Commonwealth of Massachusetts

STATE RECLAMATION AND MOSQUITO CONTROL BOARD

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Best Management Practice Plan

North Andover

Draft: 12/29/00; Revised: 3/01 3/04 11/04 6/7/06 1/07 1/08 1/09 1/10 1/11 1/12 4/13 3/14

Mosquito/Arbovirus Surveillance Summary

Introduction

Fifty-one species of mosquitoes are found in Massachusetts, a small fraction of the over 3,000 species found worldwide. The majority of them, fortunately, do not bite humans. However, for those that do, their threat to public health cannot be ignored. Their notorious biting activity aside, it is their ability to infect with viruses causing debilitating and life-threatening illnesses that is our greatest concern. Diseased individuals can often take weeks to months to years convalescing, demanding great medical attention and costs towards a recovery that may not be realized. Many of the ill die.

Infections occur as people engage in normal "innocent" outdoor summer activities. Thus, it becomes crucial that mosquito activity and abundance are monitored and addressed to help protect a community's health and economy. This is especially true now with changes in climate being experienced, which may enhance the spread and severity of mosquitoes and/or the viruses they transmit. Vigilance on mosquitoes is the mission of the Northeast Massachusetts Mosquito Control and Wetlands Management District. We possess the expertise to track mosquito populations, the protocols to collect and have mosquitoes tested for viruses, and the experience and equipment to manage disease-carrying populations.

Mosquito control has evolved in northeast Massachusetts from exclusively "nuisance control" to primarily "vector management". Surveillance and control strategies have been designed to identify, monitor, and regulate mosquito carriers (or "vectors") of the principal arboviruses. "Arboviruses" comes from "**ar**thropod-**bo**rne **viruses**"; in northeast Massachusetts they include West Nile virus (WNV) and Eastern Equine Encephalitis virus (EEEV). See the accompanying 2014 Vector Management Plan (VMP) that describes our tactics and strategies for monitoring and responding to the mosquitoes transmitting the aforementioned viruses.

The **Best Management Plan** presented here begins with summaries of mosquito and arbovirus activity this past season in both the District and your community. This will be followed by an operational summary, then preliminary plans (and costs) for surveillance and control in your municipality, as agreed upon with your Board of Health, for 2014.

Northeastern Massachusetts

The Northeast Massachusetts Mosquito Control and Wetlands Management District has thirty-two subscribing municipalities, thirty in Essex County and two in Suffolk County. Data on mosquito populations and diversity come from at least one fixed "historical trapping station" (HTS) set at each member municipality. Two types of traps are employed at each HTS and the same location is used every year. Two collections per week are made from all the HTS's.

Surveillance is supplemented when the presence and transmission of EEEV becomes of great concern. "Resting box" traps (RBx) are employed at fixed locations in habitats where EEEV is either suspected or has been found in the recent past. Collections are made from these boxes twice a week, as well. When necessary, temporary traps are set at various locations in selected municipalities throughout the season. This is done when vector species are assumed to be in greater abundance and/or dispersal as well as when presence of viruses is suspected. These temporary traps are designed for one or two-day collections and may be deployed primarily in residential, school, and public-use areas. Descriptions and photographs of all the traps employed can be found in the accompanying 2014 VMP.

We wish to remind readers that the objective of surveillance is to collect a **representative sample** of mosquitoes in a city or town, not collect every mosquito possible or collect only from known breeding areas! We trap in areas where substantial portions of municipality residents live because, in addition to sampling species and their populations, we need to determine whether these mosquitoes are transmitting viruses dangerous to people. It is true that human impact on natural mosquito-breeding habitats may dramatically lower their populations but, if there is an unusual abundance in populations in residential areas, then you know something indeed is going wrong!

The 2013 mosquito surveillance season lasted from 13 May through 9 October, for a total of 22 weeks. In addition to collections from HTS's and RBx's, temporary traps were set around the District in numbers greater than any previous year. All mosquitoes collected were identified and tallied; key species were separated and sent to the State Lab to be tested for presence of WNV and EEEV. More mosquito samples or "pools" were sent in 2013 for testing than any previous year (1,314 pools); do not confuse a "mosquito pool" with a small body of water called a "pool" (we do not invent the terms!).

This past season was **again** one of the most unusual ever experienced by our program. While the District was in the throes of a drought for most of the spring and summer, more mosquitoes were collected in our HTS traps than any previous year since the current surveillance protocols were instituted in 2002. Since more vector species collected in 2013, more virus-infected mosquitoes were detected, also more than any previous year! And finally, in the District were three human cases of encephalitis of some form caused by infections with WNV (one each in Haverhill, Salem, and Revere); no human cases of Eastern Equine encephalitis were reported.

Nearly 80,000 mosquitoes were collected in our HTS's in 2013, while only 49,000 were collected in 2012 and 78,000 in 2011. Twenty-five District municipalities experienced significant (i.e., greater

than 10%) increases in populations as compared to 2012 numbers. In a nutshell, there were two reasons for the 2013 increases recorded. There was an "explosion" of mosquitoes in June and July resulting from the abundant rains that fell in June. These were species that usually emerge in late April and May (i.e. "Spring Brood"), but were delayed until late June and early July; developing and emerging in more favorable environmental conditions allowed more "Spring brood" mosquitoes to appear. Secondly, salt marsh mosquitoes emerged in numbers not experienced for years. Nearly 30% of all mosquitoes collected at all our HTS's in 2013 came from just one HTS in Newbury (the HTS abuts the expansive salt marsh).

Although the winter of 2012-13 was plentiful with snow, the spring drought afterwards did not allow for the snow-melted water to accumulate in the environment. The unfurling of leaves by trees then took most of the remaining standing water. For early spring-hatching mosquito larvae, their "breeding sites" became bare prior to completing their development. Thus, far fewer of these "Spring Brood" mosquitoes were present. Only after heavy rains in June that flooded breeding sites was there ultimately a major emergence of these mosquitoes. "Spring Brood" mosquitoes include those we call "Floodwater mosquitoes", such as ***Aëdes vexans*** and ***Aë canadensis***, which can emerge later in the season when rain events flood dried areas. There were never significant regional-wide rain events for the rest of the summer to thoroughly flood breeding sites (in both in amount and persistence of standing water). Thus, these species were relatively rare for the remainder of the summer. ***Aë. vexans*** is both a bird-biting (from whom the mosquito can acquire these viruses) and human-biting species. With dramatically reduced populations of ***Aë. vexans*** during the peak virus-transmission season (August through September), a competent vector of both WNV and EEEV was **not** present in numbers to generate public health concerns.

