Massachusetts Department of Public Health

2017
Massachusetts Arbovirus Surveillance and Response Plan

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Executive Summary

The 2017 Massachusetts Department of Public Health's (MDPH) Arbovirus Surveillance and Response plan provides surveillance and phased response guidance for arthropod-borne viruses (arboviruses) affecting Massachusetts residents, West Nile virus (WNV) and eastern equine encephalitis virus (EEE), in particular. Since 2000, there have been 148 confirmed cases of WNV among Massachusetts residents resulting in at least 9 deaths and 26 cases of EEE resulting in at least 14 deaths. This plan reflects a comprehensive review of surveillance activities, mosquito control efforts, public information, and risk communication related to arbovirus control in Massachusetts.

The purpose of the plan is to provide guidance on operational aspects of surveillance and response by state and local agencies responsible for the prevention of mosquito-borne disease in the 2017 season. MDPH will continue to seek advice from its partners and collaborators and modify the plan, as appropriate. This document is open to continual review and evaluation. Information is provided to guide planning and actions to reduce the risk of human disease from EEE and WNV, and to respond to concerns about the introduction of Zika virus, or other emerging arboviruses, into regions of the Americas.

This plan does not address long-term, municipal planning activities. WNV and EEE are endemic diseases in Massachusetts which, although rare, are serious and likely to pose continued threats to human health. Municipalities are encouraged to consider these threats, identify contributing issues in their communities, and include mitigation activities as part of sustainable community development (e.g. source reduction, low-impact development).

Key components of the plan include:

- monitoring trends in EEE and WNV activity in Massachusetts;
- timely collection and dissemination of information on the distribution and intensity of WNV and EEE in the environment;
- laboratory diagnosis of WNV and EEE cases in humans, horses and other animals;
- effective communication, advice, and support of activities that may reduce risk of infection;
- phased response to provide measures to suppress the risk of infection; and
- monitoring for evidence of introduced and emerging arboviruses and new mosquito vector species.

This document provides information about EEE and WNV disease and program goals, and specific guidelines for mosquito, equine, and human surveillance. Additionally, this document provides guidance for the dissemination of information, including routine information; media advisories of positive EEE and WNV findings in mosquitoes, as well as public health alerts related to positive EEE and WNV human cases.

This plan describes MDPH's public outreach efforts to provide helpful and accurate communication with Massachusetts residents about their risk from arboviral diseases and specific actions that individuals and communities can take to reduce this risk. Routine precautions should include: avoiding outdoor activity during times of day with increased mosquito activity; use of mosquito repellents containing an EPA-approved active ingredient; and use of clothing to reduce mosquito access to skin. These personal protective measures form the basis of all risk reduction; the need to utilize them is not reduced by any mosquito control activities, including aerial spraying.

I. INTRODUCTION

The Massachusetts Department of Public Health, in collaboration with the State Reclamation and Mosquito Control Board (SRMCB) and regional mosquito control projects (MCP), conducts surveillance for mosquito-borne viruses that pose a risk to human health. Surveillance currently focuses on West Nile and eastern equine encephalitis viruses, which are found in the local environment and are capable of causing serious illness and death in humans, horses, and other mammals.

The 2017 Massachusetts Surveillance and Response Plan for mosquito-borne diseases is based on a comprehensive plan initially developed for WNV in 2001 in collaboration with local health agencies, other state agencies, academic institutions, the Centers for Disease Control and Prevention (CDC), and interested groups and individuals. It incorporates components of the state's EEE surveillance activities, which began in the 1950s and have continued since that time. Monitoring for WNV began following a 1999 outbreak of human WNV disease in the New York City area, the first known occurrence of this disease in North America. WNV was identified in birds and mosquitoes in Massachusetts during the summer of 2000, in humans in 2001, and has been detected during each consecutive season.

The updated 2017 plan is the result of analyses of surveillance data collected in Massachusetts and the United States. In order to address the complexity and seriousness of the human disease risk posed by EEE, MDPH convened a panel of experts in 2011-2012 who represented the fields of ecology, biology, public health, infectious disease, and toxicology to review MDPH's surveillance and response program and make recommendations for enhancing the program. Those recommendations were incorporated into the plan in 2012 and continue to serve as important components of the current plan. In addition, MDPH continues to promote collaborative efforts with multiple agencies and interest groups by seeking and accepting comment from stakeholders. The purpose of the plan is to provide guidance on operational aspects of surveillance and response by state and local agencies with responsibilities for the prevention of mosquito-borne disease. MDPH will continue to seek advice from its partners and collaborators, and modify the plan, as appropriate. This document is open to continual review and evaluation, with changes made when there is opportunity for improvement.

II. DISEASE HISTORY AND BACKGROUND

A. Eastern Equine Encephalitis Virus

1. Background

Eastern equine encephalitis is a serious disease which occurs sporadically in Massachusetts, with 30-50% mortality and lifelong neurological disability among many survivors. The first symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease rapidly worsens and some patients may go into a coma within a week. There is no treatment for EEE. In Massachusetts, approximately half of the people identified with EEE have died from the infection. People who survive this disease will often be permanently disabled due to neurologic damage. Few people recover completely.

Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 1972-74, 1982-84, 1990-92, and, 2004-06. Two cases of EEE occurred in each of 2010 and 2011; one case each of these years occurred in visitors to Massachusetts. Seven human cases of EEE occurred in 2012, a single case in 2013 and no cases in 2014 - 2016.

Massachusetts Eastern Equine Encephalitis Experience		
Year(s)	**Human EEE Cases**	**Human EEE Deaths**
1938-39	35	25
1955-56	16	9
1973-74	6	4
1982-84	10	3
1990-92	4	1
2000-01	2	0
2004-06	13	7
2008	1	1
2010-11	2 (plus 2 non-residents)	1
2012	7	3
2013	1	1
2014-2016	0	0

The U.S. Public Health Service, in collaboration with MDPH, initiated a field surveillance program in 1957; following a 1955-56 outbreak of EEE. The purpose of the program was to gather data to guide prevention and risk reduction for this disease. This program formed the basis for the Commonwealth's current arbovirus program.

2. Risk Factors for Disease Transmission

Eastern equine encephalitis virus is a virus in the genus *Alphavirus* that is native to the Massachusetts environment (enzootic) and is naturally found in some passerine (perching) bird species living in and around fresh-water swamp habitats. These habitats also support populations of the primary mosquito vector, *Culiseta melanura*, which feeds predominantly on birds. The swamp habitats, which support large populations of *Cs. melanura* and are the initial source of EEE, are known as enzootic foci. Although portions of the ecology of EEE virus have yet to be clarified, the virus has a cycle of natural infection among bird populations with occasional ‘‘incidental" symptomatic infections in susceptible species, including humans. The appearance of EEE in late June or early July coincides with the hatching of highly susceptible bird populations. The virus is circulated among the bird populations by *Cs. melanura* and under some circumstances *Cs. morsitans*, another bird-biting mosquito. Initially, a relatively smaller proportion of birds and mosquitoes carry the virus; throughout the mosquito season, continuous transmission between mosquito vectors and bird reservoir hosts increases the proportion of infected birds and mosquitoes leading to an overall greater amount of virus present in the environment. This is called the virus amplification cycle. Depending on when virus circulation begins, the size of the *Culiseta* populations, weather conditions, and probably additional, currently unidentified factors, this virus amplification cycle may eventually spill over and involve secondary, or "bridge", mosquito vectors that feed on both birds and mammals. In the Northeast, these bridge vectors are mosquito species, such as *Coquillettidia perturbans, Ochlerotatus* (formerly *Aedes*) *canadensis,* and *Aedes vexans*. These bridge vectors are presumed to be responsible for the transfer of EEE to incidental hosts, including mammals such as humans, horses, llamas, and alpacas; and large birds such as emus and ostriches. For the purposes of risk assessment and communication with the public, *Cs. melanura* is considered to be and will be reported as a “bird-biter” while *C. perturbans, O. canadensis,* and *A. vexans* are considered to be and will be reported as “mammal-biters”. *Culex* species mosquitoes found positive for EEE are not considered to play a significant role in transmission of the virus to humans or animals and are considered to be and will be reported as bird-biters.

In the Northeast, the EEE enzootic foci are large hardwood swamps of mature white cedars and red maples. To grow in the permanently wet swamps, tree roots spread out across the peat soils characteristic of these habitats. These root systems create dark holes, or crypts, that are generally filled with water. These crypts are the preferred ovipositing (egg-laying) sites for *Cs. melanura* and are where the larvae develop. *Cs. melanura* survives the winter as larvae in these crypts. The amount of rainfall during the summer and fall affects the survival of the larvae during the winter and, in part, determines the population of adult mosquitoes the following year.

