Bay County Mosquito Control

2018

ANNUAL REPORT

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A Note from Rebecca J. Brandt, Program Manager

December 6, 2018

On behalf of Bay County Mosquito Control, I am proud to present our 2018 Annual Report. This report is a summary of the various outreach, surveillance, and treatment efforts undertaken by our staff throughout the year to support our mission of reducing disease-transmitting and nuisance mosquitoes. Our program continues to follow an Integrated Mosquito Management approach to mosquito control, providing the most effective and efficient measures to reduce mosquito threats, while continuing to be positive environmental stewards.

The reduction of mosquito-borne disease is the primary focus of our program with West Nile virus again having a solid foothold in the area with 32 birds and 9 mosquito samples testing positive for the virus. No human cases were detected in Bay County, nor were any other mosquito-borne diseases evident. While minimal rainfall from May through August resulted in a lull of our primary nuisance mosquito, emerging mosquitoes from permanent-water habitats dominated trap counts through July. Late summer rains brought the flooding and high counts of biting mosquitoes that we were void of through most of the season, with effects felt into October. We commend our dedicated staff who worked flexible shifts and long hours during this time to bring mosquito counts back to tolerable levels and provide Bay County residents with the high level of service they deserve.

In 2018, Mosquito Control was fortunate to secure over $35,000 in grant funds from the State of Michigan to help recapture expenses from our 2017 flood response. We also worked diligently to obtain grant funding from Michigan Municipal Risk Management Authority to assist in funding a new video surveillance camera project to secure our property and ensure the safety of our staff. Education and public outreach continue to grow in our program with a new treatment schedule added to our website to inform residents of tentative fogging locations as well as a robust STEM-based mosquito life cycle program developed for 1st graders in the Bay City Public Schools now being expanded into other districts.

The support we receive from the Bay County community is truly appreciated as we strive to make advancements and improvements in our practice of effective, responsible mosquito control.

Respectfully submitted,

Rebecca J. Brandt

Bay County Mosquito Control Manager

PROGRAM BACKGROUND

Bay County Mosquito Control (BCMC) is a community-wide public health program that began operations in 1977 in conjunction with Saginaw County as the Saginaw-Bay Mosquito Control Commission after an outbreak of St. Louis encephalitis occurred in Michigan. To better serve their residents, the counties each began their own operations in 1985.

As one of the divisions of the Bay County Environmental Affairs and Community Development Department, the Mosquito Control program seeks to protect the health and quality of life of residents and visitors from potential disease and the annoyance caused by the bite of mosquitoes. We acknowledge the importance of serving the public by providing mosquito control services without producing adverse impacts on the environment; therefore, our goal for mosquito "control" is not elimination of the insect, but rather an Integrated Mosquito Management (IMM) approach using a variety of methods designed to prevent and reduce the number of mosquitoes so they no longer unfavorably affect the health and quality of life of Bay County residents.

Using nationally verified scientific mosquito management and control strategies, IMM methods include education on repellents and skin protection to reduce biting occurrences, source reduction through ancillary habitat management, (i.e., spare tire collection, dumping containers, and covering pools), biological surveillance, disease surveillance, and finally, field operations using larval and adulticide source control.

Bay County is one of four Michigan counties providing a comprehensive mosquito control program and efficiencies are realized through collaboration in a Mid-Michigan Technical Advisory Committee (TAC), composed of participants from academia, industry, public health, and regulatory entities. It was founded to assure that BCMC's mosquito control program runs effectively and efficiently to best protect the public health of Bay County. The TAC meets annually to review program operations for Bay, Midland and Tuscola County mosquito control programs and allows for interagency cooperation and cost savings, particularly as the three counties bid jointly on bulk insecticide orders to keep costs as low as possible.

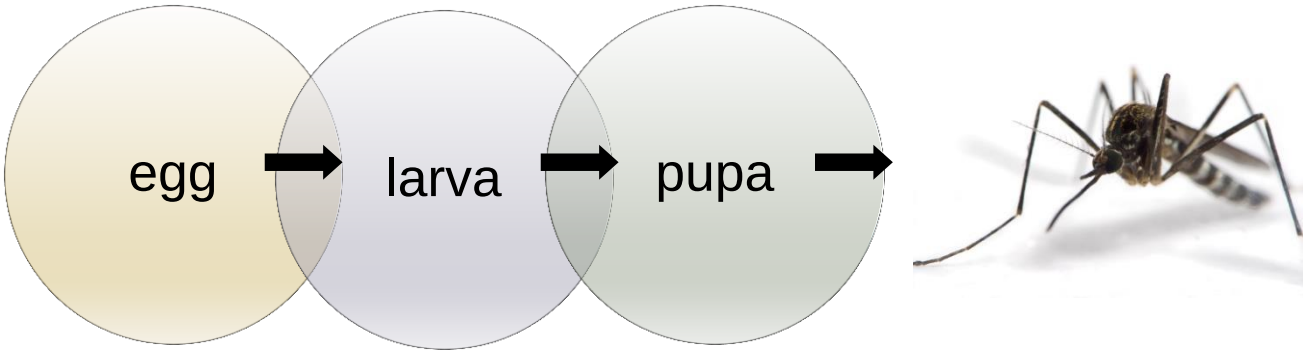
BCMC provides services to the 106,000 residents living in an area covering 443 square miles. The Mosquito Control program is funded by a voter-approved millage, which routinely has received overwhelming voter approval of 84%. After 28 years, the 0.45 mill tax levy was increased for the first time in 2016 to 0.55 mills for eight years.

MOSQUITO BIOLOGY AND LIFE CYCLE

Mosquitoes are aquatic insects that undergo a complete metamorphosis involving four distinct stages—egg, larva, pupa, adult—throughout their life cycle. Female mosquitoes can develop several hundred eggs with each blood meal and lay them in or around water. The eggs are laid (where standing water accumulates after rain or flooding) either singly or attached to one another to form an egg raft that floats on the water's surface.

Once eggs hatch, larvae emerge, wriggling through the water. The larvae are filter feeders that eat voraciously and outgrow their skin, leading to molting of the skin between each larval stage or instar. A final molt occurs as the fourth instar larva becomes a pupa, which happens about one week after the eggs initially hatch. Pupae do not feed and are often found at the surface of water (like larvae) where they breathe. Inside the pupa's protective shell, the mosquito transforms into the winged adult. Eclosion is the emergence of the adult mosquito from the pupal case. These newly-emerged adults use the cast skin for support until their wings and body dry, at which time they fly away. The whole life cycle is typically a quick process, taking about a week to complete. Once the eggs hatch, the time required to complete the life cycle is dependent on temperature—the warmer the water, the more quickly a mosquito develops.

After mating, females seek out an animal upon which to feed and this blood provides protein to develop eggs. Males do not bite, but do have sucking mouthparts to obtain plant nectar as a source of energy; females do this as well. Next, females search for an aquatic habitat or moist ground to deposit eggs. Although there are exceptions to the rule, most adult mosquitoes live for a period of four to eight weeks.



SPRING LARVAL SURVEILLANCE

As a result of spring flooding due to rainfall or snowmelt, the potential exists each year for significant spring mosquito larval development in the woodland areas of Bay County. Spring aerial treatment utilizing three fixed wing aircraft was conducted when larvae reached the second or third instar growth stage. Monitoring larval development was critical in order to have a timely application of *Bti* (*Bacillus thuringiensis israelensis*), a bacterium eaten by larvae that caused mortality within 48 hours. The *Bti* could be used as a food source by other aquatic organisms occupying the same woodland pool habitats.

Surveillance was an essential part of the spring mosquito control program. Mosquito larval surveillance began in mid-March with first instars observed in woodland pools on March 19th. The most notable feature of the woodlots at that time was that water levels were well-below average compared to a typical year. Rainfall for March was 2.63 inches with an inch of that recorded in the last 5 days of the month. That, coupled with the wet April (2.54 inches of rain recorded – most of that falling from April 12-16) created plenty of water and mosquito hatch for the 2018 aerial treatment program. Larval growth was slow during March when temperatures fell below normal for most of the month and that trend continued through mid-April. Woodland pools were set beginning on April 20, much later than usual due to the cold temperatures.

Forty woodlots were monitored to determine pre-treatment larval counts shortly before treatment began, which was followed by post counts within five days after treatment. There were five woodlots that were monitored, but which were not set due to difficulty finding mosquito larvae. These woodlots are marked on Table 1 with pre and post counts of zeroes. Aerial calibration took place on April 23 with treatment beginning immediately and lasting seven days until April 29 with one non-treatment day due to wind. Three fixed wing aircraft were calibrated to deliver 3 pounds of VectoBac® G *Bti* per acre and a high level of larval mortality was achieved with the VectoBac product.

Post counts indicated an overall average 96.1% corrected larval mortality (Table 1), which indicates favorable control was accomplished at the 3-pound per acre dosage. Most woodlots had excellent *Bti* coverage and, as usual, where there was *Bti*, there were either no mosquito larvae found or only dead larvae floating throughout the water column. In some woodlots with lower mortality, there was light *Bti* coverage due to the wind's influence on the granular product's placement. In others, several small pools were missed, with little effect on the overall efficacy. *Bti* continues to be one of the most important tools in Bay County's mosquito control program.

Quality control of the spring aerial campaign was accomplished with the help of one full-time staff and two seasonal staff members. Staff walked through 44 treated woodlots over the course of the program in order to determine both the average number of *Bti* granules per square foot, which helped confirm the dosage rate, and locate possible skips or misses occurring with the aerial application.

Frogs, tadpoles, seed shrimp, fairy shrimp, water fleas, copepods, and caddisflies that were observed in the woodland water habitats before treatment were found in large numbers after treatment, as well.

Mosquito pupae were first seen on April 27 and adult emergence of spring *Aedes* mosquitoes from seasonally flooded woodlots took place from May 7-14, with fogging operations beginning at that time. May showed temperatures above average for the second half of the month so spring *Aedes* adult counts were very close to average. There were 2,629 females captured compared to the 29-year CDC history for the month of May when the average collection totals 2,728.