The greatest increases seen in any group of mosquitoes were in salt-marsh mosquitoes. There are three species known to be primarily salt marsh-breeding mosquitoes, ***Aë. cantator*** ("Brown salt marsh mosquito"), ***Aë. sollicitans*** ("White-banded salt marsh mosquito"), and ***Aë. taeniorhynchus*** ("Black salt marsh mosquito"). One contributing factor to the observed increase was a change in 2013 of the location of the Rowley HTS (now closer to the salt marsh) which resulted in many more salt marsh species collected. However, huge increases were recorded at the two Newbury HTS's and the location of these traps had not changed for 2013. ***Aë. cantator*** increased in the District by over 300%; ***Aë. sollicitans*** increased by over 750%. Although it is too early to assume that these changes in population and distribution are the result of "climate change", something may be going on that is favoring the reproduction and spread of these species. But again, populations of all living things periodically experience dramatic rises as well as precipitous declines as part of their natural histories. Although they are principally mammal-biters, specimens from two of these species **(*Aë. sollicitans* & *Aë. taeniorhynchus*)** were reported from Norfolk County infected with WNV meaning that they acquired the infection by biting infected birds. The degree of the ability of this species to transmit WNV has yet been fully investigated.

We continued our aerial salt-marsh larvicidal applications in 2013. The bacteria ***Bacillus thuringiensis*** was applied to the salt marsh uplands immediately after the monthly spring tides, but only when larval sampling indicated that newly-hatched populations were extremely abundant. Three aerial helicopter applications were made in 2013, followed by selected localized hand-treatments where necessary. Applications were made at designated locations from Ipswich through Salisbury where historically, the bulk of adults have emerged. However, the overabundance of mosquitoes collected at the Newbury traps may indicate that these species may become better at exploiting potential new breeding sites. More areas may need to be treated, but these sites may be inaccessible to either helicopter (too much arboreal vegetation prohibiting effective dissemination of product) or hand-treatment (areas difficult to access by foot) or both.

Aë. cantator, is not only currently the dominant salt marsh mosquito in Essex County, but continues to be found in more of our traps away from the salt marsh. They can fly at some distance from the salt marsh in search of blood, but they can also "breed" in more locations away from salt marshes. Their larvae develop in water anywhere from less brackish to almost pure freshwater, thus they can expand their range deep into Essex County.

While ***Aë. taeniorhynchus*** numbers trapped remained very small, they were seen more often and in more traps than ever before. For many years, not a single specimen of ***Aë. taeniorhynchus*** was collected anywhere in the District and now they are becoming more present in both our HTS and temporary salt marsh traps. This species is another notorious human-biter and is found great abundance from south of Cape Cod all the way down the Atlantic and Gulf coasts.

Another species historically associated with the salt marsh is ***Culex salinarius*** ("Unbanded salt marsh mosquito"). Although it will "breed" at the upper reaches of salt marshes, it can develop in practically any type of standing freshwater. There was a marked increase (almost 80%) in the total numbers for this species District-wide; the increases were seen chiefly in those communities with abundant wetland habitats (both freshwater and brackish). This species is of great concern because it is considered to be the best vector of WNV in the northeast United States.

There was a collection of a single specimen of another species that was a complete surprise; this species is normally found in the southern, western, and mid-western portions of the U.S. This was ***Culex tarsalis***, also known as the "Western Encephalitis mosquito"; it was collected on Pine Island in Newbury. It was the first of this species collected in Massachusetts! In its native habitats, it can develop in almost every kind of standing freshwater habitat and their larvae can tolerate even heavily polluted waters. It is too early to determine whether the observation of this species in Massachusetts was an accidental once-only appearance or the start of an "invasion". The specimen appeared "fresh" or "newly-emerged", so it's presence was not due to it being transported from a distant location as an adult inside a vehicle of some sort. It may instead have developed in water accumulated in a boat that had traveled up the coast from the southern U. S. We will continue to monitor our trap collections for this and any other species that are "not supposed to be found" in Massachusetts.

Another species whose spread into Massachusetts may be influenced by "climate change" is the Asian tiger mosquito, ***Aë. albopictus***. It continues to be repeatedly found in Bristol county, although infrequently and in very low numbers. It has not yet become established in Massachusetts and has been found only because its eggs are being transported via used tires coming from ***albopictus***-infested areas of the country. Upon arrival, the tires fill with rainwater, the eggs hatch, and larvae develop into adults. Several adult specimens were found in Merrimac on only one occasion in 2007. This species is a ferocious human-biter and is an efficient vector for several arboviruses, including Dengue and Chikungunya viruses. It had been assumed that Massachusetts winters were too cold for its hibernating eggs to remain viable. However, if subsequent winters are similar to previous recent winters, hibernating eggs may survive and ***Aë. albopictus*** may become a permanent resident in Massachusetts.

While Dengue and Chikungunya viruses are "normally" found circulating in the more tropical/ milder temperate regions of the world, it was announced in November 2013 that a man on Long Island NY, **with no travel history**, was recent found infected and sickened with Dengue. In November and December 2013, Chikungunya virus, historically restricted from East Africa around the Indian Ocean basin to Southeast Asia, was found for the first time in the Western Hemisphere; human cases were diagnosed in islands in the eastern Caribbean. In both regions with new

infections, the vectors present were ***Aë. aegypti*** and ***Aë. albopictus***! More information on these viruses can be found in our 2014 VMP.

Tree-hole and other natural-container breeding mosquitoes (mammal biting ***Aë. japonicus*** and ***Aë. triseriatus***) remained at low levels throughout the District in 2013. Freshwater Anopheline mosquito (***Anopheles punctipennis***, and ***An. quadrimaculatus***), notorious mammal-biting species continued to remain at low levels as well. All these species are more common in suburban to rural areas rather than urban habitats.