The risk of EEE in humans varies by geographical area in Massachusetts, as well as in the United States, and is correlated with the location of the necessary swamp habitats. In Massachusetts, these areas occur across the state, but are most common in southeastern Massachusetts. The majority of EEE cases have occurred in Norfolk, Bristol, and Plymouth counties, with some cases also occurring in Essex and Middlesex County. A very few cases have also occurred further west in Massachusetts. Historically, Barnstable and the Islands of Martha's Vineyard and Nantucket have not had human cases of EEE. 2012 was unusual in that five of seven human cases and four of seven animal cases resided outside southeastern Massachusetts. The significance of this is unclear at present; this may or may not be a harbinger of more widespread risk in Massachusetts. The situation has been closely monitored since then and there was early evidence of EEE activity in one of these areas which resulted in two horses infected with EEE in 2013.

Currently, it is impossible to predict, with complete accuracy, the appearance of EEE and the probability of human EEE infection in any given year. However, over 50 years of surveillance for EEE in Massachusetts has enabled the development of a mosquito-based EEE surveillance system and the identification of several factors that help provide an estimate of human risk. These estimates are used to

alert the residents of the state and guide mosquito control activities. Risk estimates are based on the current level of EEE activity in both bird-biting and mammal-biting mosquito species, population levels of these species, timing of virus identification in these species, recent and historic levels of EEE activity, and prevailing weather conditions.

Human cases are more likely when multiple factors indicate that risk is increasing in a given place at a given time. Identification of EEE in the enzootic mosquito vector, *Cs melanura*, is useful for determining areas of virus amplification and as a proxy measure of the amount of EEE virus in the environment. The overall amount of EEE virus present in the environment correlates with the population size of the primary mosquito vector, *Cs melanura*. Abundant populations of this species provide greater opportunity for the virus to perpetuate or amplify within the bird population. Theoretically, the more virus that is circulating between mosquitoes and birds, the more likely it will be to be picked up by a bridge vector mosquito and transmitted to humans. Identification of EEE in bridge vector mosquito species confirms the presence of infected mosquitoes of a species known to feed on humans. The more virus that has spilled over into bridge vector species, the greater the chance that a person will be exposed to the virus. Warm temperatures increase the rate of both mosquito development and virus replication within mosquitoes. Consistently elevated temperatures increase mosquito populations of all species, speed up virus multiplication within mosquitoes, and therefore act to increase the amount of virus in the environment overall.

Other factors that affect the risk of EEE infection for humans are the abundance of key mosquito species at critical periods of the transmission season, groundwater levels, and the timing of rainfall and flooding during the mosquito season. Long-term weather patterns during the fall and winter that produce high ground water levels and snow cover may enhance survival of *Cs. melanura* larvae. The abundance of these larval populations may serve as an early indicator of the potential for human disease later in the year.

Multiple factors affect the development, survival, and abundance of mosquitoes. It is not currently possible to accurately forecast either the abundance of mosquitoes or the risks for encountering an infected vector later in the season. Risk assessment relies upon a robust mosquito surveillance system to monitor both mosquito populations and virus amplification as the season progresses.

B. West Nile Virus

1. Background

West Nile virus (WNV) first appeared in the United States in 1999. Since the initial outbreak in New York City, the virus has spread across the US from east to west. Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state, and federal officials, academicians, environmentalists and the public to develop recommendations to adapt the arbovirus surveillance and response plan to include activities appropriate for WNV. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity, and communication.

WNV infection may be asymptomatic in some people, but it leads to morbidity and mortality in others. WNV causes sporadic disease of humans, and occasionally significant outbreaks. Nationally, 2,038 human cases of WNV neuroinvasive disease (meningitis and encephalitis) and WNV fever were reported to the CDC in 2016. The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller proportion of people who become infected (~ 20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach, and back. Less than 1% of people infected with WNV will develop severe illness, such as encephalitis or meningitis. The symptoms of severe illness can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness, and paralysis. Persons older than 50 years of age have a higher risk of developing severe illness. In Massachusetts, there were at least nine fatal WNV human cases identified between 2002 and 2016. All but two of these fatalities were in individuals 80 years of age or older; all of them were in individuals over 60.

2. Risk Factors for Disease Transmission

West Nile virus is amplified by a cycle of continuous transmission between mosquito vectors and bird reservoir hosts. Infected mosquitoes carry virus and transmit it to susceptible bird species. WNV infection can be fatal in some species of birds, particularly American crows and blue jays (corvids). Confirmation of WNV in dead birds historically provided sentinel information used for assessing the risk of human WNV infections. However, the proportion of susceptible birds has decreased over time so that testing dead birds for the presence of virus is no longer an efficient surveillance tool.

The principal mosquito vectors for West Nile virus on the East Coast are members of the genus *Culex*, primarily *C. pipiens* and *C. restuans*. These species may be abundant in urban areas, breeding easily in artificial containers, such as birdbaths, discarded tires, buckets, clogged gutters, catch basins, and other standing water sources. Both species feed mainly on birds and occasionally on mammals, including humans. Peak feeding activity for these species occurs from dusk into the late evening. Consistently high temperatures and lower precipitation rates are factors that have been associated with higher mosquito infection and human illness rates. Additionally, warmer winter temperature conditions may result in larger numbers of *Culex* species overwintering as adults, with resulting increases in early season *Culex* abundance.

There are additional mosquito species in Massachusetts that can be involved in the transmission of WNV to humans. *Culex salinarius* lives in brackish and freshwater wetlands and feeds on amphibians, birds, and mammals; it is well known for biting humans. *Ochlerotatus japonicus* may be involved in the transmission of both WNV and EEE. This species utilizes natural and artificial containers, such as tires and rock pools as larval habitat. It feeds mainly on mammals and is an aggressive human biter. Unlike EEE, distinguishing between bird- and mammal-biting species of mosquitoes is of less importance for risk assessment purposes and these designations are not routinely used.

West Nile virus activity varies from year to year. When large numbers of infected birds and elevated mosquito populations occur in a relatively small geographic area, the result is a high mosquito infection rate and an increased risk of transmission of virus to humans. In addition, there is evidence that when meteorologic conditions are such that *Cx. pipiens* populations are increased relative to *Cx. restuans*, the risk of transmission to humans may be increased. Surveillance evidence indicates that WNV is established in the United States and that virus activity is likely to occur annually.

Most municipalities in Massachusetts will only have sporadic human cases of WNV and are unlikely to have more than one year. However, several highly urbanized areas in Massachusetts have accounted for over 80% of the human WNV infections between 2001 and 2016 (Figure 1).

Summaries of historical surveillance information for EEE and WNV in Massachusetts are available online at www.mass.gov/dph/mosquito. During the season, information is provided daily with current surveillance information and risk assessments which can be found through the same site.

III. PROGRAM GOALS

Timely and accurate information based on surveillance information is used to provide an estimate of the level of risk for human disease from WNV and EEE. Based on this surveillance information, plans and actions to reduce risk can be developed and implemented when needed. Program activities include:

- Testing mosquitoes, horses, other appropriate animals, and humans to identify EEE and WNV infections;
- Tracking trends in incidence and prevalence of EEE and WNV infections by geographic area;
- Estimating viral infection rates in mosquitoes;
- Stratification of risk by geographic areas as a function of relative risk of human disease;
- Conducting surveillance for human and animal disease;
- Educating human and animal medical practitioners on the appropriate procedures for detecting infections and disease caused by mosquito-borne viruses;

- Recommending measures to reduce virus transmission and disease risk;
- Educating the public on mosquito-borne diseases and disease risk and common-sense precautions to reduce the risk of infection;
- Working to detect emerging arboviruses, such as Jamestown Canyon virus, and introduced arbovirus infections in travelers to areas with transmission of these arboviruses, such as dengue, chikungunya and Zika viruses;
- Working to detect the introduction, establishment and geographic spread of new mosquito vector species; and
- Participating in the national Arbovirus Surveillance Network.

IV. AGENCY ROLES

A. Massachusetts Department of Public Health (MDPH)

The central purpose of arbovirus surveillance is to provide information that will guide planning and activities to reduce the risk of human disease from EEE and WNV infection. To achieve this, the main objectives are to 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; communicate effectively with officials and the public; provide guidelines, advice, and support on activities that effectively reduce risk for disease; and provide information on the safety, anticipated benefits, and potential adverse effects of proposed prevention interventions. The arbovirus surveillance program should also have the capacity to respond to concerns about the introduction of travel-associated diseases, like Zika virus, by monitoring for evidence of introduced and emerging arboviruses and new mosquito vector species

MDPH works cooperatively with the SRMCB, regional mosquito control projects, local health departments, and other agencies to collectively identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles. The use of pesticides as a means to reduce human risk is one of several methods used as part of an overall strategy.

B. State Reclamation and Mosquito Control Board (SRMCB)

The SRMCB oversees mosquito control programs and activities in the Commonwealth of Massachusetts. The SRMCB consists of three members representing the Department of Agricultural Resources (DAR), Department of Conservation and Recreation (DCR), and Department of Environmental Protection (DEP). Additionally, the SRMCB advises its respective state agency Commissioners on actions to reduce mosquito populations based on MDPH findings and characterization of risk.