Spring woodland pool

Table 1 – Spring Treat Larval Mortality

Bay County Mosquito Control Spring Treatment 2018 3 lb/acre VectoBac® G *Bti* Evaluation			
	Larval Count		
Location	**Pre**	**Post**	**Mortality**
Bangor 4 - Bangor Oil Well	0.66	0.12	81.8%
Bangor 33 - Bangor and Zimmer	0.53	0	100%
Beaver 4 - 1576 Cottage Grove	1.4	0.22	84.3%
Beaver 5 - Carter and Cottage Grove	1	0.04	96%
Beaver 9 - 1585 Cottage Grove	3.3	0	100%
Beaver 18 - 1200 Flajole	0.73	0.05	93.2%
Frankenlust 2 - 6505 Four Mile	0.78	0	100%
Frankenlust 2 - 6105 Four Mile	0.83	0.23	72.3%
Frankenlust 3 - Delta by Automotive Bldg.	1.12	0	100%
Frankenlust 3 - Mackinaw Road	0.96	0	100%
Frankenlust 7 - 259 Amelith Road	2.54	0.14	94.5%
Fraser 6 - Townline 16 by 7 Mile Rd.	1.94	0.3	84.5%
Fraser 11 - Camp Fishtales	0.47	0	100%
Fraser 15 - Fraser Twp. Firebarn	0	0	
Fraser 22 - Fraser Twp. Hall	1.26	0	100%
Garfield 9 - 11 Mile N. of Erickson	1.42	0.06	95.8%
Garfield 10 - Garfield Twp. Park	0.96	0	100%
Garfield 15 - Methodist Church	1.29	0	100%
Garfield 26 - Crump Fox Club	0.58	0.025	95.7%
Kawkawlin 2 - Dead end Shaw Lane	1.22	0	100%
Kawkawlin 30 - White Birch Village	0.4	0	100%
Monitor 9 - 1306 Wheeler	0	0	
Monitor 20 - Fraser and N. Union	0.2	0	100%
Monitor 23 - Rocking Horse Ranch	1.22	0.08	93.4%
Monitor 28 - Mackinaw Road Tech Park	1.18	0.12	89.8%
Monitor 34 - Fremont Cemetery	0.45	0	100%
Mt. Forest 9 - Sand Rd. Road Commission	0.76	0.08	89.5%
Mt. Forest 17 - Carter N. of Cody-Estey	1.16	0	100%
Mt. Forest 21 - Daycare	4.98	0.08	98.4%
Mt. Forest 21 - Mt. Forest Hall	1.02	0	100%
Mt. Forest 21 - Mt. Forest Firebarn	0.58	0	100%
Mt. Forest 30 - Pinconning and County Line	2.67	0	100%
Pinconning 23 - K C Hall Water Street	0.98	0	100%
Pinconning 30E - Pinconning County Park	0.55	0	100%
Portsmouth 11 - dead end Bullock	4.26	0	100%
Williams 16 - Peers Lane	0	0	
Williams 19 - Victoria Woods Trailer Park	0	0	
Williams 20 - Forest School/Daycare	0.8	0	100%
Williams 21 - Forest Edge	0	0	
Williams 30 - Rockwell and Salzburg	2.16	0	100%
CONTROL 6505 Four Mile	0.78	0.75	3.8%
CONTROL Mt. Forest 21 Daycare	4.98	4.67	6.2%
AVERAGE TREATED MORTALITY			**96.3%**
AVERAGE TREATED MORTALITY (Corrected)			**96.1%**

SUMMER LARVAL SURVEILLANCE

Mosquito larval activity was monitored throughout the season and considered a key component to an IMM program. Surveillance was designed to monitor mosquitoes county-wide to determine distribution, density, and species composition and was a combined effort conducted by larviciding crews, field supervisors, and biology personnel. Staff conducted routine surveillance of probable mosquito breeding sites using a standard pint-sized dipper. Stagnant water sites included ditches, catch basins, flooded fields, woodlots, and tires. Roadside ditch larval site inspections, termed sequential sampling, occurred weekly throughout the county with larval samples collected and identified to determine the need for control. One hundred eighty-three larval samples representing thirteen species were identified; the majority were *Culex pipiens, Culex restuans, Aedes vexans*, and *Anopheles species*.

Quality control continued to be an essential function for biology technicians. Habitats that were recently treated were re-checked to ensure control materials were properly applied and effective. Quality control efforts began with surveys of woodlots in April to assure proper treatment and continued through the summer as technicians checked recently-treated habitats. Tires, ornamental ponds, ditches, and retention ponds were some of the habitats that were checked within a few days of treatment to make sure the product was performing correctly; no non-target impacts were noted.

CATCH BASINS: To assess the activity and mortality of *Culex* mosquitoes in city and suburban catch basins, biology staff randomly inspected 20-40 basins on nine occasions. The basins are a perfect habitat, providing *Culex* mosquitoes with organically-rich standing water and decomposing leaf litter that provides a bacterial food source. Basin surveillance on May 25 showed no breeding with either larvae or pupae in wet basins. However, a follow-up check on June 4 showed about three-fourths of basins checked contained all mosquito stages. This prompted the initial treatment on June 5 using VectoLex® FG and Natular™ XRT, two products with naturally-occurring active ingredients. In order to determine efficacy and longevity of the control materials, basins were inspected often. Based on past experience, VectoLex is expected to provide control for about four weeks while Natular is expected to provide season-long control. A four-week post check of VectoLex-treated basins showed 11% breeding, but by the five-week mark that number had climbed to 42%. During this same time frame, only 6% of Natular-treated catch basins showed mosquito activity; the six-week mark showed 10% of sites checked were breeding.

Basins were treated with VectoLex a second time in mid-July and again in mid-August when surveillance showed 53% breeding on August 15. A final check of Natular-treated basins on September 6 showed 13% breeding. Surveillance will continue next summer to evaluate product efficacy and we may look at a different active ingredient – methoprene.

AEDES JAPONICUS

Aedes japonicus is a container-breeding mosquito species native to Asian countries. It was first discovered in Bay County in 2005 in its adult form, but began to crop up in larval samples in 2006. The following two figures show how this invasive species now occupies several habitats including artificial containers (Figure 1) and tires (Figure 2) as it competes with native species. Technicians have also sampled *Ae. japonicus* larvae to a lesser extent in ornamental ponds, cross country drains, tree holes, roadside ditches, and ponds.

Staff continue to provide control efforts as well as habitat reduction (i.e. tire drives) to inhibit this species. It is thought to serve as a "bridge" vector in transmission of West Nile and perhaps other mosquito-borne viruses in North America.

Figure 1 – Artificial Container Species, 2018

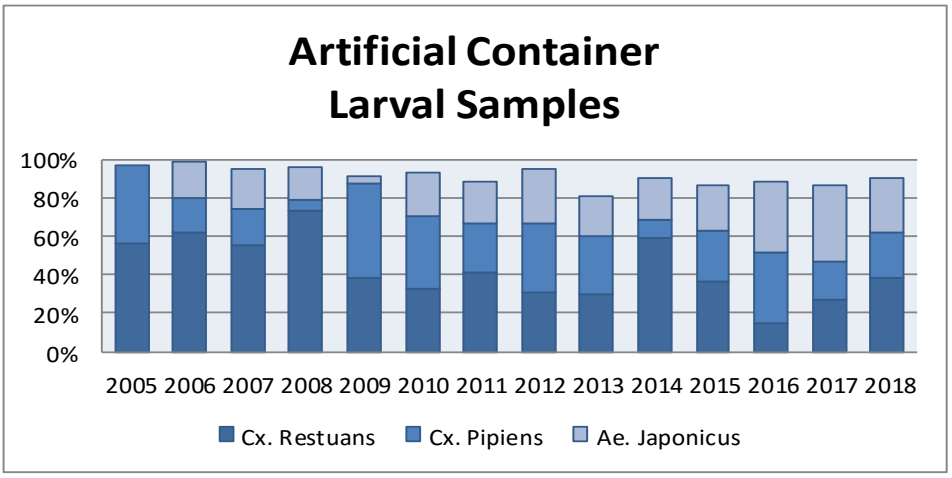
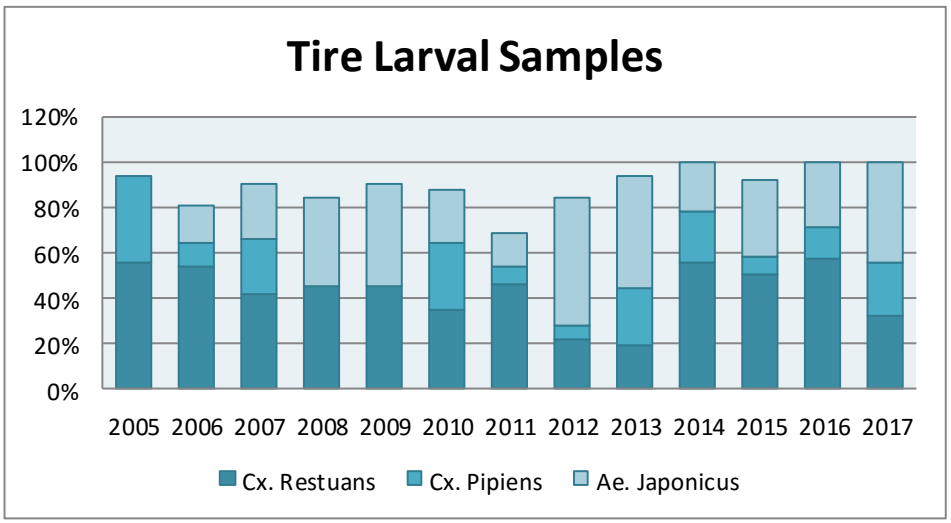


Figure 2 – Tire Species, 2018



NEW JERSEY LIGHT TRAPS (NJLT)

As in previous years, BCMC completed regular mosquito trapping throughout the season. Trapping data is critical to the mosquito management program as it helps recognize mosquito numbers, species, location, and potential disease threats. One of the main tools utilized for adult surveillance is the NJLT. From mid-May through mid-September, adult mosquitoes were collected in 14 traps placed throughout the county in backyards with little or no competing light source. Samples were gathered three times each week, followed by counting and species identification. The total capture was 17,513 (Table 2), about 16% more than the historical average of 15,110. Until later summer, most of the mosquitoes captured represented permanent water species such as *Coquillettidia* and *Anopheles*. These species are classified as both vectors and nuisance; populations tend to be heaviest along the Saginaw Bay. Heavy rains falling in late August created flooding and high counts of nuisance species like *Aedes vexans* well into September.