Historically, salt marsh mosquitoes were the dominant mosquito species in northeast Massachusetts. However, since the introduction of our salt marsh aerial larvicide program in the 1980's, the presence of salt marsh mosquitoes has been dramatically reduced. Now, the most abundant mosquito species in the District is the Cattail swamp mosquito, ***Coquillettidia perturbans***. It is a species that not only "breeds" in cattail swamps but also in similar standing freshwater habitats, which are of great abundance in the District. It is a large aggressive day- and night-time human-biting species most prevalent from late June through the middle of August. Adult females lay their eggs on surface water in areas of heavy emergent vegetation. At the end of the summer, the larvae hatch, submerge, and attach themselves to aquatic vegetation (to breathe!); they slowly grow throughout the winter. By late spring, they complete their development and emerge in numbers analogous to the number of stars in the universe (okay, this writer exaggerate only a little!)!

Overall populations of ***Cq. perturbans*** recorded in 2013 remained basically unchanged from 2012 numbers. As reported earlier, 2013 (as was 2012) was a drought year. Lack of sufficient spring rains **should** have resulted in fewer, smaller habitats available for successful development; this is a species whose larval survival is dependent heavily on local hydrology to provide a stable habitat. The result **should** have been a noticeable decrease in their overall populations. Instead, their populations District-wide remained the same! In fact, large increases were observed in nine municipalities, the biggest "catch" being at the HTS in Newbury! While the Newbury traps are situated along the salt marsh, there are abundant freshwater wetlands in the vicinity to "give rise" to these mosquitoes. As this writer often informs salt marsh residents, sometimes the biggest mosquito problems in the salt marsh are NOT salt marsh mosquitoes!

At the same time, there were some dramatic reductions in populations of ***Cq. perturbans*** in other municipalities, which is what was expected to be observed in a drought year. Why this observation was not consistent throughout the District is not fully known. One guess, presented in last year's summary, was that the swamps that "bred" these mosquitoes were consistently flooded. If this is the case, what can be causing the persistent flooding? One answer may be beaver impoundments which have increased in abundance and distribution in the District in the past decade.

Apart from its ferocious biting activity, ***Cq. perturbans*** can become infected with and transmit WNV and EEEV. Their numbers usually drop significantly after the middle of August, which is usually when arbovirus "activity" becomes high (i.e., more vector mosquitoes transmitting more virus). However, we have been noticing a trend in the past several years in which more ***Cq. perturbans*** are present into late August and early September. With another potential vector species in abundance, that prefers humans even more than the usual WNV and EEEV vectors, the probability of more human infections occurring now increases.

Beaver impoundments may also be creating or bolstering woodland swamps where the EEEV vector, ***Culiseta melanura***, readily breeds. Overall, the populations of ***Cs. melanura***, the Cedar swamp mosquito, increased this year, which was a surprise given the season-long drought. These

mosquitoes normally survive the winter as larvae (living inside crypts in swamp tree hummocks); when water levels reduce, the crypts dry and larvae within die. This explains the low numbers of adult ***Cs. melanura*** recorded this year at most of the resting box traps set at the preferred habitats (at or near cedar and red maple swamps). However, in 2013 at two locations (in Hamilton and Boxford) were ***Cs. melanura*** collected in numbers greater than last year. And at a third location, in Topsfield, the numbers trapped **increased dramatically in August**, after being very low throughout most of the year. The Hamilton and Topsfield locations were also the same locations where mosquitoes infected with EEEV and WNV were obtained. We have tried to inspect the vicinity of these sites to determine if beaver impoundments are contributing to favor the breeding and development of ***Cs. melanura,*** but access and mobility into these areas have been difficult.

The greatest mosquito-related public-health concern during a season-long drought is the abundance of ***Culex pipiens*** and ***Cx. restuans***. These two species are the principal vectors of WNV in the District; they may be the principal vectors of EEEV to humans in the District as well. It has been known that these species exhibit often "explosive" population increases during prolonged droughts and excessively warm summers; this scenario has been repeatedly observed in the District in the past thirteen years. And as their populations "skyrocket", also increasing are collections of infected mosquitoes. Such was the case in 2013 when both collections of these vectors and of virus detections were the highest ever in the history of mosquito control in Northeast Massachusetts! There were over 18,000 specimens of these species collected (nearly 20% of all mosquitoes trapped) and there were seventy-seven infected WNV-mosquito pools recorded in the District in 2013!

These two species "breed" in stagnant water. The more polluted with organic debris is the water, the more attractive the water is to egg-laying females. Eggs are deposited upon the water's surface and when they hatch, larvae encounter plenty of bacteria to eat. That rank, putrid, and foul organic water can be in found along drying pools and ponds, as well as in a variety of water-holding containers, whether natural or artificial. Water-filled artificial containers proven most favorable for breeding these ***Culex*** species include:

- ignored bird baths,
- discarded tires in unkempt backyards,
- leaf-clogged rain gutters,
- uncovered abandoned swimming pools,
- improperly folded tarps and plastic bags,
- upright kiddy swimming pools,
- forgotten rain barrels, and
- larger structures such as catch basins and retention ponds.

Often during a long drought, just enough rainfall may occasionally refill containers, but not wash the contents away. Thus the polluted containers are replenished to support further breeding. This was the case in 2013 that resulted in both unprecedented numbers of these mosquitoes and WNV detections.

The populations of ***Cx. pipiens*** and ***Cx. restuans*** increased in twenty-five of the District's thirty-two municipalities in 2013. The greatest abundance recorded for these species were the highly urbanized municipalities found along the southern portion of the District (basically from Salem south to Winthrop). However, in the more suburban to rural communities, these species were also found in great abundance, for examples, in North Andover and Newbury. Although mostly suburban, North Andover has an "urbanized" center with plenty of artificial containers beside catch basins, including a multitude of houses with clogged rain gutters and backyards with water-collecting debris, all which

are easily exploited by these species. On the other hand, Newbury has no such population center and besides, the HTS were located adjacent to the salt marsh and yet, these traps were often much filled with these species. Since most of these species were recorded after the June rains, it can be deduced that in wooded areas near salt marshes, there were plentiful pockets of standing freshwater (soon became putrid and "organic"). These in turn became the "breeding habitats" most advantageously exploited by these species. This is yet another example of how these species can take advantage of favorable conditions presented in habitats which are not usually primary breeding areas.