The SRMCB's 'Operational Response Plan to Reduce the Risk of Mosquito-Borne Disease in Massachusetts' addresses the issues related to the operational aspects of adult mosquito surveillance and control to prevent and/or reduce the risk of mosquito-borne diseases. The plan may be accessed online from http://www.mass.gov/eea/agencies/agr/pesticides/mosquito/arbovirus-response-plans.html. In 2006, the SRMCB created the Mosquito Advisory Group (MAG) to provide independent, scientific advice to the SRMCB regarding the justification, timing, location and options for intervention tactics such as to prevent and/or suppress and contain infected mosquito populations that may otherwise result in an outbreak of disease in people and animals.

C. Mosquito Control Projects (MCPs)

There are 11 organized Mosquito Control Projects or Districts located throughout Massachusetts. All of the mosquito control activities of these agencies are performed under the aegis of the SRMCB. MCPs collaborate with local boards of health in their jurisdictions to perform public education, promote the use of personal protection and to control mosquitoes. Locally authorized mosquito control efforts employ a variety of targeted activities for source reduction, larviciding and adulticiding that are in compliance with the SRMCB Operational Response plan. Additional details relating to MCPs may be found within the

SRMCB Operational Plan and online at
http://www.mass.gov/eea/agencies/agr/pesticides/mosquito/arbovirus-response-plans.html

D. Local Boards of Health (LBOHs)

LBOHs are the local health authorities and the primary points of contact within a community for MDPH. Surveillance information is communicated to the LBOH who may work with their MCP (if any) to determine mosquito control response activities, conduct educational outreach via the media and/or other means, investigate cases, disseminate surveillance and risk assessment information to other community leaders and undertake other activities based on their community's needs.

V. SURVEILLANCE

A. Mosquito Surveillance

Surveillance of certain species of mosquitoes for arboviruses is a core function of MDPH. Although there are up to 51 indigenous species of mosquitoes found in Massachusetts, only species involved in the spread of disease are tested for surveillance purposes. Monitoring mosquitoes for the presence of virus provides an estimate of risk to humans. Massachusetts has a long-term field surveillance program that was initiated in 1957 for EEE and was enhanced in 2000 to include WNV surveillance. The extensive experience in Massachusetts with surveillance for mosquito-borne disease provides expertise and capacity to guide risk reduction efforts. MDPH uses a comprehensive and flexible strategy that modifies certain surveillance activities in response to trends in disease risk.

On an ongoing basis, MDPH monitors national and regional surveillance data and current scientific literature to assess risk of newly emerging arboviruses in Massachusetts. In addition, a defined subset of mosquitoes will be tested for the presence of new or emerging viruses using tissue culture methods.

1. Fixed and Long-Term Trap Sites

MDPH field staff trap mosquitoes at long-term sites maintained primarily in the EEE high-risk areas of southeastern and eastern Massachusetts (Figure 2) and from other areas as circumstances demand and resources allow. Trapping of gravid (egg-bearing) mosquitoes for WNV testing is conducted both by MCPs and MDPH field staff at various locations throughout the state during the arbovirus season. After trapping, all collected mosquitoes are sorted into groups by species and counted by hand. At the Massachusetts State Public Health Laboratory (MA SPHL), these samples (grouped or pooled sets of 10-50 mosquitoes) for WNV and EEE. These are frequently referred to as "mosquito pools" which indicates the grouping 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 24 hours after delivery of mosquitoes to the MA SPHL. 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 for human infection from EEE virus and WNV. MDPH field staff monitor larvae from select sites in late fall and early spring to determine end-season and pre-season larval abundance. Informal monitoring of larval abundance from these sites continues on a weekly basis during the arbovirus season.

2. Supplemental Trap Sites

When EEE or WNV activity is detected in an area, additional trap sites and/or trap types are used to obtain more information regarding the intensity of virus activity in mosquitoes. The following risk indicators may result in the implementation of more intensive mosquito trapping: 1) virus isolations in mosquitoes; 2) emergence of large numbers of human-biting mosquitoes in an area with a high rate of virus activity and 3) identification of human or animal cases.

3. Mosquito Control Project Trap Sites

MCPs use a variety of available control strategies to impact mosquito abundance. Monitoring mosquito abundance is accomplished through various surveillance methods including but not limited to larval dip counts and the use of light/ CO_2 baited traps and gravid traps.

4. Results

Results of mosquito trapping and testing provide information on:

- the numbers of positive mosquito samples (mosquito pools) from a community;
- general measures of mosquito populations; and
- relative EEE infection rates in mosquito populations.

B. Avian Surveillance

MDPH discontinued avian surveillance for WNV as of April, 2009. When the virus was first introduced into the United States, WNV caused high mortality rates in certain species of birds, particularly corvids, thus reporting and testing of dead birds was a productive way to detect and monitor WNV activity in an area. However, in recent years, the tracking and testing of dead birds has become significantly less useful as a surveillance tool. Monitoring mosquitoes for presence of virus is the primary predictive indicator of human arbovirus disease risk. Therefore, the routine laboratory testing of dead wild birds for West Nile virus (WNV) has been eliminated. This is consistent with recent policy changes in multiple states.

Most birds that are infected with EEE virus survive the viremia, making individual dead bird EEE monitoring impractical. Non-native bird species such as emus, ostriches, and exotic game birds are highly susceptible to EEE and infections within farmed flocks have occurred in Massachusetts. Testing of highly suspect bird specimens for EEE and/or WNV infection is done on an as-needed basis as determined by MDPH.

C. Animal Surveillance

Specimens from horses and other domestic animals that have severe neurological disease suspected of being caused by EEE or WNV infection are tested at the MA SPHL. Testing can take up to several weeks to complete depending upon the type of sample submitted and the testing protocol required to obtain a definitive result. Veterinarians, DAR, the United States Department of Agriculture (USDA) and Tufts University Cummings School of Veterinary Medicine collaborate with MDPH to identify and report suspect animal cases. In addition, blood and/or tissue samples from animals from other sources, such as zoos, horse stables, or the wild are tested, as appropriate. Current information on WNV and EEE infections in horses, along with clinical specimen submission procedures, are disseminated to large animal veterinarians, stable owners, and others through various distribution methods and are posted on the MDPH arbovirus website at www.mass.gov/dph/mosquito. Horses and other animals can be immunized against infection with WNV and EEE with available veterinary vaccines. Vaccination is the primary means of preventing infection in animals.

Due to the time delay inherent in specimen acquisition and testing, specimens from animal with an illness compatible with either WNV or EEE infection that test positive on the screening test will be reported as a preliminary result to the ordering veterinarian, the local board of health in the town of the animal's residence, the local board of health in the likely city/town of exposure (if different from place of residence), and the local mosquito control project, if there is one. This information may be used to inform clinical decisions first and foremost, and secondarily to inform planning for public health and mosquito control activities. This animal will not be considered to represent a confirmed case until testing is completed; appropriate changes to risk levels will be made following confirmatory testing.

D. Human Surveillance

1. Routine surveillance

Specimens from human cases of encephalitis and meningoencephalitis should be submitted to the MA SPHL for WNV and EEE testing. Testing for both viruses usually consists of a preliminary screening test (an enzyme immunoassay for antibody to the viruses), followed by confirmatory testing by plaque reduction neutralization test (PRNT) for specific antibody. Certain specimens, cerebrospinal fluid drawn shortly after symptom onset, may be tested by polymerase chain reaction (PCR). Only specimens that are positive on the confirmatory PRNT test or on PCR at the MA SPHL are considered to represent true cases and will be used for risk assessment. Increasing availability of commercial laboratory testing for

WNV has diverted submission of samples away from the MA SPHL. Current commercially available testing is equivalent to the screening test that MDPH runs, but does not extend to the confirmatory testing capability available at the MA SPHL. Not all specimens reported to be positive based on commercial laboratory testing will confirm with the more specific confirmatory testing that is performed by the MA SPHL. Only those tests that are confirmed positive (through testing at the MA SPHL) will be officially reported out. Specimens from any individual reported to be positive based on commercial laboratory testing will be requested for additional testing.

Testing may take several weeks to complete dependent upon the type of sample submitted and the testing protocol necessary to obtain a definitive result. Under certain circumstances, definitive results cannot be obtained by the MA SPHL and samples are forwarded to the Centers for Disease Control and Prevention (CDC) for additional testing. Time to receipt of final results from CDC is variable. Current information on WNV and EEE infections in humans, along with clinical specimen submission procedures, are disseminated to physicians (infectious disease, emergency medicine and primary care), emergency department directors, hospital infection control practitioners, and local boards of health through various distribution methods and are posted on the MDPH arbovirus website at www.mass.gov/dph/mosquito.

Due to the time delay inherent in specimen acquisition and testing, specimens from patients with an illness compatible with either WNV or EEE infection that test positive on the screening test will be reported as a preliminary result to the ordering provider, the local board of health in the town of the patient's residence, the local board of health in the likely city/town of exposure (if different from place of residence), and the local mosquito control project, if there is one. This information may be used to inform clinical decisions first and foremost, and secondarily to inform planning for public health and mosquito control activities. These patients will not be considered to represent confirmed cases until testing is completed; appropriate changes to risk levels will be made following confirmatory testing. Samples reported to be preliminarily positive from blood donor screening programs will also be reported to the local board of health and the mosquito control project, if there is one, for similar reasons.

