2013. Dengue in the United States of America: A Worsening Scenario? Biomed Research International Epub. 2013 Jun 20. (http://www.hindawi.com/journals/bmri/2013/678645/)

Angelini, R. *et al.* 2007. An outbreak of Chikungunya fever in the province of Ravenna, Italy. Eurosurveillance. **12**(36). 6 September. http://www.eurosurveillance.org/ViewArticle.aspx?PublicationType=W&Volume=12&Issue=36&OrderNumber=1.

Barrett, Alan. 2014. The Economic Burden of West Nile Virus in the United States (editorial). American Journal of Tropical Medicine and Hygiene. 90(3): 389-390.

Bonds, J. A. S. 2012. Ultra-low-volume space sprays in mosquito control: a critical review. Medical and Veterinary Entomology. http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2915.2011.00992.x/pdf

Butts. W. L. 1986. Changes in local mosquito fauna following beaver (*Castor canadensis*) activity. Journal of the American Mosquito Control Association. 2:300-304.

Butts. W. L. 1992. Changes in local mosquito fauna following beaver (*Castor canadensis*) activity-an update. Journal of the American Mosquito Control Association 8:331-332.

Butts. W. L. 2001. Beaver ponds in upstate New York as a source of anthropophilic mosquitoes. Journal of the American Mosquito Control Association 17:85-86.

Centers for Disease Control. 2000. Morbidity and Mortality Weekly Report: January 21, 2000.

Centers for Disease Control. 2006. CDC Japanese Encephalitis Home Page. http://www.cdc.gov/ncidod/dvbid/jencephalitis/index.htm.

Centers for Disease Control. 2008. Chikungunya Fact Sheet. http://www.cdc.gov/ncidod/dvbid/Chikungunya/CH_FactSheet.html

Centers for Disease Control. 2009. Dengue-Frequently Asked Questions. http://www.cdc.gov/Dengue/faqFacts/index.html

Centers for Disease Control. 2010. Eastern Equine Encephalitis. http://www.cdc.gov/EasternEquineEncephalitis/.

Centers for Disease Control. 2010. Dengue-Epidemiology. http://www.cdc.gov/Dengue/epidemiology/index.html

Centers for Disease Control. 2014. Chikungunya in the Caribbean. last update: 27 Feb. 2014. (http://wwwnc.cdc.gov/travel/notices/watch/chikungunya-saint-martin)

Centers for Disease Control. 2015. Zika virus. http://www.cdc.gov/zika

Duckworth, T. *et al.* 2002. Beaver activity – Impacts on mosquito control. Proceedings of the 48th Annual Meeting of the Northeastern Mosquito Control Association. Mystic CT. pp. 100-107.

Enserink, Martin. 2006. Infectious Diseases: Massive Outbreak Draws Fresh Attention to Little-Known Virus. Science. 311: 1086.

Enserink, Martin. 2008. A mosquito goes global. Science. 320: 864-866.

Florida Dept. of Health-Dengue. 2011. Dengue Fever in Key West. http://www.doh.state.fl.us/Environment/medicine/arboviral/Dengue_FloridaKeys.html.

Florida Dept. of Health-Dengue. 2011. Dengue Fever. http://www.doh.state.fl.us/Environment/medicine/arboviral/Dengue.html

Foss, K.A. 2007. Municipal Pest Management Services, Inc. Personal communication.

Hartley D. et al. 2011. Potential effects of Rift Valley fever in the United States. Emerging Infectious Diseases. [serial on the Internet]. http://dx.doi.org/10.3201/eid1708.101088

Kilpatrick, A.M. *et al*. 2007. Ecology of West Nile Virus transmission and its impact on birds in the Western Hemisphere. 124: 1121-1136.

Kreston, Rebecca. 2013. Imported goods: Dengue's return to the U.S. Discover. 26 Nov. (http://blogs.discovermagazine.com/bodyhorrors/2013/11/26/imported-dengues-united-states/#.UybnVKhdU9w)

Lallanilla, Marc. 2014. Chikungunya Fever: Will it spread to the US? (http://www.foxnews.com/health/2014/02/11/chikungunya-fever-will-virus-spread-to-us/)

Legal Information Institute, Cornell University Law School. 2010. Definitions U.S. Code, Title 7 Chapter 6 Subtitle II. § 136. http://www.law.cornell.edu/uscode/html/uscode07/usc_sec_07_00000136----000-.html

Matton, Pricilla. 2011. 2011 Season in Review (Bristol County Mosquito Control Project). Presented at the 57th Annual Meeting of the Northeastern Mosquito Control Association. Plymouth MA. 5 December 2011.

Mutebi, Jean-Paul. 2009. Public health importance of arboviruses in the United States. Presented at the 55th Annual Meeting of the Northeastern Mosquito Control Association; Sturbridge MA. 3 December 2009.

Mutebi, Jean-Paul. 2011. Arboviruses of public health importance in the United States. Presented at the 57th Annual Meeting of the Northeastern Mosquito Control Association. Plymouth MA. 7 December 2011.

Moutailler, S. *et al.* 2007. Short Report: Efficient oral infection of *Culex pipiens quinquefasciatus* by Rift Valley Fever virus using a cotton stick support. American Journal of the Tropical Medicine & Hygiene. 76(5): 827- 829.

Murray, K. *et al*. 2010. Persistent infection with West Nile Virus years after initial infection. Journal of Infectious Diseases. 201:2-4. (http://www.scienceblog.com/cms/west-nile-infection-may-persist-kidneys-after-initial-infection-28072.html).

Nasci, R. 2004. West Nile Virus in Fort Collins, Colorado in 2003 Surveillance and Vector Control. http://www.cdc.gov/ncidod/dvbid/westnile/conf/pdf/nasci_6_04.pdf

Reisen, W.K. *et al*. 2008. Delinquent mortgages, neglected swimming pools, and West Nile Virus, California. Emerging Infectious Diseases. 14: 1747-1749.

Sejvar, J. 2007. The long-term outcomes of human West Nile virus infections. Emerging Infections. 44: 1617- 1624.

Staples, J. Erin et al. 2014. Initial and long-term costs of patients hospitalized with West Nile Virus Disease. American Journal of Tropical medicine & Hygiene. 90(3): 402-409.

Takashima, I. *et al.* 1989. Horizontal and vertical transmission of Japanese Encephalitis virus by *Aëdes japonicus* (Diptera: Culicidae). Journal of Medical Entomology. 26(5): 454- 458.

Turell, *et al.* 2008. Potential for North American mosquitoes to transmit Rift Valley Fever Virus. Journal of the American Mosquito Control Association. 24: 502-507.

USGS & CDC. 2013. Maps of Dengue Fever in U.S. (http://diseasemaps.usgs.gov/)

Voelker, R. 2008. Effects of West Nile Virus May Persist. Journal of the American Medical Association. 299: 2135-2136.

Wilson, J. M. 2001. Beavers in Connecticut: Their natural history and management. Connecticut Department of Environmental Protection, Wildlife Division. Hartford, CT. 18 pp.

World Health Organization. 2011. Frequently Asked Questions. http://www.who.int/suggestions/faq/en/index.html

World Health Organization. 2007. Programmes & Projects: Rift Valley Fever. http://www.who.int/mediacentre/factsheets/fs207/en/index.html.