Not everywhere in the District were excessive numbers of these ***Culex*** mosquitoes encountered! We felt that decreases seen in some towns were due in large part to the District's aggressive season-long campaign to treat the catch basins with larvicides ("kill or retard larvae"). Depending on agreements between the District and individual municipalities, the larvicidal agents employed were formulations of either a "mosquito hormonal analog" or bacteria. The hormone is similar to one produced by insects, called juvenile hormone, that in high concentrations keep larvae from maturing into adults. The bacteria used were either the same as those used in our aerial salt marsh application or of a closely related species, ***B. sphaericus***, or formulations of both. The operational section of this BMP will discuss the use of these agents in some detail.

We believe that in normal rainfall years, the greatest source for breeding of these ***Culex*** species in Northeast Massachusetts are the catch basins. On average, 50,000 to 55,000 basins are treated annually, as they were in 2013. However, not all basins were treated at the same time. First, we prioritized basin treatments to those communities with historically more abundant WNV detections. Secondly, treatments were done after basins were cleaned by the respective municipalities; larvae-killing bacteria do not work effectively in basins are excessively polluted. Thirdly while more basins could be treated by more workers, state law mandates that treating basins with these larvicidal agents can only be done by licensed personnel. Although the materials applied are either bacterial or hormonal-analog, these products are considered by the state to be "pesticides" and "chemicals" and thus, are subject to state regulations regarding application of chemical agents. Municipal employees and non-licensed mosquito control seasonal employees cannot treat catch basins, thus the number of personnel available for such applications is further reduced.

Nonetheless, as it has been stated in previous BMP summaries, even if all the basins were treated, the treatments alone will not keep ***Culex*** populations down during droughts. The heavy rains during June and subsequent occasional rainfalls kept flooded all the other aforementioned containers, and allowed mosquito development to continue. And drying natural bodies of water, whether standing or flowing, eventually became stagnant breeding grounds for these species.

Finally, low populations of potential vectors will **NOT** guarantee that human infections will not occur. The best example was Revere in 2013. Revere has had WNV-infected mosquitoes detected in five of the previous seven years. After numerous weekly detections of WNV in 2012, this city was heavily larvicided and adulticided with the result that relatively few mosquitoes survived that summer. With additional larvicidal treatments in 2013, far fewer ***Culex*** mosquitoes were collected at the HTS (reduced by nearly 80%), as well as in temporary traps set through the city during the peak of virus transmission (early September). Even with dramatically reduced vector populations, Revere still had a human WNV-infection! The public needs to realize that with all the mosquito control measures implemented and vector populations reduced, there is **always** risk for human infection, at least for the foreseeable future.

Although the following accounts have been presented in previous BMP summaries, they bear repeating! These two ***Culex*** species primarily feed off infected birds to acquire the viruses.

However, ***Cx. pipiens*** in particular can also feed off humans. If an infected female mosquito (its only females that seek blood) bites a person, that person will get infected. How sick that person will become depends on his or her age and their immune system's health status. Most infected people with WNV will not exhibit any symptoms (we are still not sure if the same can be said for people infected with EEEV). However, people younger than five years and older than fifty as well as people whose immune systems have been "challenged" or "compromised" (i.e., not in peak health) are at much greater risk of becoming diseased. Diseased WNV-infected people will exhibit symptoms ranging from a severe fever to neurological ailments manifesting as some form of encephalitis. Although the viruses are different, both operate in the same manner and cause similar symptoms and fatalities.

For the remainder of this report, we will focus on the arboviruses. This was the third consecutive season of intense arboviral activity throughout the District. However, whereas in 2011 the virus encountered was only WNV, in 2012 and 2013 both WNV and EEEV were detected (see maps below). There were also three human cases of encephalitis in 2013 caused by WNV (in Haverhill, Salem, and Revere).

1,314 mosquito samples ("pools") were sent to MA DPH for testing in 2013, surpassing the 1,038 pools sent in 2012 and 1,001 pools sent in 2011. This year's pool submissions were the most this District has ever sent for testing and the most sent by any mosquito control project in Massachusetts. A "pool" consists of anywhere between two to fifty mosquitoes of a single species of mosquito taken from a single location on a specific date. With regards to our pools:

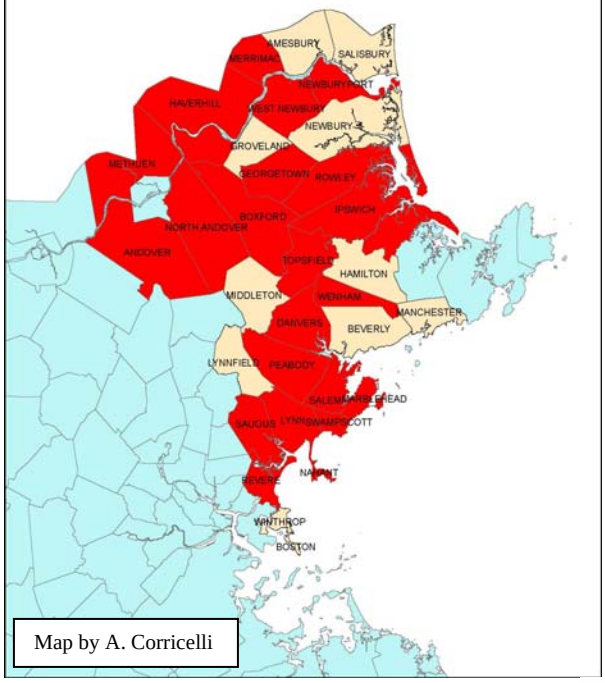
- A total of **eighty-one** infected pools were collected in 2013, whereas sixty infected mosquito pools were collected in 2012, and fifty-six in 2011. Seventy-eight of these infected pools came from Essex County and the remainder came from Winthrop, which is in Suffolk County. There were seventy-seven pools that tested positive for WNV and four tested positive for EEEV.