Because antibodies to WNV can persist for months, a positive laboratory test alone does not necessarily indicate evidence of current infection. Laboratory data must be correlated with clinical information and exposure risk in order to identify current, confirmed cases for the purposes of surveillance. The frequency of positive laboratory tests from individuals who otherwise do not appear to represent true, current instances of infection will be highest immediately following very active years, such as occurred in 2012.

2. Active surveillance

If surveillance data estimate a high risk of human disease, active surveillance may be instituted in targeted areas. Active surveillance involves regularly contacting local health care facilities to communicate current surveillance information, promoting disease prevention strategies, reviewing specimen submission procedures, and highlighting the need for testing patients presenting with signs and symptoms possibly representing infection with EEE virus or WNV. The Health and Homeland Alert Network (HHAN), a secure electronic alerting system, is used to send information to local boards of health upon confirmation of EEE or WNV in any specimen.

3. Pesticide related surveillance

Outreach on pesticide illness reporting is coordinated by the MDPH's Bureau of Environmental Health. In the event of an aerial pesticide application, active surveillance efforts will be implemented with emergency departments and intensified outreach efforts will be made to health care providers.

VI. COMMUNICATION OF CONFIRMED SURVEILLANCE INFORMATION

MDPH works with the SRMCB and MCPs to identify and support the use of risk reduction and disease prevention methods that are specific to the causes of disease, and supports planning and practices which incorporate the most appropriate prevention methods. Additionally, MDPH routinely communicates with health agencies in neighboring states to share relevant arbovirus findings.

Prior to the beginning of the arbovirus season, general disease information and specimen submission procedures are provided to local boards of health via the HHAN. The local boards of health (LBOH) are asked to provide routine and emergency contact information for a primary and secondary arbovirus contact during the season. Although routine surveillance specimen notifications are scheduled during normal business hours, test results sometimes become available after hours. General information and fact sheets are posted on the MDPH arbovirus website and are available publicly.

Summaries of surveillance findings are compiled and released in weekly reports issued on Monday afternoons to local boards of health and mosquito control projects.

Initial identification of virus in mosquitoes from a given town is reported to the LBOH and MCP by telephone. Adjacent towns are notified via a moderate level HHAN alert. In order to encourage risk communication on a larger area level rather than a city/town level; all subsequent positive findings in mosquitoes are reported once daily to all affected towns and adjacent towns, via a moderate level HHAN alert. All subsequent positive mosquito findings will also be reported once daily to all MCPs and the SRMCB.

Laboratory confirmation of a human WNV or EEE case is immediately reported to the submitting physician, submitting laboratory and LBOH in the town where the case resides. If the LBOH cannot be reached in a timely manner, a severe level HHAN alert is sent.

Laboratory confirmation of WNV or EEE in a veterinary specimen is immediately reported by telephone to the submitting veterinarian, the MDAR Division of Animal Health, and the LBOH. If the LBOH cannot be reached via telephone in a timely manner, a severe level HHAN alert is sent.

Risk assessment changes will be reported to the LBOH, the MCP and any immediately adjacent community. Routine risk assessment level changes from low to moderate will be done twice per week, on Mondays and Thursdays. Assessed changes to high or critical will be communicated immediately.

The MDPH Regional Health Office (RHO) and the Office of Preparedness and Emergency Management (OPEM) Regional Public Health Preparedness Coordinator in the area can offer assistance with local response. All laboratory confirmed results for WNV and EEE in humans, veterinary specimens, and mosquitoes are provided to the RHO, OPEM, MCPs and members of the SRMCB once the LBOH has been notified.

At the time of notification, MDPH encourages LBOH to share the information with other local agencies and high-risk populations in their community, as appropriate. MDPH provides LBOH with sample press releases for their use. Depending on the circumstances, MDPH may also issue a public health alert. In addition, weekly summaries of results from mosquito samples submitted and tested will be posted by town as News Items on the HHAN.

After all appropriate individuals and agencies have been notified, positive surveillance findings are made available to the media and general public on the MDPH Arbovirus website at http://www.mass.gov/dph/mosquito. In order to protect patient confidentiality, only limited information is released on any individual. MDPH generally releases only age category, gender, current patient status, county of residence and likely exposure location, if known. This website, which also includes links to a variety of educational materials related to mosquito-borne diseases, is updated on a daily basis throughout the arbovirus season. Results are also reported to the CDC's ArboNET reporting system.

MDPH usually issues public health alerts through the media when surveillance information indicates an increased risk of human disease or if a significant surveillance event occurs (for example, the first arbovirus activity of the season). In general, alerts include current surveillance information and emphasize prevention strategies.

VII. PREVENTION AND RESPONSE: RECOMMENDATIONS FOR PHASED RESPONSE TO SURVEILLANCE DATA

The guidance provided here is based on current knowledge of risk for human disease, and appropriateness and efficacy of interventions available to reduce that risk. Multiple factors contribute to the risk for mosquito-transmitted human disease. Decisions about risk reduction measures should be made after consideration of surveillance information.

Public awareness of what can be done to reduce risk of infection is of utmost importance. Typically, risk for any individual is expected to be relatively low, and the routine precautions taken by individuals may be sufficient to reduce opportunities for infection. Routine precautions should include:

- avoiding outdoor activity in areas, and during times of day, with increased mosquito activity;
- use of mosquito repellents containing an EPA registered active ingredient; and
- use of clothing to reduce mosquito access to skin.

These personal protective measures **must** form the basis of all risk reduction and the need to utilize them is not reduced by any mosquito control activities, including aerial spraying. When multiple factors that indicate an increased risk for transmission to humans are present, additional risk reduction measures may be necessary. These guidelines take into consideration the complexity of reducing risk of human disease from EEE and WNV infection, and form a framework for decision-making by both individuals and agencies.

General guidelines are provided for an array of situations as noted in the Surveillance and Response Plan tables that follow. Specific situations must be evaluated individually and options discussed before actions are taken. Estimating risk from mosquito-borne disease(s) is complex and many factors modify specific risk factors. MDPH assesses risk and works with LBOH, MCPs, and the SRMCB to develop the most appropriate response activities to reduce the risk of human disease. There is no single indicator that can provide a precise measure of risk, and no single action that can completely ensure prevention of infection.

MDPH works collaboratively with other state agencies, the SRMCB and MCPs to collectively identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles.

Risk for mosquito-borne disease is virtually eliminated by the first local hard frost which kills most remaining adult mosquitoes. Since *Culex* species, which spread WNV, find warm, protected areas to survive the winter, isolated cases of WNV may rarely occur even after a hard frost.

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. MDPH does not have meteorologic data or expertise and cannot determine when individual communities have experienced a hard frost. Sources of information to assist local officials with determining when a hard frost has occurred can be found on the weather reports from local media outlets, through the National Weather Service (http://w2.weather.gov/climate/) and other online resources such as Weather Underground (https://www.wunderground.com/). Community officials may be aware of additional local resources that are available. 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, and communities may wish to consider this information when making decisions about scheduling or cancelling planned outdoor events late in the season.

Criteria for re-evaluating late season risk in communities that reached high or critical levels of risk from EEE are not clearly defined. MDPH is working with mosquito and disease experts to assess whether or not surveillance and/or temperature data can be used to accurately predict declining risk, toward the end of the mosquito season and prior to the occurrence of a hard frost. Multiple challenges to this exist including potentially increasing infection rates among surviving late-season mosquitoes, yet decreasing

trapping success as evenings cool. This limits data available to assess accurate mosquito abundance and infection rates. Any actionable information will be released as an addendum to the plan.

A. MDPH Guidance

Human cases of WNV and EEE occur primarily in August and September although the specific timing of the peak disease transmission season is affected by mosquito populations, level of virus activity and weather conditions (Figure 3).

MDPH uses data from arbovirus surveillance to assess human risk levels as outlined in the phased response tables of this plan. **Risk levels are defined for "focal areas". Focal areas frequently, but not always, 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, 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.** In general, focal areas are likely to include the municipality with the positive finding and at least all adjacent communities. In general, assignment of risk will involve identifying the highest risk communities and then setting surrounding communities at the next highest risk level. For example, when evidence exists that a focal area is at high risk for EEE, in most cases, all adjacent communities will be set at moderate. Geographic areas commonly associated with human cases will have larger focal areas than those without a repeated history of human cases.

Prolonged heat promotes risk from both WNV and EEE by increasing the rate of mosquito reproduction and development, as well as decreasing the amount of time it takes for an infected mosquito to become able to transmit the virus. Weather conditions favorable for development of elevated WNV risk include hot, generally dry weather with rain occurring as downpours rather than light precipitation. Weather conditions favorable for development of elevated EEE risk include increased rainfall in the preceding fall and/or spring and mild winters or those with insulating snow cover. Evidence for elevated risk is also indicated by EEE activity in the preceding year, isolation of virus from a mammal-biting species of mosquito and isolations of the virus before mid-July.

Although mosquito surveillance data will be reported to local jurisdictions as it becomes available, in general, risk assessments that result in changes of low to moderate levels in communities are conducted twice per week, on Mondays and Thursdays. This streamlines communication and improves the ability of the MCPs to plan and schedule response activities. An exception to this schedule will be when information is obtained that indicates a community should be moved from moderate to high risk because of the need for timely consideration of recommended response activities. Additional exceptions to this protocol may be made as dictated by rapidly evolving situations.