Table 2 - New Jersey Light Trap Data, 2018

2018 LIGHT TRAP DATA						
Species	**May**	**June**	**July**	**August**	**September**	**TOTAL**
Aedes atropalpus	0	0	1	0	0	1
Aedes canadensis	28	35	1	0	0	64
Aedes cinereus	3	21	5	0	0	29
Aedes implicatus	0	2	0	0	0	2
Aedes intrudens	12	36	10	1	0	59
Aedes japonicus	1	5	7	5	3	21
Aedes provocans	1	3	0	0	0	4
Aedes sticticus	3	3	2	0	0	8
Aedes stim/fitchii	18	27	1	0	0	46
Aedes triseriatus	0	2	3	4	4	13
Aedes trivittatus	1	0	2	1	15	19
Aedes vexans	327	391	504	520	1083	2825
Anopheles perplexens	0	6	18	6	1	31
Anopheles punctipennis	14	47	131	80	39	311
Anopheles quadrimaculatus	45	883	3382	1597	453	6360
Anopheles walkeri	93	191	352	157	43	836
Culiseta inornata/morsitans	2	4	2	0	0	8
Coquillettidia perturbans	0	2528	2849	106	5	5488
Culex restuans	51	194	323	233	102	903
Culex pipiens	10	122	89	127	34	382
Culex tarsalis	0	0	0	2	0	2
Culex territans	0	9	26	6	14	55
Psorophora ciliata	0	0	0	1	1	2
Psorophora ferox	0	0	0	0	1	1
Uranotaenia sapphirina	0	0	3	6	6	15
Damaged	5	13	8	0	2	28
TOTAL FEMALES	**614**	**4522**	**7719**	**2852**	**1806**	**17513**
TOTAL MALES	822	1544	1499	912	783	5560
Historical Female Totals (36 yrs)	**384**	**4152**	**5503**	**3893**	**1178**	**15110**

Twenty-six species were collected during the 2018 season with the most predominant being the four *Anopheles* species that collectively represented 43% of the total. The second most abundant species was *Coquillettidia perturbans*, the cattail marsh mosquito, with 5,488 females collected representing 31% of the catch. In a typical year, *perturbans* would account for 9% of the total, but it represented a higher proportion in 2018 due to the low numbers of floodwater species like Aedes vexans, which usually rank first. A hot, dry summer accounted for fewer numbers of floodwater species, however.

Figure 3 shows a 23-year historical view of light trap collections with the average number collected in a given year represented by the solid red line (15,110). Total number of females collected in 2018 was above average and the season ranked the ninth heaviest mosquito year in a 36-year history. Typically, total number of females corresponds with the amount of rainfall received and this year our heaviest rains came in late August. Figure 4 (page 12) shows mosquito species collected per trap night throughout the summer. In 2018, there was only one major hatch of summer floodwater *Aedes* with the peak occurring on September 13, which followed the heavy rains of late August and early September by about two weeks. Traps were inundated with *Coquillettidia perturbans* from early June until mid-July with counts especially high along the Saginaw Bay. *Anopheles* species, too, showed a major spike that corresponded to the heavy *Cq. perturbans* population along with two other spikes in mid-July and August. Like *Cq. perturbans*, the highest *Anopheles* populations were distributed along the Saginaw Bay.

Figure 3 - New Jersey Light Trap Historical Data

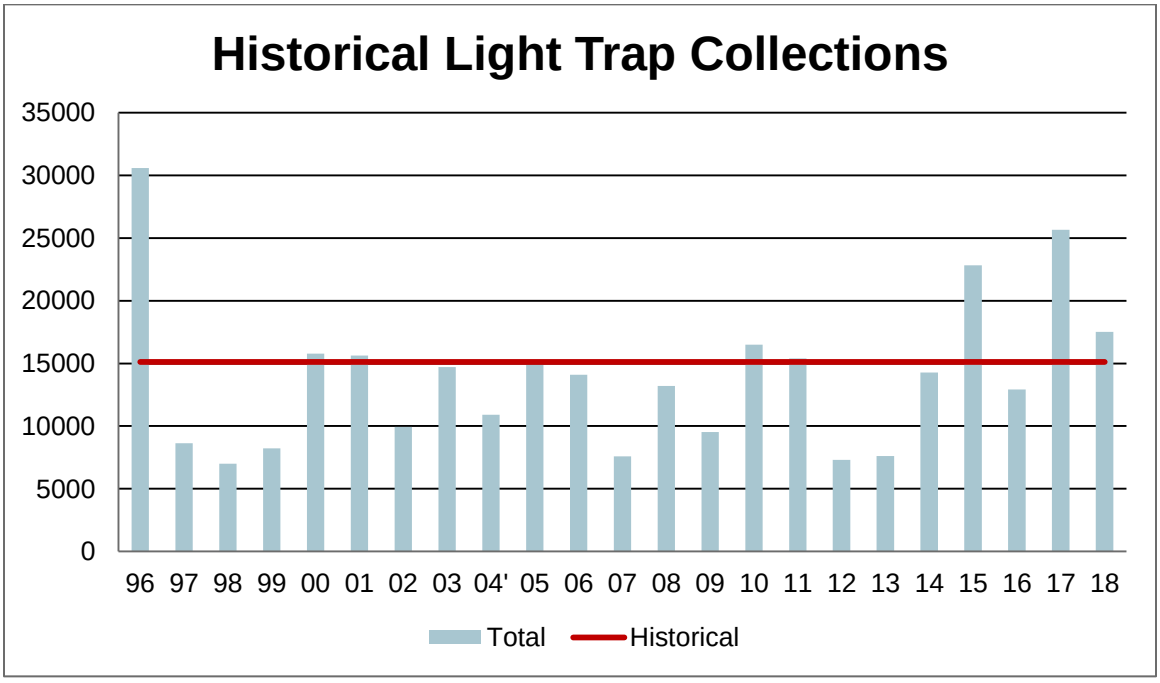
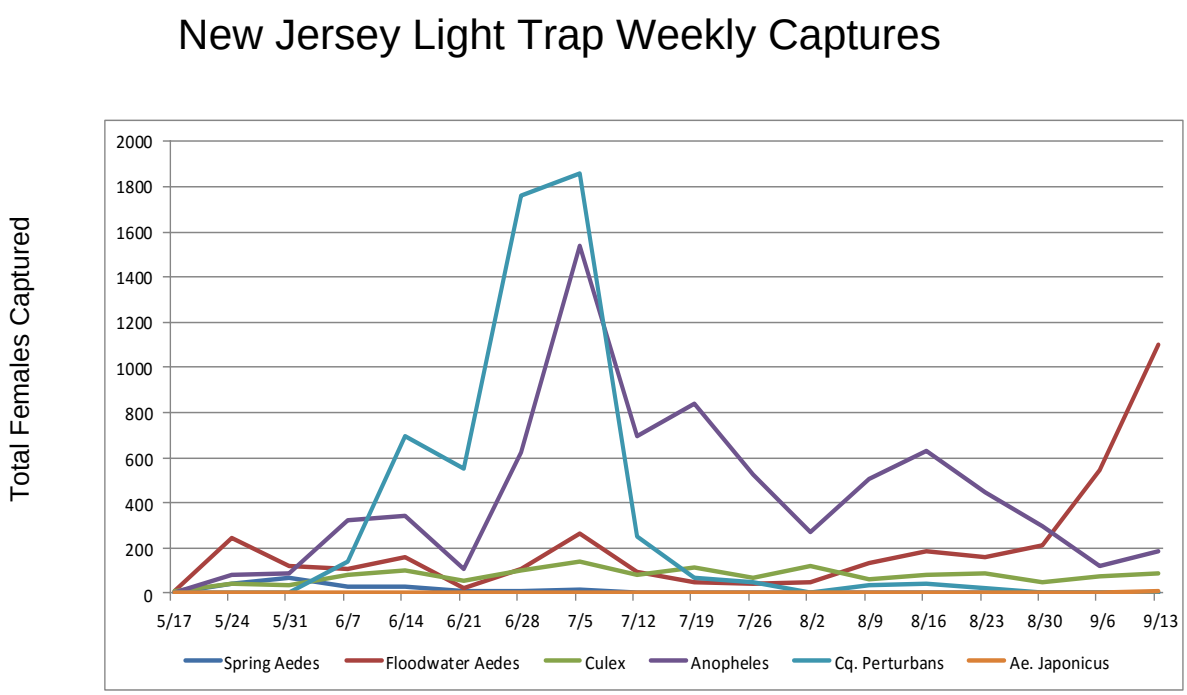


Figure 4 - New Jersey Light Trap Weekly Data, 2018



Unsorted light trap collection (left) with male and female mosquitoes sorted (right)

CDC TRAPS

CDC Traps are another mechanical trap utilized in BCMC's adult surveillance program. The CDC Trap attracts blood-seeking female mosquitoes with the use of dry ice (carbon dioxide) as bait. Traps are placed overnight within woodlots, summer festival grounds, treatment sites, and residential properties. Usually the traps hold diverse species and larger mosquito numbers compared to New Jersey Light Traps. Traps are also used to assess homeowner complaints, gather mosquito-borne disease information, and record changes in abundance of mosquitoes before and after control operations. These traps are quite good at sampling most of the district's individual mosquito species, each one being slightly different from the other due to breeding site preferences, biting habits, flight range, and ability to transmit disease.

The total number of mosquitoes captured in 377 CDC traps this year was 47,548 (Table 3, page 15). There were high populations of *Coquillettidia perturbans* in June and July with 81% and 62% of trap counts, respectively, identified as this cattail marsh mosquito. Historically, *Cq. perturbans* numbers are elevated about once every three years, but their counts have been higher than average and they've been coming on earlier for the last five years. An overall hot, dry summer meant that there wasn't a large influx of floodwater species until mid-September when heavy late-August/early-September rains caused a large hatch of A*edes vexans, Ae. trivittatus, and Ps. ferox.* Thankfully, they were only bothersome for about a week and a half before fogging operations and low nightly temperatures helped alleviate the problem.

Twenty-three species in six genera were collected and identified, averaging 126 females per trap, down considerably from 2017 when there were 187 females per trap. The average number of females in 2016 and 2015 was 74 and 188, respectively. This year we increased the number of traps placed in the field by 30% by utilizing a third lab technician who rotated between the daytime larviciding crew and the biology department. We were able to place 28 traps each week (normally 20 would be placed). Traps were placed in previously sampled locations or based on dead bird reports, nuisance mosquito complaints, locations not previously sampled, or other indicators of possible virus or nuisance risk.

Studies have shown that more *Culex* mosquitoes can be collected when a CDC trap is suspended in the tree canopy compared to traps placed at ground level. To aid in disease surveillance efforts, CDC traps were elevated on five occasions to collect additional *Culex* mosquitoes that feed on birds as they roost in tree canopies. In every case, *Culex* dominated the species captured in elevated traps; on average 74% of the species collected were *Culex*.