- Twenty-eight of the District's thirty-two municipalities had one or both viruses detected (**the most municipalities with virus ever collected**). Twenty-four municipalities had only WNV detected and four municipalities had both WNV and EEEV collected. The municipalities with infected mosquito pools (number of pools in parentheses with red numbers being WNV pools and blue being EEEV pools) include:

  Amesbury (**1, 1**), Beverly (**5**), Danvers (**1**), Georgetown (**2**), Groveland (**3**), Hamilton (**2**), Haverhill (**4**), Ipswich (**1**), Lynn (**9**), Lynnfield (**5**), Manchester (**1**), Marblehead (**1**), Merrimac (**3, 1**), Methuen (**4, 1**), Middleton (**5**), Nahant (**1**), Newbury (**1**), Newburyport (**3**), North Andover (**3**), Peabody (**1**), Rowley (**1**), Salem (**2**), Salisbury (**1**), Saugus (**7**), Swampscott (**5**), Topsfield (**1, 1**), West Newbury (**1**), and Winthrop (**3**).

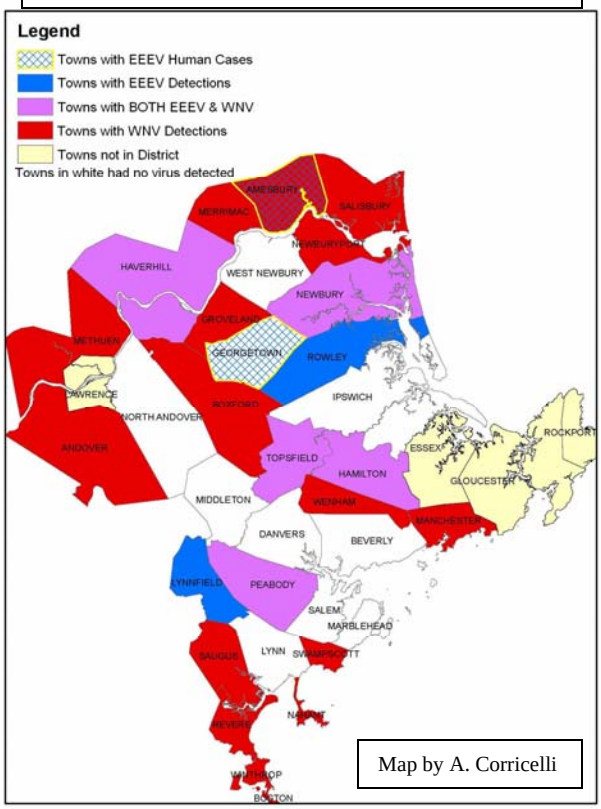
  Beverly and Middleton were the last municipalities in the District to have infected mosquitoes collected for the first time. Every municipality in the District has had at least one infected mosquito pool detected since 2000, the overwhelming majority of these detections were of WNV. Only Bristol County had more infected WNV pools detected in 2013 (79). Statewide, there were 335 WNV-positive pools and 61 infected EEEV pools. In 2012, there were 307 WNV-infected mosquito pools and 267 EEEV mosquito pools statewide with most coming from the eastern half of the state.

Figure 1. NE MA Mosquito Control District Municipalities reporting one or more WNV-infected mosquito pools in 2011.



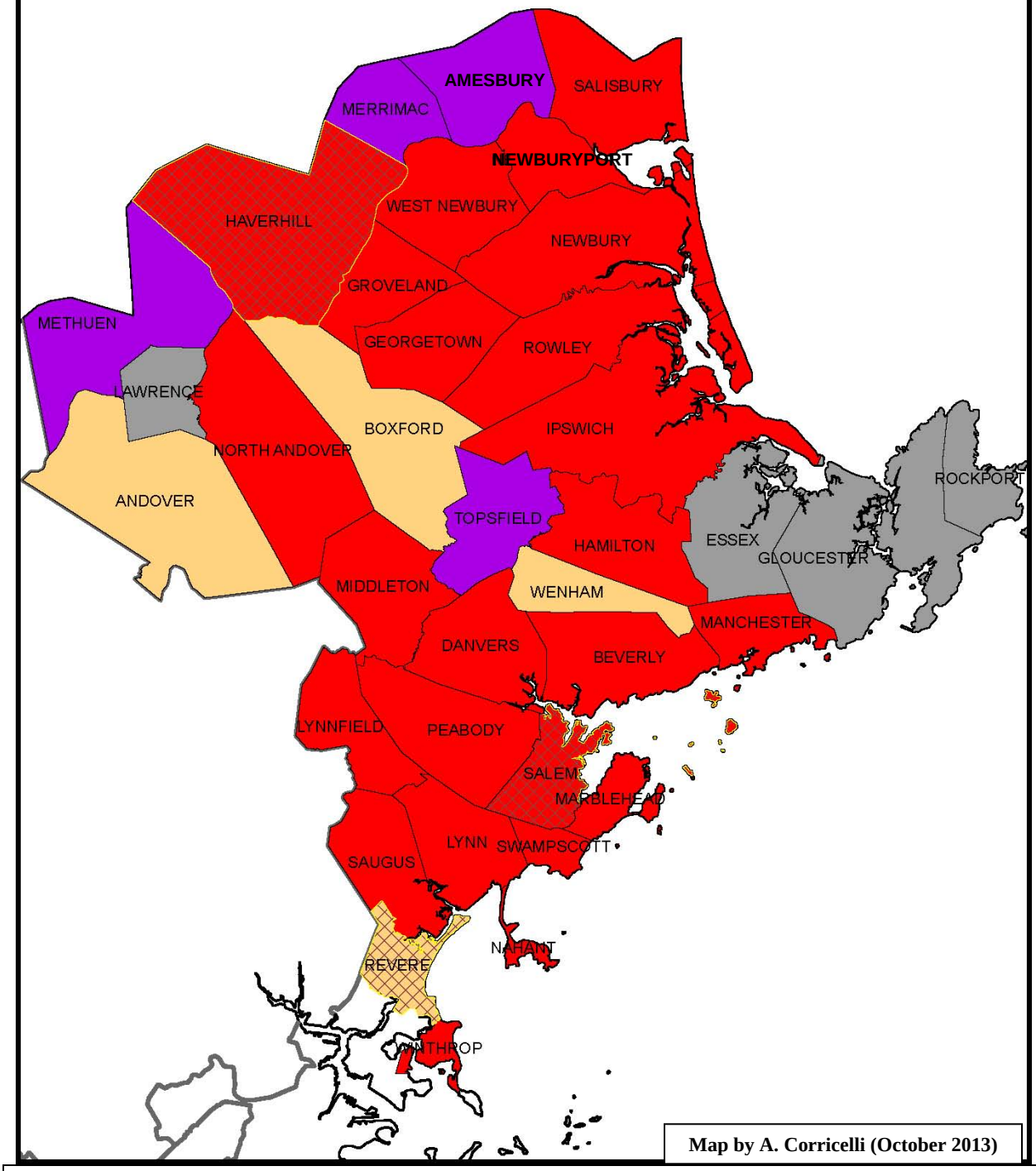
Map by A. Corricelli

Figure 2. NE MA Mosquito Control District Municipalities reporting WNV and EEEV infections in 2012