B. Risk Reduction and Prevention Guidance for Seasons with Indicators of Increased EEE Risk

Based on historical experience with EEE, MDPH has identified specific critical indicators for overall EEE, risk, and provides specific risk reduction and prevention guidance for seasons with an anticipated increased EEE risk. Activities that may be undertaken in response to indicators of increased risk include:

- MDPH may release public health alerts throughout the season to remind the public of the steps to take to reduce their risk of exposure to mosquitoes. Local boards of health are encouraged to conduct their own outreach which should include information about personal prevention measures such as: avoiding outdoor activity during times of day, with increased mosquito activity; use of mosquito repellents containing an EPA-approved active ingredient; and use of clothing to reduce mosquito access to skin. These personal protective measures must form the basis of all risk reduction and the need to utilize them is not reduced by any mosquito control activities, including aerial spraying.
- Local municipalities may be encouraged to reschedule outdoor evening events to avoid the period between dusk and dawn which correspond to peak mosquito activity.

- For communities that participate in a local mosquito control district, MCPs may increase their source reduction activities to reduce mosquito-breeding habitats and to reduce adult mosquito abundance. This may include ground and aerial larviciding.
- For communities that participate in a local mosquito control district, after sustained findings of positive mosquito isolates, adult mosquito control efforts including targeted ground adulticiding operations should be considered, if not already in progress, where surveillance indicates human risk. The decision to use ground-based adult mosquito vector control will depend on critical modifying variables including the time of year, mosquito population abundance, and proximity of virus activity to populations.
- Other intensified efforts may be implemented following coordination between MDPH and other agencies including DEP, DAR, and DCR.
- If the risk for multiple human infections with EEE virus becomes widespread and involves multiple jurisdictions, MDPH will convene the SRMCB, MCPs, and MAG to get their recommendation for appropriate mosquito control interventions to reduce public health risk. The SRMCB will provide recommendations on appropriate pesticide(s), route(s), and means of treatment for specific areas. Interventions may include state-funded aerial application of mosquito adulticide. Assessment of the need for and utility of a focal or large-scale aerial application of mosquito adulticide includes evaluating evidence that the seasonal and biological conditions present a persistent risk of human disease, and that those same conditions permit the effective use of an aerially applied pesticide. Aerial applications cannot and do not eliminate risk and must not be viewed by the public or municipalities as a solution to EEE risk; aerial applications are one tool that can be used in conjunction with all other available risk mitigation tools.

VIII. EMERGING ARBOVIRUS ISSUES

A. Expanding EEE Virus Habitat

As indicated by virus activity surveillance, the geographic area of risk for EEE has increased outside the historical areas of southeastern Massachusetts. Human and animal cases have occurred in Essex, Franklin and Hampshire counties. EEE risk has also increased throughout New England; New Hampshire, Maine and Vermont have all detected unusual activity. Based on the surveillance data tracked by MDPH, there are communities outside of the Southeastern Region of the state that either do not belong to an established MCP, or do not have an MCP operating in their region, that are now at increased risk for EEE virus activity. Expansion of the current mosquito virus surveillance network is required to provide adequate surveillance data to assess the public's risk for arboviral diseases.

B. Introduced Mosquito Species

MDPH and the MCPs are taking proactive measures to conduct surveillance for mosquito species that are expanding northward, especially *Aedes albopictus*. *Ae. albopictus* is an aggressive mammal-biting species that was introduced to North America from Asia around 1985; it has been implicated in the transmission of arboviruses such as dengue, chikungunya, yellow fever, and Zika, where these viruses circulate. Where it occurs, this species is generally more abundant in urban areas, breeding easily in artificial containers, such as birdbaths, discarded tires, buckets, clogged gutters, catch basins, and other standing water sources. These mosquitoes are aggressive biters that actively seek out mammals, including humans, including during ***daytime*** hours, unlike the more familiar mosquito vectors for WNV and EEE. The adult mosquitoes are black with distinctive white stripes on their legs and thorax and are sometimes referred to as "Asian tiger mosquitoes". While *Ae. albopictus* has displaced native mosquito species across the southern US, its establishment in northern latitudes has been limited to date.

The range of *Ae. albopictus* is expanding into the Northeast likely due to changes in the climate and based on new surveillance data, there is evidence that focal *Ae. albopictus* populations can over-winter, particularly during mild winters or in protected environments such as tire piles, in Massachusetts. Surveillance specifically targeting the adult stage of this species in Massachusetts began in 2008. Beginning in 2014, MDPH and the MCP's began a more coordinated effort to systematically survey for the presence of *Ae. albopictus* in MA. This survey centers on areas and activities known to correlate with

Ae. albopictus introduction in other states. The targeted areas are closely monitored using traps specifically designed to capture both adult *Ae. albopictus* and their eggs. Adult *Ae. albopictus* are identifiable based on their distinctive appearance; eggs must be allowed to develop into the adult stage in captivity in order to identify the species. Surveillance for this invasive species of mosquito is critically important at this time and requires the continued collaboration and cooperation of all MCPs and MDPH.

Because these mosquitoes almost exclusively feed on mammals and not the bird species that serve as reservoirs for WNV and EEE, these mosquitoes are not expected to play a significant role in spreading either WNV or EEE. However, if large populations of this mosquito species become established in Massachusetts over time, as has been suggested may happen with changes in climate, it could eventually serve as a vector for other arboviruses that do not currently circulate in the area. See Table 3 for recommendations related to a phased response for surveillance and response to *Ae. albopictus* and Figure 4 for a map of communities with any finding of *Aedes albopictus* since 2009.

Control of *Ae. albopictus* is difficult once it is established although its flight range is quite limited at approximately 150 yards. Commonly used larval control measures include: environmental sanitation focused on the permanent elimination of containers producing *Ae. albopictus*; chemicals or biological agents used as larvacides to kill or prevent development of mosquito immature stages; and biological control which relies on aquatic predators. Both larvaciding and biological control measures are limited in efficacy due to the preference of this species for breeding in small containers. Identification and removal of non-essential containers (e.g. refuse and tires) and reduction and regular cleaning of useful containers (e.g. toys, bird baths, and gutters) are critical to reduce breeding sites and therefore mosquito populations. Because this species is most active during the day, mosquito control techniques employed during the dusk to dawn hours when local vector mosquito species are most active, will be less effective. The use of personal precautions such as avoiding outdoor activity in areas with increased mosquito activity, use of mosquito repellents containing an EPA registered active ingredient, and use of clothing to reduce mosquito access to skin must form the basis of all risk reduction, as they do for all mosquito-borne diseases.

Any identifications of *Ae. albopictus* will be reported to the LBOH and MCP by telephone and will be shared with the SRMCB and MAG by email. MDPH will work with the MCP, if there is one, to perform any necessary enhanced surveillance. Simply identifying the presence of the species in a particular area is not evidence of any immediate public health risk.

In the extremely unlikely event that a human case of dengue, chikungunya, Zika, yellow fever, or other non-endemic arbovirus is reported, and patient history does not include out-of-region travel, then surveillance for and testing of *Ae. albopictus* may be indicated in the area. If any virus of public health importance is identified from *Ae. albopictus* mosquitoes, both mosquito control and public health intervention measures may be necessary. Appropriate responses will be determined in collaborative efforts between state and local health and the Mosquito Control Projects.

Aedes aegypti, another important vector species for arboviral diseases, has been reported as far north as New York state, and its range may also be expanding northward; however, it has not been detected in Massachusetts. MDPH and MCPs will continue to be vigilant for the appearance of this, or any other invasive mosquito vector species.

C. Introduced or Emerging Arboviral Diseases

MDPH is continuing to work with its partner agencies to monitor for emerging arboviral diseases. Every year, some Massachusetts residents traveling abroad, become infected with mosquito-borne diseases such as dengue, malaria, chikungunya and Zika. Given the species of mosquitoes that are currently found in Massachusetts, it is very unlikely that these diseases will become established at this time.

However, the diagnosis of any arboviral disease in Massachusetts residents is reportable to the LBOH and MDPH (http://www.mass.gov/eohhs/docs/dph/cdc/reporting/rprtbldiseases-hcp.pdf) and requires public health investigation. If an investigation indicates that the disease was acquired locally (i.e. NOT

acquired through foreign travel), MDPH may test banked mosquito specimens for the presence of the virus and/or perform enhanced mosquito surveillance, alone or in conjunction with a local MCP, in order to assess the risk to public health. Specific surveillance and response activities will be situation dependent and will be determined drawing on the expertise of all partners. Specific public health risk messages will be developed, shared with local partners, and communicated to the public as indicated.

In addition, MDPH, as part of its routine surveillance, has the potential to test a portion of trapped and submitted mosquitoes with a non-specific screening test which, if positive, would trigger more specific testing to detect an introduced or emerging disease.