Table 3 - CDC Trap Data, 2018

2018 CDC TRAP DATA						
Species	**May**	**June**	**July**	**August**	**September**	**TOTAL**
Aedes canadensis	1360	370	1076	19	0	2825
Aedes cinereus	24	8	8	0	0	40
Aedes dorsalis	0	0	1	2	0	3
Aedes implicatus	2	0	1	0	0	3
Aedes intrudens	104	86	10	5	2	207
Aedes japonicus	0	0	1	0	0	1
Aedes provocans	46	7	0	0	0	53
Aedes sticticus	23	37	19	6	16	101
Aedes stim/fitchii	41	151	25	4	0	221
Aedes triseriatus	0	5	3	20	5	33
Aedes trivittatus	6	43	76	40	784	949
Aedes vexans	649	2735	528	340	2415	6667
Anopheles earlei	0	0	1	0	2	3
Anopheles perplexens	3	295	13	17	2	330
Anopheles punctipennis	26	60	38	10	9	143
Anopheles quadrimaculatus	14	914	1074	409	422	2833
Anopheles walkeri	219	634	61	54	13	981
Culiseta inornata	1	0	0	1	0	2
Coquillettidia perturbans	10	23927	5536	730	88	30291
Culex restuans	87	60	331	658	353	1489
Culex pipiens	5	13	31	44	60	153
Culex territans	0	0	0	0	0	0
Psorophora ciliata	0	0	1	2	0	3
Psorophora ferox	0	0	2	3	123	128
Uranotaenia sapphirina	0	0	0	0	0	0
Damaged	9	17	56	7	0	89
Total	**2629**	**29362**	**8892**	**2371**	**4294**	**47548**

CATCHMASTER OVI-CATCH TRAP

The Ovi-Catch trap is a low-cost, easy-to-use, mosquito surveillance tool that is designed to capture gravid (egg-bearing) female mosquitoes looking for a suitable site to lay eggs. The traps use Catchmaster AGO Trap Replacement glue boards with a specially formulated adhesive designed to catch mosquitoes during the critical breeding cycle when females look for a location to lay their eggs. The traps were initially developed by the Centers for Disease Control and Prevention (CDC) at the agency's Puerto Rico research and testing facility.

AP&G Co. introduced the product to the professional pest management industry in 2017 and the company is working with distributors to market it to pest management professionals and other customers.

Bay County Mosquito Control was given two traps to utilize during the 2018 season. Traps were placed in wooded areas sampling both the north and south ends of Bay City. Traps were checked weekly from June 20-September 5. Ten inspections of glue boards at both locations showed very little mosquito activity. In fact, inspections on five different days showed no activity whatsoever. On the other five occasions, there were 12 mosquitoes collected – 6 *Anopheles quadrimaculatus*, 2 *Culex* spp., 2 *Aedes triseriatus*, 1 damaged female, and 1 male *Cq. perturbans*.

The trap was initially designed to capture adult *Aedes aegypti* or *Ae. albopictus* species, vectors of Dengue and Zika viruses, who utilize containers for breeding. Bay County does not currently have any wild populations of either species. In our case, while some mosquitoes were captured, there was little return on investment in this preliminary investigation; however sticky ovitraps may provide greater potential for monitoring and reducing vector populations of *Aedes aegypti* and *Ae. albopictus* where these species thrive. It is also possible that greater species variety and numbers of mosquitoes would be collected if more traps were employed in more locations throughout the county.

SPECIES FOCUS – PSOROPHORA CILIATA

Psorophora ciliata is one of the largest known mosquitoes in the U.S. - in fact, it is the largest Michigan species. Floodwater species like *Psorophora* lay eggs in low-lying areas with damp soil; when the areas flood following a dry period, the eggs hatch, producing many adult mosquitoes. *Psorophora ciliata* occurs in traps especially after heavy flooding. Similar to adults, larvae are larger than most other mosquito larvae and as a fourth instar larvae have a square-shaped head and prey on larvae of other mosquito species. Adults are persistent biters and are relatively intimidating due to their large appearance. They are easy to distinguish from other species not just due to their size, but also because of the shaggy dark scales on the hind legs.

Distribution maps for *Ps. ciliata* show it occupying most of the states from Texas to Nebraska and east to the Atlantic Ocean. In Michigan the maps show the species occurring in the southern half of the Lower Peninsula.

According to the CDC, *Ps. ciliata* have tested positive for the presence of Eastern Equine encephalitis (EEE) and West Nile virus (WNV), but there are no confirmative studies indicating the species is a bridge vector for those viruses. Furthermore, although they are considered a nuisance species, they usually occur in low enough numbers compared to other pest mosquito species so are not usually thought of as a major annoyance.

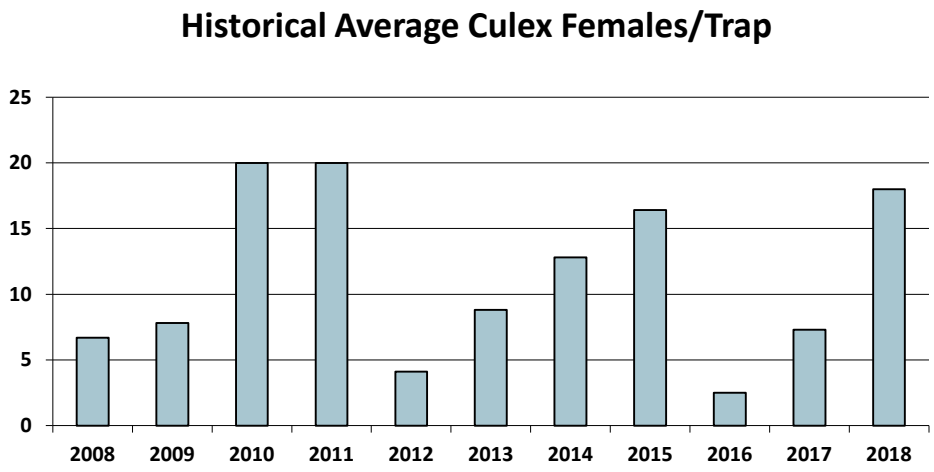
Psorophora ciliata

GRAVID TRAPS

Two *Culex* species, namely *Cx. pipiens* and *Cx. restuans*, are considered the main vectors of West Nile virus in Bay County. The abundance of these species is closely monitored and is used in the risk assessment for West Nile virus transmission. Gravid traps offer another method to collect female mosquitoes; primarily these *Culex* species that have taken a blood meal and are searching for a suitable place to lay eggs (oviposit). This trap is selective for blood-fed female *Culex* mosquitoes; therefore, the traps provide a good means for early West Nile virus (WNV) detection. A solution containing water, brewer's yeast, whey, and guinea pig pellets is allowed to ferment for about a week before it's poured into a plastic tub, over top of which sits the gravid trap. This organically-rich water is the attractant to gravid (egg-bearing) females.

Gravid trap placement ran from June through September with 64 traps capturing 1,551 mosquitoes (1,169 *Culex* species, 30 Ae. japonicus, 18 Cq. perturbans, 5 *Ae. vexans*, 6 *An.quadrimaculatus, 1 An. punctipennis, 1 Cx. territans, 1 Ae. cinereus, 1 Ae. triseriatus, and 319* males). Traps were placed in a variety of locations, including the immediate area of WNV activity. *Culex* mosquitoes collected in gravid traps were grouped together and submitted to Michigan State University (MSU) for WNV-detection. Figure 5 shows a historical view of the average number of *Culex* mosquitoes collected per gravid trap. Collections from 2018 increased substantially, with an average of 18 female *Culex* mosquitoes per trap; however most of the females came from several key locations including a sewage lagoon that produces numerous *Culex* mosquitoes.

Figure 5 – Historical Average *Culex* species per Gravid Trap, 2018



DISEASE SURVEILLANCE

Since the inception of BCMC's program, efforts have been targeted at controlling known disease vectors as well as nuisance mosquito species. While reducing annoyance and improving quality of life are important, the primary goal of our program has always been to reduce mosquito numbers in order to decrease the risk of disease transmission. Since WNV came on the scene in 2001, our efforts at disease prevention and public education have taken on a bigger role.

St. Louis encephalitis, Eastern Equine encephalitis, LaCrosse encephalitis, West Nile virus, and dog heartworm are all mosquito-borne pathogens found in Michigan. Captured mosquitoes are submitted to MSU's Microbiology and Molecular Genetics Department to be analyzed for one or several of these disease agents. West Nile virus was the only pathogen detected this season.

Mosquitoes are submitted in "pools", which are groups of up to 50 mosquitoes of the same species collected from one of various traps that are then placed in a vial and tested for mosquito-borne disease. Five hundred fifteen (515) pools containing 18,160 females representing a variety of species were tested with the following results:

- *Coquillettidia perturbans* (380 pools/15,029 females/no positives);
- *Aedes japonicus* (2 pools/17 females/no positives);
- *Culex restuans/pipiens* (133 pools/3,114 females/**9 WNV-positives**

A positive pool indicates local mosquitoes are infected with West Nile virus and are capable of transmission to humans and other hosts. The positive pools were collected from adult surveillance traps – **57 *Culex***, 25th and Johnson (Gravid Trap), 7/25/18; **50 Culex**, 2 Mile north of Beaver (GT), 7/25/18; **22 Culex**, 204 Grant St. (Light Trap), 7/30/18; **20 Culex**, Almeda Beach/Railroad Tracks (CDC Trap), 8/15/18; **40 Culex**, Wendy's Essexville (GT), 8/15/18; **20 Culex**, Lincoln Road Hall (CDC), 9/24/18; **6 Culex**, Wilder and Four Mile (CDC), 9/24/18; **50 Culex**, Trumbull/26th (CDC), 9/24/18; and **23 Culex**, 204 Grant St. (LT), 9/24/18.

Mosquito surveillance data are useful in tracking virus activity. The minimum infection rate (MIR) is a calculation of the number of infected mosquitoes per 1,000 of a particular species. The higher the MIR, the more elevated the level of viral activity and the greater the chance for human infections. A MIR of 4 or above indicates a high level of viral activity. The MIR for *Culex* mosquitoes at BCMC in 2018 was 0.05; for *Coquillettidia perturbans* and *Aedes japonicus* the MIR was 0. The MIR for *Culex* in 2017 was 0.46.

The Avian Surveillance program was established in 2001 by the Michigan Department of Community Health in collaboration with local health agencies. Bay County citizens report dead birds as one method of WNV surveillance. This season 76 phone calls reporting dead birds throughout the community were received with 88 dead birds reported, most of which were American Crows (36), Blue Jays (18), and blackbirds (Common Grackles/European Starlings) (11). Other species reported were American Robins (9), English Sparrows (8), and Other (6). Dead bird reporting and testing typically produce the earliest evidence of WNV

activity in the county each season.

All dead bird sightings were logged onto Michigan's Emerging Diseases website www.michigan.gov/emergingdiseases. After initial screening by staff, 36 crows or jays were found to be suitable for testing (using the WNV Vector Test™ kit) and **28 tested positive for West Nile virus in-house**. An additional four birds tested by the Michigan DNR (crow, blue jay, starling, and ruffed grouse) were also positive. In all, **32 birds tested positive for West Nile virus in Bay County**. Most of the WNV-positive birds were located in a cluster around the more urban areas of the County (page 47). Tracking WNV risk geospatially allows for targeted mosquito surveillance and control efforts. Compared to 2017, disease activity increased for Bay County.