Map by A. Corricelli

Figure 3. NE MA Mosquito Control District Municipalities reporting WNV and EEEV infections in 2013



Map by A. Corricelli (October 2013)

Legend:
Municipalities in **RED**..... WNV detected in mosquitoes
Municipalities in **PURPLE**..... **BOTH** EEEV and WNV detected in mosquitoes
Cross-hatching..... Municipalities with one WNV-infected human
Municipalities in **TAN**..... NO virus detected in mosquitoes
Municipalities in **GREY**..... Non-subscribing municipalities

- Nearly all of the types of traps deployed, regardless of whether they were permanent or temporary, collected infected mosquitoes. Fifty infected pools came from mosquitoes trapped at permanent season-long HTS; fifteen infected pools came from resting box traps; sixteen infected pools came from temporary gravid traps; and unlike in 2012, no infected pools came from temporary CDC traps.

Whereas more mosquitoes of other species were sent for testing in 2013, including a multitude of salt marsh mosquitoes, only three species/species complexes were found infected with virus. The species found infected were:

- ***Culex pipiens/Cx. restuans*** complex. A species complex is one which two or more species are morphologically identical but biologically distinct (i.e., we just can't tell them apart). This species complex, as stated earlier, is the both the principal bird-to-bird (i.e., "enzootic") and bird-to-human (i.e., "epidemic") vector of WNV in Massachusetts. There were **sixty-six** pools of this complex infected with WNV.

- ***Culiseta melanura***. This species is the usual enzootic vector for EEEV, but since its preferred hosts are birds, this species can pick up WNV from infected birds as well. There were four pools of this species infected with EEEV and ten with WNV.

- ***Cs. morsitans***. This species is found with some regularity only along the municipalities bordering New Hampshire; it is an uncommon vector for EEEV. It is also primarily a bird-biting species which accounts for why the sole pool of this species, collected in Merrimac, was infected with WNV! This is the first account of this species being infected with virus in the District.

As already stated, there were three reported human cases of WNV infections in our District. Nonetheless, the numbers of WNV-human infections are known to be much underreported, according to public health experts, such as Dr. Alfred DeMaria (MA state epidemiologist); only the more severe cases draw attention. There were eight human cases statewide, as of 31 December 2013 (one case of WNV fever and seven cases WNV neuroinvasive diseases, usually some form of meningitis); in 2012 there were 33 human WNV cases. Nationwide so far, the CDC has reported 2,374 human cases and 114 fatalities (as of 7 January 2014). Of greater concern is the increasing prevalence of WNV-neuroinvasive infections in recent years. The reasons are not yet fully known for this increase; hypotheses range from improved diagnosis to genetic changes in the virus to cause more serious illness (i.e., increasing its "virulence").

More EEEV and WNV were detected in the District in the past three years than all the previous years combined. This pattern was also seen statewide. Nationally in 2013, EEEV remained regional (eastern seaboard and upper Midwest), but WNV appeared again across the country in mosquitoes and humans; there were human-WNV cases in every state except in Maine, West Virginia, Alaska, and Hawaii. The cause of the increase in the transmission and amplification of WNV in the U.S. in the past two years is not known. It is suspected that in many parts of the country, decline in mosquito pre-emptive and responsive control funding and operations may be behind the increase. However, funding for surveillance and control operations was not decreased in our District for 2013. So, what is going on?

As discussed last year, changes in climate patterns may be part of the answer and how these changes affect pathogen-vector-host interactions may now becoming better understood. Dr. Theodore Andreadis (Connecticut Agricultural Experiment Station) at 2012 Northeastern Mosquito Control Association, presented examples on how climate change may be affecting vector species. The effects from increased atmospheric warming include:

- extending the season mosquitoes are active;
- increasing survival of overwintering adults;
- shortening larval developmental time thus allowing adults to mature faster;
- increasing the frequency of adult feeding and survival;
- extending the distribution range of many/most vector species.

The increases in overall ambient summer temperatures may allow viruses to complete their "development" in mosquitoes more quickly and to be more quickly transmitted by mosquitoes. Increases in precipitation will increase the numbers and quality of larval breeding sites of many vector species; increases in humidity will favor the overall survivorship of adults. However, decreases in overall precipitation can be advantageous to other vector species by increasing their breeding sites (natural and containers) during droughts, as exemplified by the vectors of West Nile virus.

The overall take home message from what has been observed and analyzed during the past three seasons is that we will continue to see widespread and abundant activity of arboviruses and the mosquitoes that transmit them. Therefore, the risk of human infections from these viruses will persist and possibly increase, as well as the costs to protect and treat the human cases.

North Andover

Descriptions and procedures of our mosquito and arbovirus surveillance programs are presented in the previous section. Also, as stated in that section but nevertheless worthwhile repeating, our surveillance objective is to collect a **representative sample** of mosquitoes in a community, not collect every mosquito possible or collect from every breeding area! We focus our collections in areas where substantial portions of residents live because in addition to sampling species and their populations, we need to determine whether these mosquitoes are transmitting viruses dangerous to people. From the collections from our Historical Trap Stations (HTS's) and our knowledge of the history and ecology of the community, we make an estimate of mosquito diversity and abundance for that municipality.