Testing for non-endemic arboviruses is not routinely performed at the Massachusetts State Public Health Laboratory. However, due to the recent emergence of Zika virus in Central and South America and the Caribbean, MDPH rapidly implemented human testing for dengue, chikungunya and Zika viruses. Developing the capacity to test for Jamestown Canyon in mosquitoes is being explored. Decisions to perform surveillance for any arboviral pathogen within local mosquitoes will be based on information indicating new or unusual activity and/or local environmental detection of mosquito vectors that could support new viral agents. This continues to be part of an ongoing risk assessment performed by MDPH and CDC's Arbovirus Surveillance Network.

Aerial Adulticide Application in Response to Threat of EEE
2017 Multi-Agency Response Flowchart

1. Determination of Response

- When human risk is elevated to a high level of concern as indicated by the MDPH Surveillance and Response Plan; DPH will determine, in consultation with Mosquito Control Projects, SRMCB, and the Mosquito Advisory Group whether aerial application is warranted.

2. Characterization of Area of Risk

- Once consensus is obtained, DPH characterizes the area of risk and delineates the perimeter of the spray area based on current surveillance information, habitat, areas of historical activity likely to contribute to current risk and known patterns of virus spread.
- DPH/BIDLS provides the GIS perimeter map to inter-agency collaborators as soon as possible.

3. Commissioner Certification

- DPH/BIDLS requests that the Commissioner of Public Health issue a "Certification that Pesticide Application is Necessary to Protect Public Health"

Action Items 4a-4c Occur Simultaneously:

4a. Determination of Appropriate Pesticide

- Prior to July 1 of each season, DPH/BEH and DAR will determine the type of pesticide to be used in the event that an aerial application will be warranted and obtain any EPA pesticide waivers, if necessary, for use in aerial application.
- In the event that aerial application is warranted, DPH/BEH and DAR will confirm this selected pesticide for use.

4b.Determination of No-Spray Zones

- Aerial no-spray zones (mosquito treatment sensitive areas data layers) defined:
  1) Certified organic farms
  2) Priority habitats for federally listed endangered and threatened species
  3) Surface water supply resource areas
  4) Commercial fish hatcheries/aquaculture
- DAR reviews any emergency waivers needed to use pesticides on school property and ensure compliance with pesticide laws.
- DAR/SRMCB will submit a 'Notice of Intent' to EPA to obtain an NPDES permit within 30 days of the aerial adulticide event.

4c.Exclusion/Inclusion of Priority Habitats:

- DPH will determine, in consultation with SRMCB, DAR, DEP, and DFW if spraying in mosquito treatment sensitive areas is necessary to protect the public health.
- If spraying in these areas is necessary to reduce the risk to public health then:
  - DPH requests a permit from DFW be issued to DAR for taking endangered, threatened, or special concern species.

4d. Spray Efficacy Monitoring

- DAR/SRMCB and MDPH initiates plans for standardized monitoring of pre- and post-spray mosquito activity as part of spray efficacy determination. MDPH may assist DAR/SRMCB with GIS mapping
- All agencies to follow procedures outlined in the SRMCB/Massachusetts Mosquito Control Surveillance Protocol for Evaluation of Efficacy of Aerial Adulticide Application Regarding Mosquito-Borne Disease(SRMCB Protocol, Appendix 3)
- SRMCB provides a report of the intervention that includes percent efficacy results (SRMCB SOP, p.23 'Assess Operation').

5. Preparation of Final GIS Data Map

- DAR coordinates compilation of mosquito treatment sensitive areas data layers (no-spray zones) developed by DAR, DFW, and DEP within designated DPH spray area into a final map.

6. Environmental Monitoring

- DEP, DAR, DFG and DPH/BEH notify partner environmental agency collaborators of planned environmental monitoring to provide opportunity for input/collaboration.
- DEP, DAR, and DPH/BEH and BIDLS initiate plans for pre-/post-monitoring for public drinking water reservoirs, honeybees, surface waters, and cranberries in designated spray area.

7. Emergency Room and Poison Control Contacts

- DPH/BEH contacts and provides pesticide illness surveillance protocols to emergency departments, poison control centers, and local health departments.

8. Notification of Date & Time of Application

- DAR and DPH provide public notices regarding the locations, dates, and times of aerial spraying.
- DAR will maintain a website with GIS maps of the aerial spray area and will update this site daily during spray operations.
- DPH will provide recorded hotline information regarding the spray zone, precautionary measures, and telephone numbers to report fish kills or other environmental impacts.

9. Operational Procedures-Aerial Application

- DAR/SRMCB initiates aerial spray operations using collective guidance and consensus developed through multi-agency, cross-secretariat process.
- The aerial application operational procedures are followed as described in the SRMCB Operational Response Plan.

DPH- Department of Public Health
BIDLS- Bureau of Infectious Disease and Laboratory Sciences
BEH- Bureau of Environmental Health

DAR- Department of Agricultural Resources
SRMCB- State Reclamation and Mosquito Control Board
DFG- Department of Fish and Game
DFW- Division of Fisheries and Wildlife

Table 1. Guidelines for Phased Response to WNV Surveillance Data

Risk Category	Probability of locally acquired human disease	Definition of Risk Category for a Focal Area[1]	Recommended Response
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 Definitions: ***Sporadic*** WNV activity- when 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. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., the elderly). 3. Passive human and horse surveillance. 4. Public health alert sent out by MDPH in response to first WNV virus positive mosquito pool detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 5. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans. For localities participating in local mosquito control projects: 6. Assess mosquito populations, monitor larval and adult mosquito density. 7. Routine collection and testing of mosquitoes. 8. Initiate source reduction; use larvicides at specific sites identified by entomologic survey. In making a decision to use larvicide consider the abundance of *Culex* larvae, intensity of prior virus activity and weather. 9. Locally determined, standard, adult mosquito vector control activities are implemented. No specific supplemental control efforts are recommended.

[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	WNV - Moderate	Current Year 1. Sustained or increasing WNV activity in mosquitoes in the focal area. OR 2. One confirmed animal or human case Definitions: ***Sporadic*** WNV activity- when 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.	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. 2. Local boards of health are contacted via phone or HHAN (Health and Homeland Alert Network) upon confirmation of WNV in any specimen. Advise health care facilities of increased risk status and corresponding need to send specimens to the MA SPHL for testing. 3. Supplemental mosquito trapping and testing may be performed in areas with positive WNV findings. For localities participating in local mosquito control projects: 4. Increase larval control and source reduction measures. 5. If not already in progress, standard, locally determined adult mosquito vector control efforts including targeted ground adulticiding operations should be considered against *Culex* mosquitoes and other potential vectors, as appropriate. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to populations.
3	WNV - High	Current year 1. Multiple isolations during the same week from the focal area plus at least one multiple meteorological or ecological conditions (such as above average temperatures, dry conditions, or larval abundance) associated with increased abundance and increased risk of human disease. Or 2. 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 public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, etc.) and educate them on personal protection and avoiding outdoor evening events. c. Advisory information on pesticides provided by MDPH Bureau of Environmental Health. 2. Intensify and expand active surveillance for human cases. For localities participating in local mosquito control projects: 3. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito control. 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	An excessive number of human cases clustered in time and space AND evidence that 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 4, plus: 1. MDPH will confer with local boards of health, the SRMCB and Mosquito Control Projects to discuss the need for additional interventions. 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.

Table 2. Guidelines for Phased Response to EEE Surveillance Data

Risk Category	Probability of locally acquired human disease	Definition of Risk Category for a Focal Area[2]	Recommended Response
1	EEE - Remote	All of the following conditions must be met: Prior Year 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. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., children and the elderly). 3. Passive human and horse surveillance. 4. 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. 5. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans. For localities participating in local mosquito control projects: 6. Assess mosquito populations, monitor larval and adult mosquito density. 7. Routine collection and testing of mosquitoes. 8. Initiate source reduction; use larvicides at specific sites identified by entomologic survey. In making a decision to use larvicide consider the abundance of *Culex* larvae, intensity of prior virus activity and weather. 9. Locally determined, standard, adult mosquito vector control activities are implemented. No specific supplemental control efforts are recommended.

[2] 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	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 cases. Definitions: ***Sporadic*** EEE activity- when 1-2 mosquito isolates are detected during non-consecutive weeks within one focal area. ***Sustained*** EEE activity- when mosquito isolates are detected for 2 or more consecutive weeks within one focal area.	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. For localities participating in local mosquito control projects: 2. Increase larval control and source reduction measures. 3. Locally established standard adult mosquito vector control activities continue.
3	EEE - Moderate	Prior Year Sustained 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 Current year 1. Sustained 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 and thus likely to increase the risk of human disease AND 4. No confirmed animal or human EEE cases in current year	Response as in category 2, plus: 1. Outreach and public health educational efforts are intensified including media alerts as needed. 2. Public health alert sent out by MDPH in response to first pool of EEE positive mammal-biting mosquitoes detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 3. HHAN (Health and Homeland Alert Network) alerts or phone calls are provided to local boards of health upon confirmation of EEE in any specimen; advise health care facilities of increased risk status and corresponding needs to send specimens to the MA SPHL for testing. 4. Supplemental mosquito trapping and testing in areas with positive EEE findings if MDPH resources allow. Notify all boards of health of positive findings. For localities participating in local mosquito control projects: 5. If not already in progress, standard, locally established adult mosquito vector control efforts including targeted ground adulticiding operations should be considered where surveillance indicates human risk. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations. 6. 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. 7. Supplemental mosquito trapping and testing in areas with positive EEE findings. Notify all boards of health of positive findings.