The Great Lakes states collaborated on West Nile virus monitoring in ruffed grouse in fall 2018. West Nile virus in ruffed grouse has become a topic of concern because of a recent study in Pennsylvania reporting that the virus may have contributed to population declines in areas of lower-quality habitat or where habitat was scarce. While Michigan, Minnesota, and Wisconsin are planning to test samples from grouse in fall 2018, there is no evidence that the virus is having a population-level impact in the Great Lakes region.

There was a high number of positive mosquitoes and birds in Bay County and statewide during the 2018 season. Statewide, there were 104 WNV human cases with eight fatalities, one Eastern Equine Encephaliltis human case, and an additional 12 WNV-asymptomatic blood donors (Table 4 and Figure 6 as of December 31, 2018). Human cases were clustered around Detroit-metro and Grand Rapids-metro areas. As of January 8, 2019, the CDC has reported a total of 49 states and the District of Columbia with 2,544 West Nile virus human cases nationwide and 137 deaths. Forty-four percent of the cases were reported from six states (Nebraska – 245, California – 204, North Dakota – 201, Illinois – 172, South Dakota – 169, and Texas– 133).

Table 4 – Michigan's WNV Human Cases

Year	Total Cases	Fatalities	Year	Total Cases	Fatalities
2018	104	9	2009	0	0
2017	39	1	2008	17	0
2016	43	2	2007	13	2
2015	18	2	2006	55	7
2014	2	0	2005	62	4
2013	36	2	2004	16	0
2012	202	17	2003	19	2
2011	33	2	2002	614	51
2010	29	3			

Figure 6 – Arbovirus Activity, Weekly Summary, as of December 31, 2018

Arbovirus* Activity, Including West Nile Virus:

Final Summary, Michigan 2018

**Arboviruses are viruses transmitted by mosquitoes or other insects*

159 Mosquito pools testing positive for West Nile virus infection

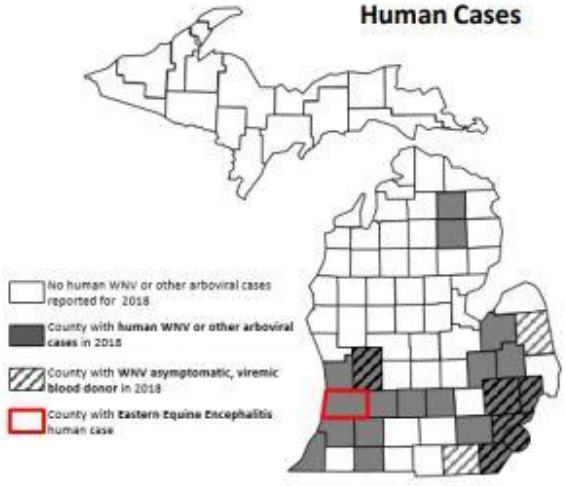
197 Birds testing positive for West Nile virus infection

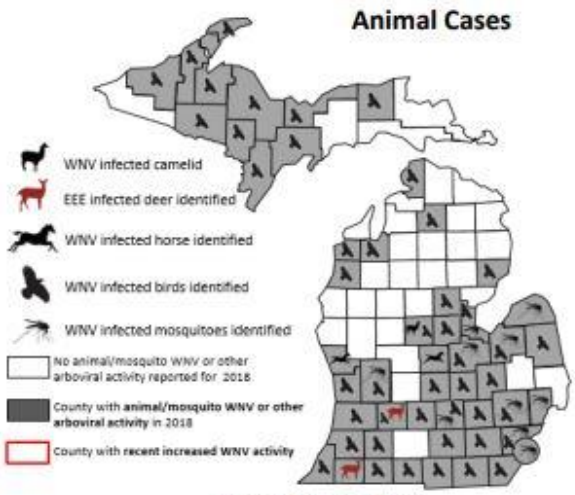
105 Human cases of West Nile virus or other arboviruses reported

2018 Michigan Arbovirus Surveillance *(click links below to see cases by county)*	
West Nile virus Positive Mosquito Pools	**159**
Total Number of Mosquito Pools Tested	**4,142**
Total Number of Mosquitoes Tested	**56,952**
Human WNV cases reported	**104**
WNV asymptomatic, viremic blood donor	**12**
Equine/Other Animal WNV cases reported	**3**
Avian WNV cases reported	**197**
Human Eastern Equine Encephalitis cases reported	**1**
Animal Eastern Equine Encephalitis cases reported	**2**

Highlights

- The Michigan mosquito season has ended. However, travelers to warm weather destinations should continue to protect themselves from mosquito bites.
- In 2018, West Nile virus sickened both Michigan residents (102) and visitors (2), resulting in many hospitalizations and nine fatalities, the most since 2012, when 202 cases and 17 deaths occurred.
- Routine testing of the blood supply identified WNV in 12 Michigan blood donors.
- WNV infected at least two horses (Muskegon, Gratiot), and 1 alpaca (Isabella).
- An Allegan County resident and two white-tailed deer from Cass and Barry Counties were infected with Eastern Equine encephalitis virus (EEE).





MDHHS Michigan Department of Health & Human Services
Bureau of Epidemiology & Population Health
Emerging & Zoonotic Infectious Diseases (EZID) Section

For more information

www.michigan.gov/westnile

JAMESTOWN CANYON VIRUS

The Midwest Center of Excellence for Vector-Borne Disease was established in 2017 with a $10 million grant from the Centers for Disease Control and Prevention to research illnesses transmitted by ticks and mosquitoes and train new professionals who can stop the diseases from spreading. The center is a direct response to the struggle the U.S. faced when Zika arrived and is part of a system of regional groups tasked with studying and preparing for vector-borne diseases. These consortia form the basis of a federal plan to build a barricade against what is seen as a rising threat.

In 2018, in response to a request from Michigan State University researchers who work with entomologists from the Midwest Center of Excellence, Bay County Mosquito Control collected 489 samples (10,771 females) of spring snowmelt *Aedes* and *Anopheles* species mosquitoes, known or suspected vectors of Jamestown Canyon virus. These particular species were collected from all surveillance traps and set aside to be analyzed upon completion of the 2018 season. Results showed that ten of the samples tested positive for Jamestown Canyon virus: 6 *Anopheles quadrimaculatus*, 3 *Anopheles walkeri*, and 1 *Anopheles punctipennis*. The Midwest Center of Excellence also collected *Culex* larvae and egg rafts from the Great Lakes Bay Region in an effort to examine them for insecticide resistance; results are pending.

Jamestown Canyon virus disease is an illness transmitted to people through the bite of an infected mosquito. Symptoms may include a sudden onset of flu-like illness with fever, but severe cases may develop neurologic symptoms such as meningitis or meningo-encephalitis. There is no treatment for the illness other than supportive care. Illness can occur in any age group, but people who work outside or participate in outdoor activities are at greater risk because of exposure to mosquitoes.

The best way to prevent Jamestown Canyon virus disease is to protect yourself from mosquito bites by using repellents registered by the Environmental Protection Agency, wear loose-fitting, long sleeved shirts and pants, keep mosquitoes out of your home by maintaining screens on windows and doors, empty standing water from around your home at least once a week to prevent mosquitoes from using containers as breeding sites, check gutters and remove leaves to ensure proper drainage, tighten loose tarps/covers so water does not pool, tightly cover or screen water storage containers like rain barrels, and recycle old tires or store them where they can’t collect rainwater.

ZIKA VIRUS

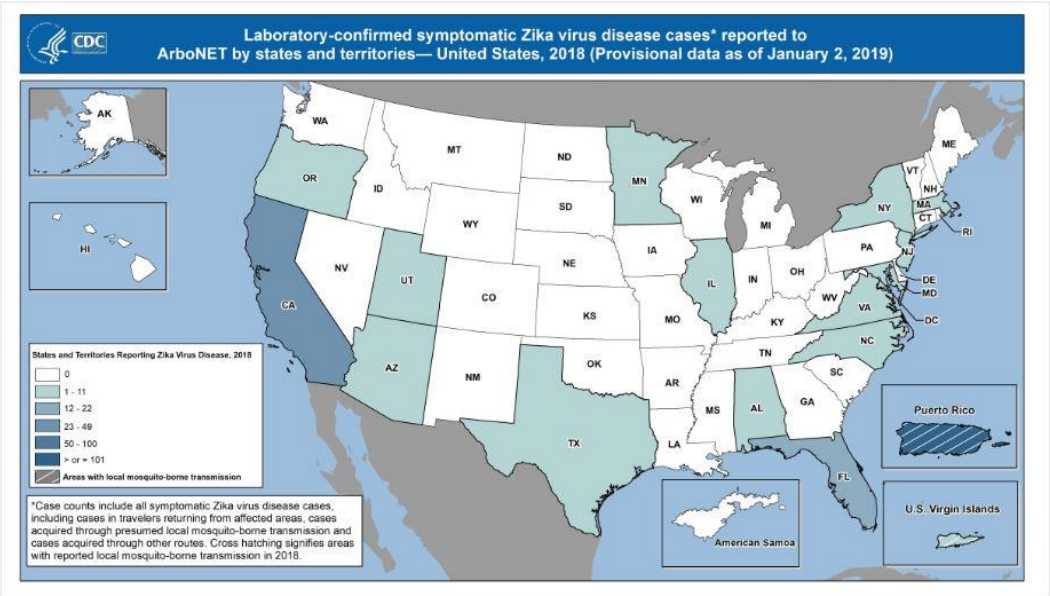
Invasive mosquito species are becoming an increasing concern for mosquito control districts. *Aedes aegypti* (yellow fever mosquito) and *Aedes albopictus* (Asian tiger mosquito) are undergoing range expansion in the United States. These mosquito species are container breeders that often make use of man-made containers such as tires, tarps, and trash for breeding. These species are aggressive human biters and are often found in close proximity to humans and are known vectors of several important human viruses, such as: Yellow fever, Dengue, Chikungunya, and Zika. BCMC has a surveillance program in place for these invasive species, but none have been detected in Bay County. *Aedes albopictus* has been identified as close as Livonia, MI in August, 2017.

Zika virus first appeared in the Western Hemisphere in Brazil in 2015 and spread rapidly throughout Central America. Zika is spread mostly by the bite of an infected *Aedes aegypti* or *Aedes albopictus* mosquito. On February 1, 2016, the World Health Organization declared Zika a public health emergency and the CDC warned pregnant women against traveling to countries with large-scale Zika infections.