As overall mosquito populations increased dramatically District-wide in 2013, they also increased in North Andover by over 150% from 2012 numbers, as collected at both trapping stations, the regular HTS at the DPW lot and the gravid trap-only station behind the Senior Center. The sole sources of this increase were the "organic-water breeding" mosquitoes, namely ***Culex pipiens*** ("Northern House mosquito") and ***Cx. restuans*** ("White-Spotted mosquito"). As reported in the previous section, these species are the principal vectors (i.e., "carriers") to humans of both Eastern Equine Encephalitis (EEEV) and West Nile viruses (WNV); their population increases in North Andover may explain the detections of WNV in your municipality. Also as reported in the preceding section, populations of these two species increased overall district-wide given that conditions that promote their numbers were most prevalent last summer,

All other common species had lower populations recorded in 2013 than in 2012. These include the Cattail Swamp mosquito, ***Coquillettidia perturbans***, the principal floodwater mosquito species (***Aëdes vexans*** and ***Aë. canadensis***), the "Spotted-winged" and "Mottled-winged" mosquitoes (***Anopheles quadrimaculatus*** and ***An. punctipennis***, respectively), and the principal tree hole-breeding species (***Aë. japonicus*** and ***Aë. triseriatus***).

As for arbovirus detections in 2013, there were three mosquito pools (i.e., "samples") infected with WNV; there were no EEEV-infected pools collected in North Andover. Nineteen WNV-infected mosquitoes have been collected in North Andover, all since 2008 (with twelve pools with WNV detected alone in 2010); EEEV-infected mosquitoes have yet to be detected in North Andover. In immediate surrounding communities last year, EEEV was collected in Methuen and WNV was collected in Haverhill, Middleton, as well as in Methuen. There was also a WNV-infected human in Haverhill.

The Public Health Council of the Massachusetts Department of Public Health announced, in mid-February 2014, that EEEV and WNV, that both potentially deadly diseases "are here to stay and should be considered a yearly concern" (**Newburyport Daily News**, 14 Feb. 2014). Therefore, North Andover cannot reduce its vigilance or concern with regards to arboviruses. No changes are projected for surveillance in 2014.

Focus of Operations

The District's Vector Management Plan VMP will take precedence over all operations prescribed in this BMP. Regional control efforts will focus primarily on adult mosquito surveillance, virus testing and preemptive virus intervention strategies. Specific to North Andover, the primary focus of control efforts will be on virus intervention for West Nile and EEE through freshwater larviciding and catch basin treatments, with adulticiding as requested by the BOH.

Regional Control Measures

Regional Adult Mosquito Surveillance Program: The importance of surveillance data in reducing the risk of vector borne disease can not be overstated. By focusing on areas of heightened viral activity, preemptive control measures can be timely, efficient and effective. In 2002 we expanded and greatly improved our surveillance program by developing and implemented an automated carbon dioxide (CO_2) surveillance system. This system incorporates a CO_2 modified light trap and gravid trap into one automated unit. CO_2 traps are used to sample the general adult mosquito population, monitor both short and long term trends, and determine dominant species and population density.

Gravid traps are designed to collect adult female ***Culex*** species the primary vectors of WNV. At least one of these dual function units is placed in a fixed location in each member municipality for a total of 37 deployed throughout the District. Mosquitoes are collected and identified from each trap twice a week beginning on or about May 12th through October 9th and beyond if conditions and circumstance warrant.

To supplement ***Culex*** collections from fixed gravid trap locations, the District will deploy additional gravid traps at multiple random locations in communities with a history of WNV activity as conditions and circumstances warrant.

The District will operate 152 resting boxes at 18 sites. Resting boxes are designed to collecting blood fed female ***Culiseta melanura*** mosquitoes relevant to EEE transmission. The District began deployment of resting boxes in 2006 in response to the emergence of EEE in the Northeast and they have proven to be a valuable tool in early intervention. Six to eight resting boxes will placed at each fixed location and there will be two fixed locations in communities bordering New Hampshire as

well as other communities considered to be at risk. The District will collect and identify samples from each trap twice a week and the specimens will be tested for virus.

In the event ***Cs. melanura*** mosquitoes collected from resting box sites test positive for EEE the District will deploy portable CO_2 traps at those sites. Whereas ***Cs. melanura*** rarely bites humans they serve as an early indication of the presences of EEE in the environment. CO_2 traps attract human biting mosquitoes and mosquitoes testing positive from CO_2 traps indicated heightened risk.

Virus Testing: Specimens from our trap collections will be sent to The Massachusetts Department of Public Health (DPH) to be tested for the presence of encephalitis viruses.

Regional Vector/Virus Intervention: Control efforts will focus on early intervention strategies in municipalities that have shown a greater risk to mosquito borne virus based on events of the previous season and surveillance data. This approach is in the best interest of all member municipalities as focused early intervention strategies seem to demonstrate containment of WNV and EEE, and may reduce the risk of exposure to humans and the spread of this disease to other municipalities. Regional efforts will continually adjust throughout the season to accommodate the current surveillance and virus data and reflect the wishes of each community as it is affected.

Control Measures Specific to North Andover

Catch Basins: Catch basins, retention ponds, detention basins, etc. will be checked and treated as necessary, not to exceed one day per week from May 1st to August 31st.

Ground Larviciding: Larviciding sites will be treated first in those communities prioritized in the Districts VMP. Sites will be monitored by degree of breeding in relationship to proximity to human populations and evaluated for short term treatment considerations.
Mosquito larviciding sites from the District's data base and areas requested by the Board of Health will be checked and treated as necessary, in lieu of catch basin treatments, not to exceed one day per week from March 15th to August 31st and beyond if circumstances warrant and conditions allow.

Manual Ditch Maintenance: In the course of catch basin treatments and larviciding, roadside ditches and culverts will be manually cleared of manageable blockages and debris in order to reduce mosquito breeding habitat and or potential habitat.

Tire Recycling Program: Tires have historically been dumped/abandoned in any number of locations including public and private properties in both upland and wetland environments. Once a pile is started it can quickly grow into a substantial public health issue in terms of mosquito proliferation but also as a potential fire hazard or worse; a source of toxic fumes once ignited that can be extremely difficult to extinguish.

Used tires almost always hold water and are a prime location for artificial container breeding mosquito species, most notably *Culex pipiens* and *Aedes japonicus*. *Culex pipiens* is considered a key vector species of West Nile Virus. *Aedes japonicus* is a relatively new species to the Massachusetts area, since 2000, and was originally thought to have been imported to the United States in tires. *Aedes japonicus* has tested positively for West Nile virus.