4	EEE - High	Current Year 1. Sustained 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 3. Sustained or increasing EEE activity in mosquitoes plus multiple meteorological or ecological conditions (rainfall, temperature, seasonal conditions, or larval abundance) associated with elevated mosquito abundance and thus very likely to increase the risk of human disease. AND 4. No confirmed animal or human EEE cases in current year	Response as in category 3, plus: 1. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, schools, workers employed in outdoor occupations, etc.) and educate them on personal protection c. Advisory information on pesticides provided by MDPH Bureau of Environmental Health. d. Urge towns and schools to consider rescheduling outdoor, evening events.† 2. For localities participating in local mosquito control projects, intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito vector control. 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. 3. Active surveillance for human cases is intensified. Health care facilities are advised of increased risk status and corresponding needs to send specimens to the MA SPHL for testing. 4. Local officials should evaluate all quantitative indicators including population density and time of year and may proceed with focal area aerial adulticiding. 5. MDPH will confer with local health officials, SRMCB and MCPs to determine if the risk of disease transmission warrants classification as level 5. 6. MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods. If elevated 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.

† See Appendix 2 for schedule of recommended cancellation time for use

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.

† See Appendix 2 for schedule of recommended cancellation time for use

Table 3. Guidelines for Phased Response to *Aedes albopictus*

Risk Category	Definition of Risk Category	Recommended Response
1	No identification of *Aedes albopictus* activity in a given area	-MDPH, SRMCB and MCDs identify areas proven to serve as routes of entry for *A. albopictus* (examples: shipping ports, tire recyclers, etc.) -Coordinate surveillance in these areas
2	Isolated or intermittent identification in a given area of adult *Aedes albopictus* likely to represent introduction or repeated reintroductions	-Continue or expand surveillance -Submit any adult mosquitoes for storage and possible testing at the MA SPHL as the situation warrants -Work with LBOH to identify possible habitat/potential breeding sites and initiate clean-up as necessary
3	Consistent findings of adult *Aedes albopictus* or evidence of possible overwintering	-Submit any adult mosquitoes for storage and possible testing at the MA SPHL as the situation warrants -Expand surveillance to detect extent of geographic distribution -Work with LBOH to identify possible habitat/potential breeding sites and initiate clean-up - Educational efforts directed to the general public on personal prevention steps and source reduction -DPH consultation with MCDs, SRMCB, and MAG to assess and evaluate the need for larvaciding or adulticiding interventions

Figure 1: Municipality of Residence of West Nile Virus Human Cases, 2001-2016

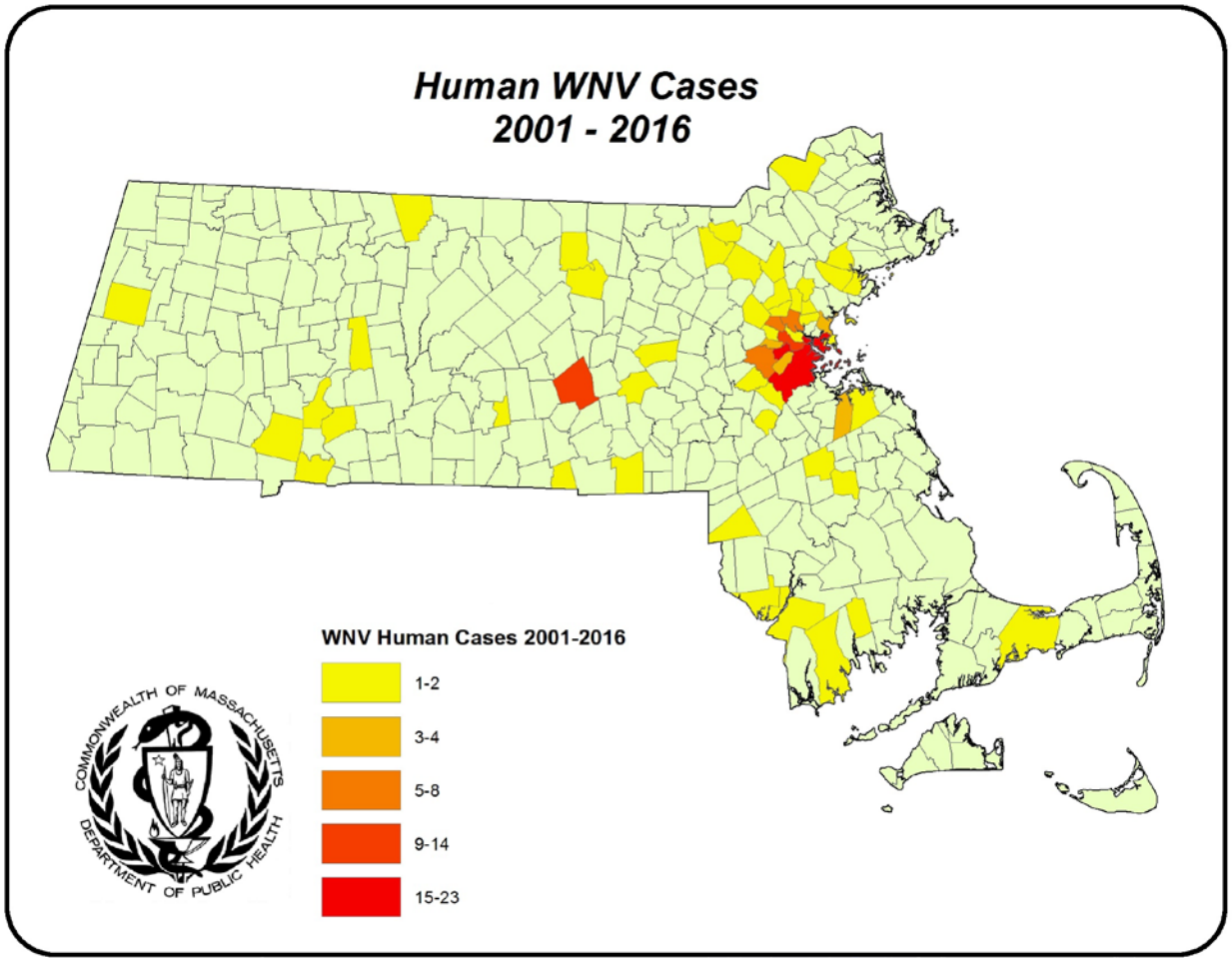


Figure 2: Location of MDPH Long-Term Mosquito Trap Sites

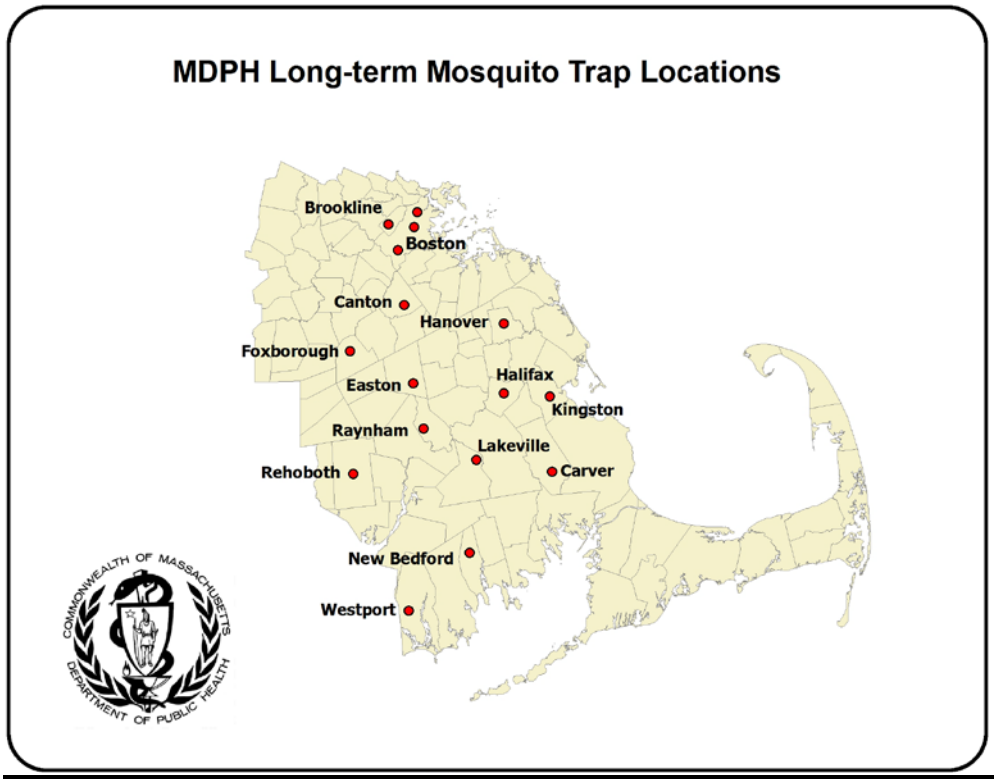


Figure 3: Month of Symptom Onset of WNV and EEE Human Cases in Massachusetts, 2000-2016.