Zika can be passed from a pregnant woman to her fetus, which can cause birth defects such as microcephaly. There is currently no vaccine for Zika and while it has not been found in Michigan, local mosquito-borne Zika virus transmission has been reported in Florida and Texas. In the United States from January 1, 2018 – October 31, 2018, there were 64 Zika virus disease cases reported (Figure 7) – all from travelers returning from affected areas (none in Michigan).

Figure 7 – Lab-confirmed Zika cases (no local transmission in the states) – U.S. 2018

Cases by State and Territory



WEATHER

The relationship between weather and mosquito activity is especially important in an IMM approach to mosquito control. Monitoring both rainfall and temperature are paramount in estimating mosquito larval and adult activity. Flooding rain creates ideal breeding conditions for mosquitoes, but what also matters is how long the water remains on the ground after a storm. Average rainfall for Bay County from May 1 through September 30, 2018 was 16.9 inches, 0.82 inches above the average of 16.08 (Figure 8). However, most of that total fell during the last week of August when 3.5-7.1 inches of rain (4.89 inches average) were recorded in light trap rain gauges with the southern portion of Bay County seeing significant flooding.

The most noteworthy weather phenomena during the 2018 season included a colder than average April causing a delay in the commencement of spring aerial treatment, a hot dry summer where May, August, and September were at least four degrees warmer than average, and little flooding noted until the heavy rains of late August and early September that led to high mosquito populations to finish the year.

Figure 9 shows the average weekly rainfall amounts that were measured in a rain gauge network placed throughout the county from May to October. Rain events that drop over an inch of rain are typically sufficient to cause a new hatch of summer floodwater mosquitoes. There were three such rain events that occurred, although the early August rain event was preceded by such dry conditions, that most of the rain water soaked in. The most significant rain event occurred in later August when rains of 6-7" fell throughout the southern portion of the County along the U.S. 10 corridor. Heavy mosquito counts and complaint calls followed two weeks later.

Table 5 lists weather data occurring in Bay County from Nov. 2017-Oct. 2018 and the monthly departures from normal for temperature and rainfall.

Figure 8 – Bay County Total Rainfall May 1 – September 30, 2018 (Observed vs. Historical)

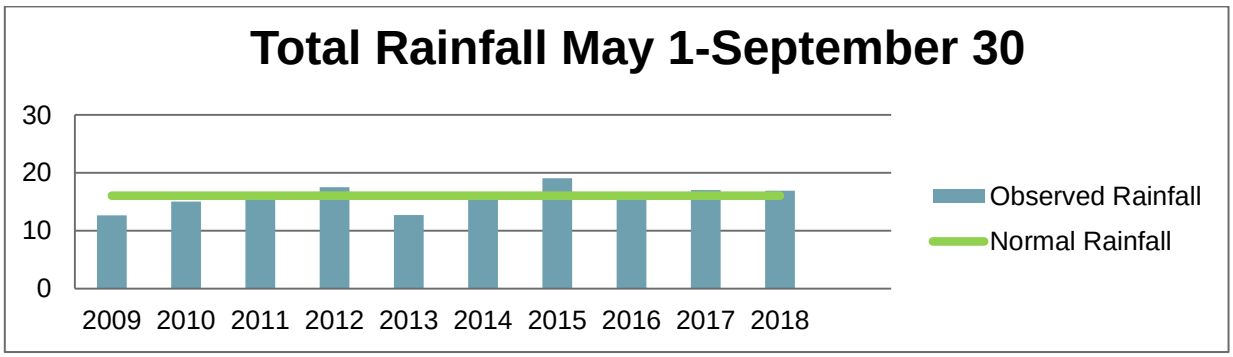


Figure 9 – Average Weekly Rainfall, 2018

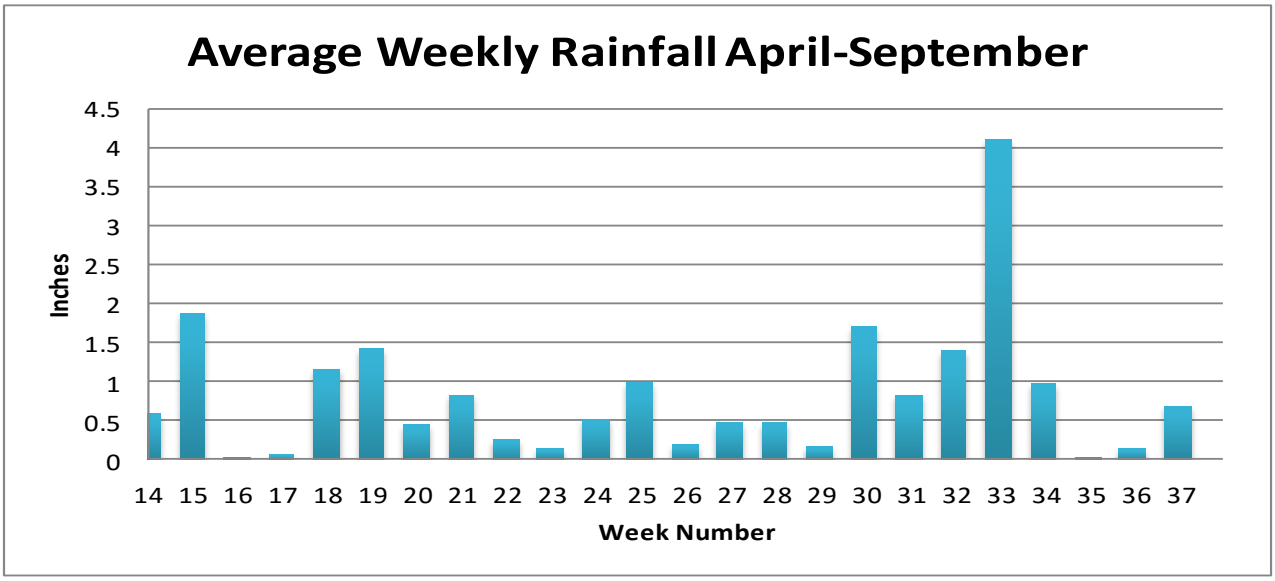


Table 5 – Rainfall and Temperature Data, 2018

Month	Normal Rainfall	2017/18 Rainfall	Departure from Normal	Normal Mean Temp.	2017/18 Mean Temp	Departure from Normal
November '17	2.7"	2.05"	-0.65"	38.5˚	37.7˚	-0.8˚
December '17	1.86"	1.03"	-0.83"	27.3˚	23.5˚	-3.8˚
January	1.71"	1.24"	-0.47"	22.2˚	23.0˚	+0.8˚
February	1.61"	2.69"	+1.08"	24.5˚	27.3˚	+2.8˚
March	2.06"	0.69"	-1.37"	33.7˚	32.6˚	-1.1˚
April	2.89"	2.54"	-0.35"	46.1˚	39.0˚	-7.1˚
May	3.38"	3.85"	+0.47"	57.3˚	63.7˚	+6.4˚
June	2.98"	1.92"	-1.06"	67.2˚	68.4˚	+1.2˚
July	2.58"	1.30"	-1.28"	71˚	73.3˚	+2.3˚
August	3.31"	8.02"	+4.71"	68.8°	72.6°	+3.8°
September	3.83"	1.81"	-2.02"	61.3°	65.1°	+3.8°
October	2.63"	3.22"	+0.59"	49.7°	49.7°	0.0°

SPRING AERIAL LARVICIDING

Aerial larviciding of seasonally flooded woodlots signals the beginning of the mosquito control season and approximately 50,000 acres were treated throughout Bay County. Historically, treatment begins in mid-April, but the actual date is dictated by larval development and weather.

The spring aerial campaign began on April 23 and lasted seven days until April 29; there was one non-treatment day due to wind, but the project was completed in a timely manner. The operation targets larvae before they reach the adult, biting stage. The aerial program has gone on for over three decades in the Great Lakes Bay Region and remains the best way to dramatically decrease numbers of spring *Aedes* mosquitoes. The preferred control method uses a bacterial product known as *Bti* (*Bacillus thuringiensis israelensis*) applied to seasonally flooded woodlots to control mosquito larvae.

Earl's Spray Service, Inc. of Wheeler, Michigan used three aircraft to apply *Bti* to 49,834 woodland acres in the following townships: Bangor (4,054 acres), Beaver (4,637), Frankenlust (970), Fraser (4,463), Garfield (8,160), Gibson (1,769), Hampton (1,177), Kawkawlin (1,907), Merritt (328), Monitor (2,245), Mt. Forest (11,009), Pinconning (5,418), Portsmouth (548), and Williams (3,149).

Calibration, loading, and fueling of the fixed wing aircraft took place at James Clements Airport in Bay City. Sites were treated with VectoBac® *G 5/8 mesh Bti* corncob granules at a dosage rate of 3 pounds per acre.

Pilot Jake Baker during spring aerial treatment

SPRING GROUND TREATMENT

Three staff members helped with aerial quality control, conducting post-treatment surveys in 44 woodlots to assess *Bti* application. After the completion of the aerial treatment program, about ten technicians were brought on board to begin inspections and subsequent ground treatment to manage the larvae or pupae. Field technicians treated woodland pools from April 30-May 18 with larvicide oils or *Bti*, concentrating on smaller woodlots not feasibly treated by aircraft. Ground crews concentrate on sensitive woodlots such as those near eagles' nests, no spray zones, and towers. In the past few years, heavily vegetated woodlots previously treated by ground crews have been re-assigned to the aerial application to increase efficiency.

Table 6 lists the number of acres treated by foot crews and material used in smaller tracts of woodlots during the 2018 spring season. Just over 36 acres received larval treatment by ground crews to control the emergence of pestiferous spring *Aedes* mosquitoes. The crews checked 150 sites, dipping each one, to determine the need for treatment. A total of 81 sites were treated; untreated sites were either dry or were wet with no larval activity. A total of 25.58 lbs. of *Bti*, 17.95 lbs. of Provect 1%, and 26.17 gal. of BVA2 larvicide oil were dispensed at a dosage rate of three pounds/acre, 10 pounds/acre, and 1-2 gallons/acre, respectively.

Pupae were first noted on April 27, but were found en masse on April 30. Significant emergence of spring *Aedes* adults occurred May 7-10. Adult emergence initiated adulticiding, the control of adult mosquitoes through fogging operations.