The District has facilitated the removal and proper disposal of used tires from its service area for many years during the course of coordinated clean-ups and petitioned wetland management projects. This practice is considered an important part of the District's source reduction efforts and a strong component to their integrated pest management (IPM) approach. Tire disposal can be costly and increased economic woes may be adding to the problem as more and more people look for ways to cut expenses. For these reasons the District will be offering on a limited basis a tire removal and disposal program for some of its member communities. The District hopes this pilot program will be well received amongst its communities and that it may some day find a valuable place amongst other mosquito control best management practices area wide.

Inspectional Services: While the District is authorized under the provisions of Chapter 252: section 4 of the General Laws of the Commonwealth to enter upon lands for the purpose of inspection, it is not a regulatory agency. Nor is it our intention to impose on any resident or business, but rather to be a resource for information and technology to help property owners prevent or abate mosquitoes to the mutual benefit of the property owner and the community. The District will act as a technical advisor as requested by the Board of Health and represent the municipalities public and animal health and human annoyance concerns relative to mosquito breeding, potential breeding and proposed development. The District, at the request of the Board of Health will also review site plans and inspect sites were storm water structures are planned or under construction. Upon inspection of a site the District will make written recommendations, submit these recommendations to the Board of Health and "cc" a copy to the land owner.

Property Inspection: Socioeconomics often plays an important role in mosquito control and associated public health risk. This is evident by a study conducted in 2007 entitled "Delinquent Mortgages, Neglected Swimming Pools, and West Nile Virus, California" which demonstrates a 276% increase in the number of human WNV cases in the summer of 2007 associated with a 300% increase in foreclosures which led to a large number of neglected swimming pools in Bakersfield, Kern County. Each year we receive many requests from Boards of Health to inspect abandoned properties.

While the district has a long standing policy of property inspections at the request of Boards of health, in the past we have taken a passive approach to property inspection. Given the current economic climate and likelihood of increasing property abandonment and the potential for increased health risk associated with property abandonment the district will take a more aggressive approach to property inspections. In the course of our routine activities in your community we will be on the lookout for such properties and report such properties to Boards of Health. We understand that addressing concerns related to such properties is a matter of time and process. In the long term we will offer any support that may be appropriated to resolve mosquito problems related to such properties and in the short term with the Boards of Health's support we will implement the necessary control measures to mitigate the immediate mosquito problem associated with such properties.

Adulticiding: Science based selective adulticiding will be coordinated through the Board of Health. (BOH 2013) For a faster response to data and recommendations for adulticiding, the decision to spray (adulticide and or barrier) will be made by the Chairman or Health Director with the entire Board to be notified as soon as possible. (Ground adulticiding exemption- for those property owners wishing to exempt their property from direct ground application must notify the Town Clerk in writing each year prior to March 1st in accordance with 333 CMR Section 13.03
Nuisance mosquito adult spraying (adulticiding) requests by residents are to be made to the Health Department with the decision for spraying to be made by the Board of Health Chairman and or

Director with input from the Mosquito Control District and the entire Board.(Protocol for the decision to spray to be developed internally.)

Barrier Treatment: The District uses a system called Ultra Low Volume (ULV) for ground adulticiding applications. ULV is designed to dispense very small amounts of pesticides over a large area. While this is a cost effective means of reducing mosquito populations on a large scale, it only affects those mosquitoes present at the time of the application and repeated applications are sometimes necessary to sustain the initial reduction in the mosquito population in some areas. To reduce the need for repeated applications and provide more sustained relief from mosquitoes in high public use areas, the District will provide barrier treatments to public use areas such as schools (applications to schools must be incompliance with MGL ch85), playgrounds, athletic fields, etc., at the request of the Board of Health.

Wetlands Management: The Town may petition the District to undertake larger scale ditch maintenance projects, wetlands enhancement and restoration projects requiring specialized mechanized equipment and expertise. Petitioned sites will be evaluated and a site specific proposal will be written for acceptable projects. Wetlands management projects may be beyond the scope of any municipality's assessment and may require separate and additional appropriation.

Mosquito Habitat Mitigation: The District will represent the Towns mosquito control concerns in an advisory capacity relative to proposed development and where prudent as requested by local health officials.

Research and Development: Evaluate the efficacy and efficiency of current control methods. Investigate new methods, procedures and technologies in mosquito control and wetlands management and evaluate their implications for use in North Andover.

Education: Present educational displays and programs on mosquito control and related wetlands management programs at the request of health officials, schools or civic organizations. Monitor and update local schools, daycares etc. regarding IPM plans and current child protection requirements. (The Board of Health encourages the Health Director and the Mosquito Control work with the school department to update the School IPM plans annually by March 1st)

FY15 Percentage of assessment allocated to control measures as prescribed by individual municipality's Best Management Practice Plan, (BMP) in the Town of North Andover

For 2015 the District is asking for a level funded budget. For FY15 our primary goal is to protect our subscribing communities from virus. We will do all in our power to reduce the mosquito populations on a regional and town wide basis thus reducing the virus risk to our residents. We look for continued support and understanding from all the communities we serve if we are to be successful.

Assessment: As estimated by the Massachusetts Department of Revenue, Division of Local Services, in accordance with Chapter 516 of the General Laws of the Commonwealth. The assessment formula is based on a regional concept, which considers square miles and evaluation. The District offers this breakdown as a general guide to how these funds are allocated specific to your community.

FY15 Estimated Assessment for the Town of North Andover $ 91,385.00 (FY14 $91,385.00)

District Breakdown of Administrative and General Operational Cost

State Reclamation and Mosquito Control Board	2.45%	$ 2238.93
Administration and Facilities Cost Share	28.8%	$ 26,318.88
Balance of assessment allocated to Operational Cost	68.75%	$ 62,827.19

Specific Control Measures as Prescribed by BMP

General Operational Cost Share

Regional Adult Mosquito Surveillance Program

Regional Vector/Virus Intervention

Catch Basins/Larviciding/ Manual Ditch Maintenance

Wetlands Management

Mosquito Habitat Mitigation

Inspectional Services

Adulticiding (Board of Health request 2013 – see “Control Measures Specific to N. Andover”)

Research and Development

Education

Tire Recycling Program