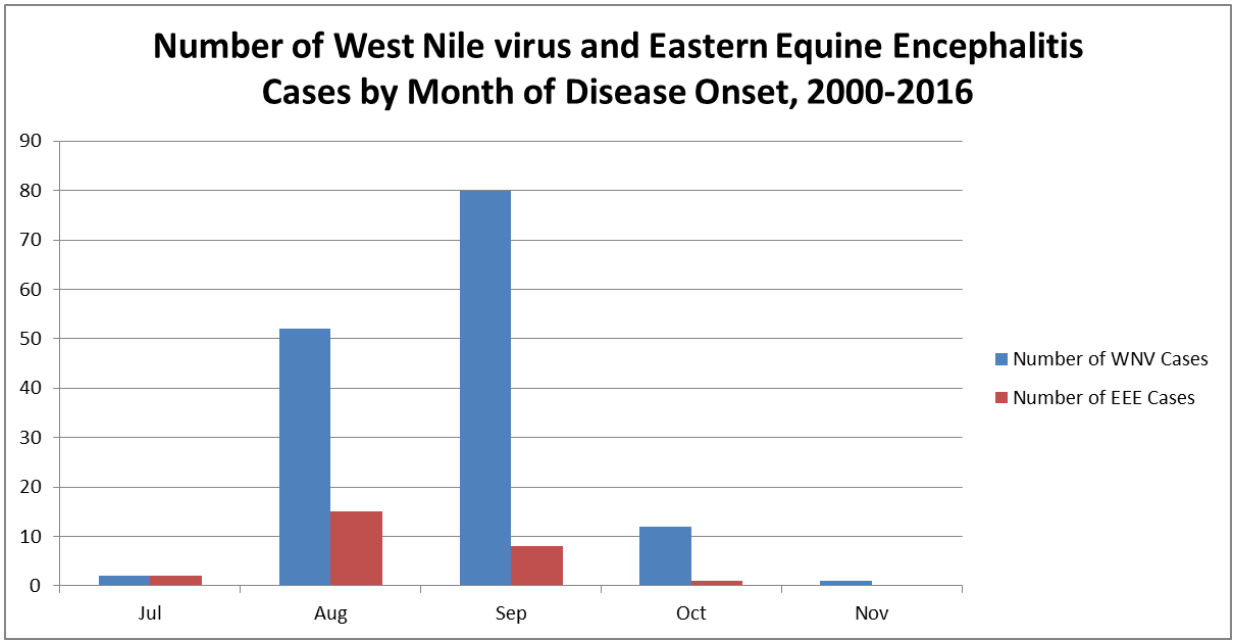
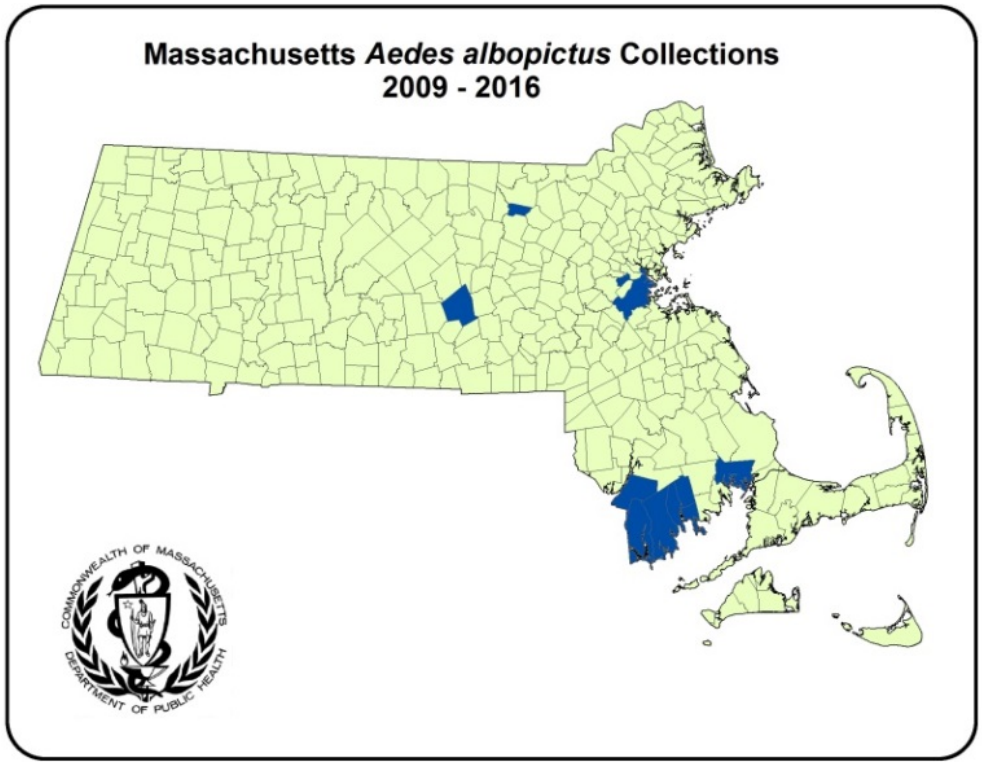


Figure 4: Location of *Aedes albopictus* collections, 2009-2016



Appendix 1: Mosquitoes Associated with Arboviral Activity in Massachusetts

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 an epizootic (bridge) vector of eastern equine encephalitis (EEE) virus.

Coquillettidia perturbans - Cattail marshes 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 an epizootic (bridge) vector of EEE virus.

Culex pipiens – Artificial containers 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 in man-made structures. *Cx pipiens* is the primary vector of West Nile Virus (WNV).

Culex restuans – Natural and artificial containers are the preferred larval habitat of this mosquito. It feeds almost primarily on birds but has been known to bite humans on occasion. This species is typically collected from May to October but can be found year round as it readily overwinters 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 in natural and man-made structures. *Cx salinarius* may be involved in the transmission of both WNV and EEE.

Culiseta melanura –White cedar and red maple swamps are the preferred larval habitat of this mosquito. It feeds almost exclusively on birds. This species is typically collected from May to October. *Cs melanura* is the primary enzootic vector of EEE.

Ochlerotatus 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. *Oc canadensis* is an epizootic (bridge) vector of eastern equine encephalitis EEE virus.

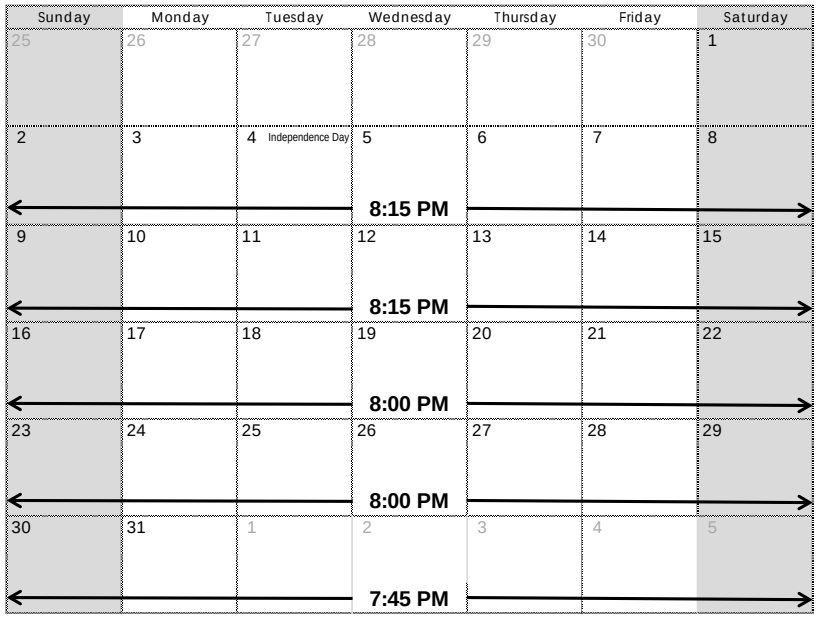
Ochlerotatus japonicus – Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is an aggressive human biter. This species is typically collected from May to October. *Oc japonicus* may be involved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

APPENDIX 2: RECOMMENDED CANCELLATION TIMES FOR OUTDOOR ACTIVITIES IN AREASOF HIGH RISK FOR EASTERN EQUINE ENCEPHALITIS (EEE)

The types of mosquitoes most likely to transmit EEE infection are likely to be out searching for food (an animal to bite) at dusk, the time period between when the sun sets and it gets completely dark. **The exact timing of this increased activity is influenced by many factors including temperature, cloud cover, wind and precipitation and cannot be predicted precisely for any given day**. Here, the approximate time of sunset was used to establish standardized recommendations for cancellation times of outdoor activities during periods of high EEE risk.

This does not eliminate risk nor does it alleviate the need for the use of repellants or clothing for protection from mosquitoes.

JULY 2017



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SEPTEMBER 2017

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