Table 6 – Spring Ground Treatment of Flooded Woodlots, 2018

Township	Acres Treated	BVA2 (gal)	Provect 1% (lbs)	*Bti* (lbs)
Bangor	0.34	0	1.18	0.68
Bay City East	0.05	0	0.48	0
Bay City West	1.94	1.94	0	0
Frankenlust	0.49	0	4.92	0
Fraser	1.00	0	0	3
Garfield	19.85	18.36	1.23	4.11
Gibson	10.01	5.12	6.1	12.83
Hampton	0.01	0	0.08	0
Kawkawlin	0.67	0	0	2
Monitor	0.98	0	2.14	2.3
Portsmouth	0.08	0	0.82	0
Williams	1.07	0.75	1.00	0.66
TOTAL	**36.49**	**26.17**	**17.95**	**25.58**

SUMMER LARVICIDING

Bay County residents enjoy spending time outdoors during summertime, but the presence of mosquitoes can interfere with outdoor recreation and an enjoyable quality of life. We try hard, therefore, to reduce mosquito numbers so residents can enjoy Michigan's all-too-short summer while also reducing vector mosquitoes.

Our comprehensive mosquito control program focuses on routine surveillance and control of potential breeding sites to prevent adults from emerging. The program involves MDARD-certified technicians applying insecticides to stagnant water throughout the county and/or dumping water from man-made containers (i.e., buckets, pails) that act as breeding habitats. During the breeding season, a team of 18 technicians inspect habitats guided by a database of known breeding sites, citizen complaints, and high trap numbers. Homeowners are notified of property inspections either in person or through the use of a door hanger.

Efforts directed at larval control are accomplished by using bacterial, chemical, or cultural/sanitary methods. The sanitary method relies on a source reduction component to eliminate the breeding source (i.e., scrap tire drives). The district uses several natural bacterial products for control of larval mosquitoes. These include VectoBac®G and VectoBac 12AS (*Bti*), *Bti* Briquets™, VectoLex® FG (*Bacillus sphaericus*) and Natular® XRT and 2EC (*Saccharopolyspora spinosa*). Chemical insecticides routinely used include temephos (Allpro® ProVect 1G and Allpro® ProVect 4E Larvicide), and petroleum-based oil (BVA2 Mosquito Larvicide Oil or Sunspray® MLO).

Larval Sites: The total number of breeding sites changes each year as new sites are added to the database and others are deleted. A total of 25,807 larval site inspections were conducted this season; only 5.5% (1,419) of those required treatment with a larvicide material. Some of these sites were permanent breeding habitats while others were temporary and included ditches, containers, fields, woodlots, tires, idle pools, ornamental ponds, and Saginaw Bay beachfront. Larvae are sampled by quickly skimming the water's surface with a dipper; some are collected and returned to the lab for identification. Technicians also control mosquitoes by dumping water from buckets, pails and other man-made containers (source reduction) on a regular basis. This is the preferred method to eliminate mosquitoes from breeding in containers.

Events: In addition to surveillance and control in neighborhoods throughout the county, special attention is given to summertime outdoor recreational events, such as the Auburn Cornfest, Munger Potato Festival, and River of Time, to name a few. According to the Bay Area Convention and Visitors Bureau, over a half million people attend these types of festivals, which contribute significantly to local economies. Residents participate in a variety of outdoor activities including gardening, biking, walking, golfing, and barbecuing. As activities like these grow in popularity, more and more people spend time outdoors and BCMC strives to control mosquito larvae and pupae to prevent the emergence of large adult mosquito populations. It is

always BCMC's goal to decrease mosquito populations to decrease mosquito annoyance and disease threats.

Ditch Treatments: Bay County's topography is very flat and most roadways are flanked by ditches that divert water from the county's 1,400 linear miles of roads. Many ditches breed mosquitoes because they hold water for extended periods of time. Culverts are often dug deeper than the ditch itself so even if a ditch dries, areas near the driveway culverts often still hold water. So attention is given to monitoring mosquito activity in ditches throughout the county. In fact, surveys are made by lab personnel once each week. Most problems with breeding occur after major rainfall events, which stimulate mosquito eggs to hatch.

This year, ditch trucks logged 2,095 miles treated, which is 58% less than the historical average (Figure 10) as a result of less significant rain events and a basically hot, dry summer until heavy rains fell in late August-early September. Control materials dispensed included 739.25 gallons of Natular 2EC mix (4.5 gallons of Natular 2EC concentrate), 502.49 gallons of VectoBac 12AS liquid *Bti* mix (34.9 gal VectoBac 12AS concentrate), and 7.14 gallons of VectoLex WDG mix. Figure 11 portrays product usage for each township. Most of the treatment (59%) occurred in Bangor, Pinconning, Williams, Merritt, and Fraser Townships with 290, 250, 244, 237, and 209 miles treated, respectively.

Figure 10 – Historical Ditch Truck Miles

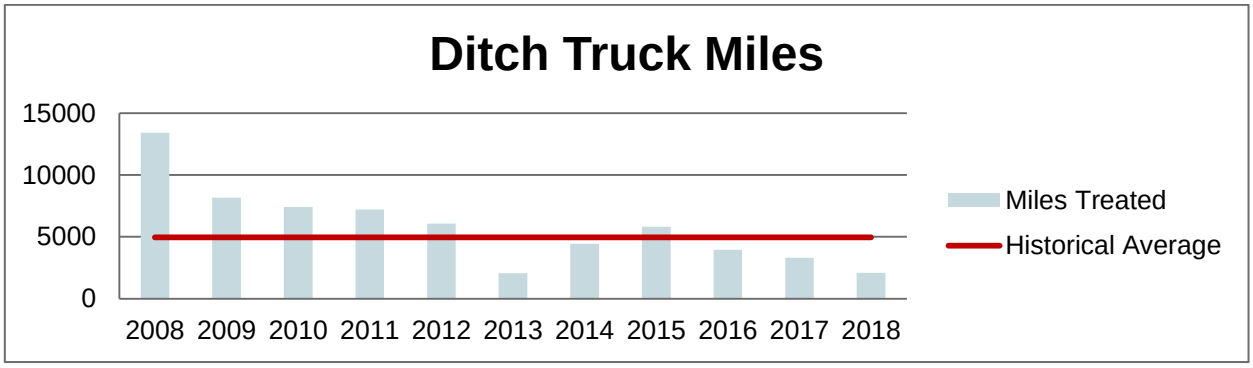
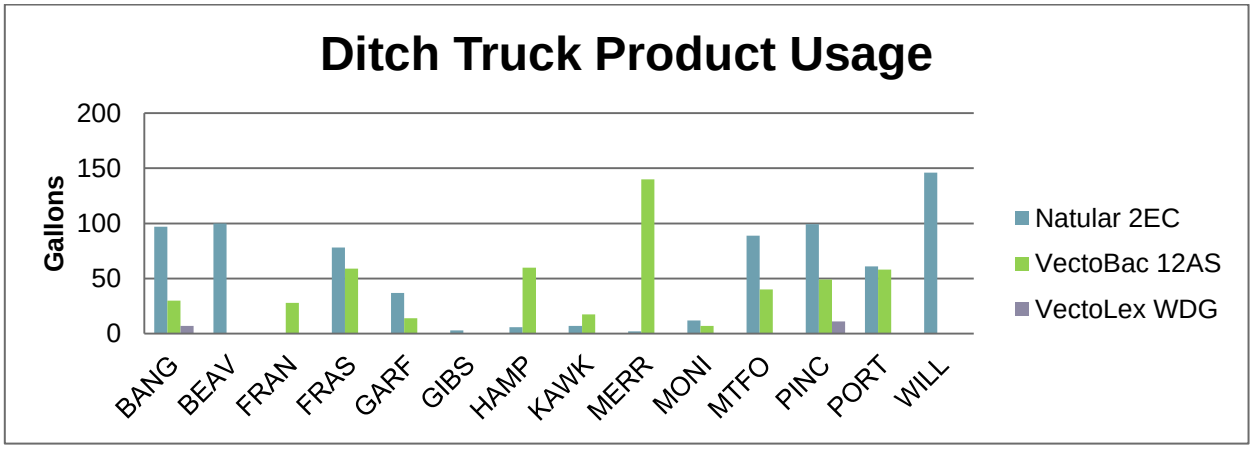


Figure 11 – Ditch Truck Product Usage, 2018



Catch Basins: Treatment of catch basins, or storm drains, will control *Culex restuans* and *Culex pipiens* mosquitoes, known vectors of both St. Louis encephalitis and West Nile virus. These species are not considered nuisance mosquitoes, as they feed primarily on birds; however, controlling disease vectors is extremely important in our efforts to decrease disease potential and maintain public health.

Catch basins may be found along streets, in parking lots, and sometimes in backyards. Staff monitored mosquito breeding in catch basins and treated a total of 30,376 individual habitats. Figure 12 shows the total number of catch basins treated for each township. The bulk of treatment took place in Bay City, Bangor, Hampton, and Monitor Townships, which are the most urban areas of the county and, therefore, areas with the most catch basins. Treatments reduce vector mosquitoes during late summer, the period of time of greatest disease risk to humans.

Catch basins were primarily treated with either Natular® XRT (5,058 individual tablets) or VectoLex® FG bacterial larvicide (747.59 pounds). Basins in Bay City, Bangor Township, and Hampton Township were treated three times with VectoLex, with the first treatment commencing June 5. Basins treated with Natular XRT received a single, season-long treatment. Figure 13 shows the amount of product applied to catch basins in each township or city for the two main products dispensed. VectoLex is applied at 7 grams of granules per catch basin; the dosage rate of Natular tablets is one table per basin.

Figure 12-Total Catch Basins Treated Per Township, 2018

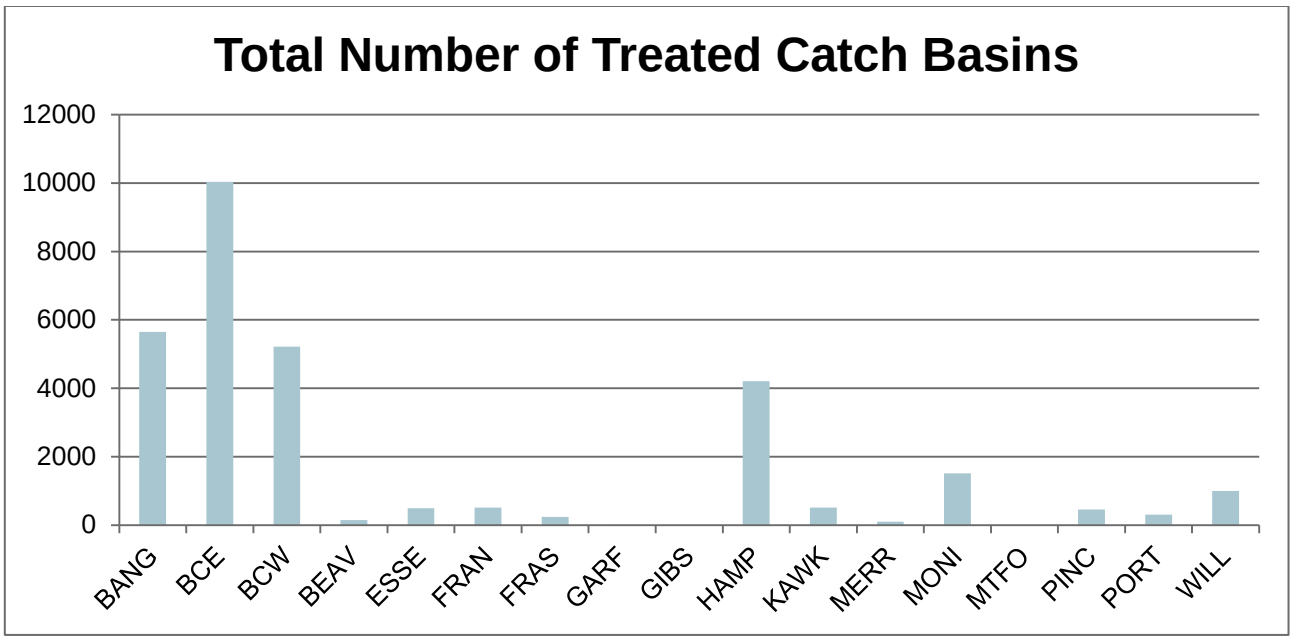
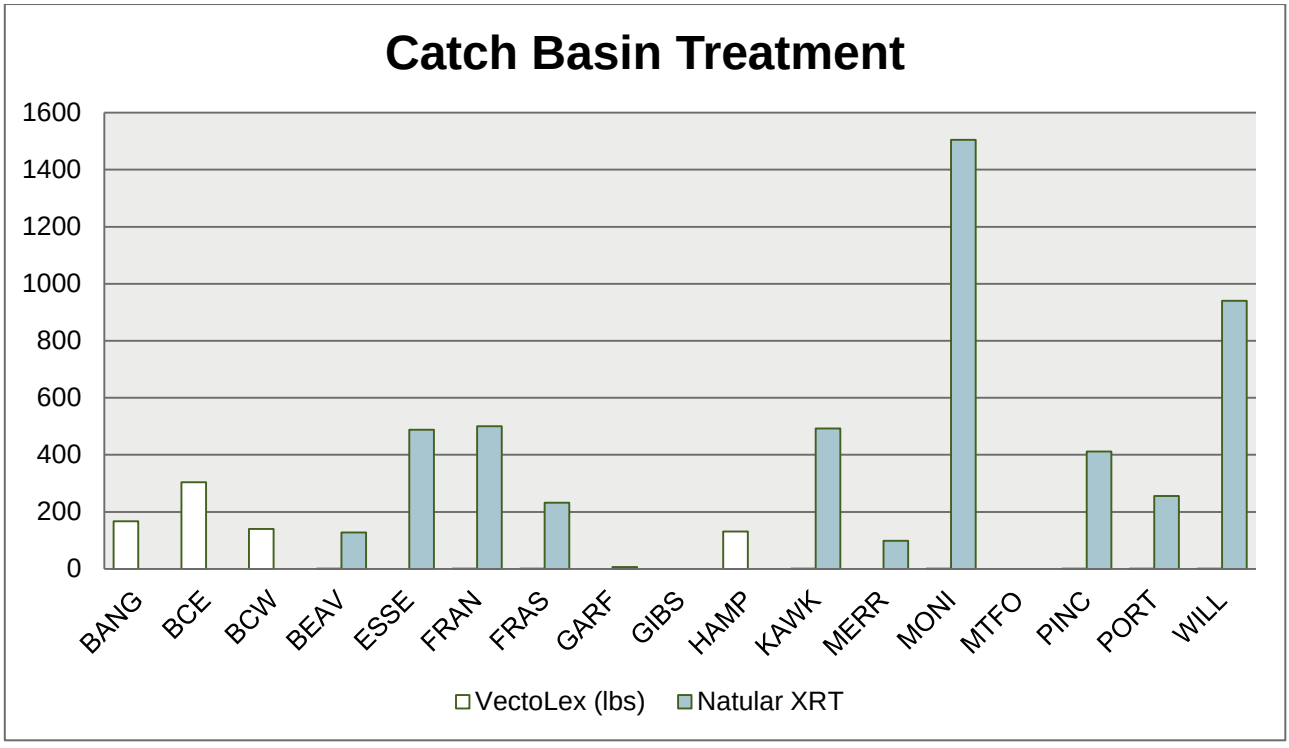


Figure 13 – Catch Basin Treatment By Product, 2018



Retention & Detention Ponds: Bay County is home to approximately 140 retention ponds or detention basins that are designed to manage storm water runoff to prevent flooding. Retention ponds usually include a permanent pool of water in their design, while a detention pond holds storm water for a limited time or until the water either percolates or evaporates, which returns the area to its normally-dry state.

All mosquitoes need water to complete their life cycle, but some species live in permanent and semi-permanent waters while others live in temporary waters. Permanent and semi-permanent water is found in retention ponds, where it's present except during drought periods. Pools of water that accumulate in low-lying areas during and immediately following a flood, like those seen in detention basins, are examples of temporary waters and these waters can produce large populations of floodwater mosquito species. Mosquitoes need a minimum of four consecutive days of stagnant water for larvae to grow to adulthood.

Floodwater mosquitoes are usually the first to appear in detention ponds, but *Culex* and *Anopheles* mosquitoes can also be found. Certified technicians surveyed the ponds making 686 individual visits throughout the summer, 87% of which did not result in treatment. This is a trend often seen in "search and destroy" operations.

When conducting surveys and/or larviciding of these ponds, technicians utilized aerial maps that detailed the location and size of each pond. This gives technicians a way to quickly locate the ponds allowing for more efficient surveillance and treatment.

Sewage Lagoons: Sewage lagoons are a prolific source of mosquitoes, especially *Culex* mosquitoes that prefer permanent, polluted, highly organic water in which to lay eggs. Surface and emergent vegetation along a lagoon's shoreline provide both shelter and food for the developing larvae. This is where most mosquito breeding occurs – in a zone about 10 feet wide from the shoreline outward. Populations of mosquito larvae and pupae in lagoons may become high from time to time in spite of the best prevention efforts, but treatment will quickly bring an infestation under control.

One sewage lagoon was monitored 28 times this season—White Birch Village Mobile Home Park sewage lagoon — resulting in 25 treatments. In order to treat sewage lagoons, a Michigan DEQ Water Treatment Additive permit was obtained.

Search and Destroy: Through data gathered during field surveillance, BCMC technicians conduct daily mosquito surveillance in a variety of habitats in a procedure known as Search and Destroy. This simply means that technicians search for and control immature mosquitoes in various breeding habitats, such as those listed below. In the case of man-made containers, staff will educate and enlist the help of homeowners who are encouraged to dump water from containers or cover them to reduce mosquito breeding.

Man-Made Habitats	Natural Habitats
• Artificial Containers • Idle Pools • Rain Barrels • Catch Basins • Ornamental Ponds • Ponds • Retention/Detention Ponds • Sewage Lagoons • Tires	• Flood Plains • Flooded Fields • Roadside Ditches • Cross Country Drains • Flooded Woodlots

It is important to select the appropriate control material/formulation based on what life stage is encountered in the water habitat. Timing of the application is also crucial as is dosage rate. Technicians leave door hangers when they encounter tires, reminding citizens about the residential scrap tire drives and the need to recycle tires.

The larvicide products utilized during the 2018 season are listed in Table 7 according to where they were dispensed.

Table 7 – Larvicides Dispensed During Search and Destroy Operations, 2018

Twp.	Briquets (each)	Granular Bti (lbs)	Liquid Bti Mix (gal)	BVA2 (gal)	Natular XRT (each)	Provect 1G (lbs)	Provect 4E Mix (gal)	VLex (lbs)	VLex WDG (lbs)
BANG	23.83	128.25	14.78	30.68	123	7.71	8.23	5.27	1.11
BCE	10	16.35		1.23		2.62	2.29	5.69	0.30
BCW	7.5	5.15	1.00	5.22		29.64		20.26	
BEAV	20.25	*8.52		9.16	6	2.13		0.01	
ESSE	2	0.3				0.12			
FRAN	36.5	24.18		1.58		0.38			
FRAS	29	26.3		1.89	28	12.22	2.83		
GARF	20.5	10.74		7.06	9	0.65		0.01	
GIBS	7	*0.53		2.37		3.11		9.61	
HAMP	34.5	51.09	1.00	24.30		0.76	0.42	0.99	0.30
KAWK	10	15.75		32.37	27	6	0.22	119.77	
MERR	16	21.48		0.01		2.82			
MONI	36	80.91		30.01		0.83		14.09	
MTFO	13	*1.06		0.49		2.36			
PINC	5	140.52		2.93	1	2.42			
PORT	8	45.91		3.62		1.60			
WILL	17	27.29		8.11		6.2		0.26	
TOTAL	**296.08**	**604.33**	**16.78**	**161.03**	**194**	**81.57**	**13.99**	**175.96**	**1.71**

*Bti totals include both VectoBac and Sustain brands (only 0.55 lbs Sustain dispensed) brands

Additional control materials: 2 gallons of Natular 2E was applied in Gibson Township; 0.3 ounces Agnique in Williams Township.

Field Technicians Adam Ramseyer and Jim Hughes prepare to treat a mosquito-breeding habitat using Hudson® pressure sprayers

ADULTICIDING

While larval control is the preferred method of treatment, it is virtually impossible to find and treat all breeding sites, so adulticiding (fogging to kill adult mosquitoes in flight) is also a part of the control program. Mosquito numbers vary between seasons and a major contributing factor to this is the amount of rainfall received. While it is not possible to eliminate mosquitoes, it is important to take measures to reduce the risk of being bitten by nuisance or infected mosquitoes. Adult mosquito activity will increase following periods of heavy rains that cause new mosquito broods to hatch.

Fogging adult mosquitoes includes the use of both gas-powered and electric Ultra Low Volume (ULV) machines that allow a relatively small amount of material to be dispensed from the spray unit. Truck-mounted units are fitted with flow control monitors that can adjust the flow rate of the insecticide pump based on truck speed. Label recommendations are strictly followed to assure proper dosage rate and droplet size during application. To accomplish the latter, droplet measurements are taken several times throughout the season. This year, droplet characterization took place on May 1, May 14, and August 8 using a DC-IV droplet measuring device where a probe is inserted into the fog to measure droplet diameters.

Resistance is monitored through bottle bioassays to determine the response of adult mosquitoes to a given insecticide. The bottles are coated with insecticide, adult mosquitoes are added to treated and un-treated bottles, and mortality is measured, which essentially detects possible resistance. We remain vigilant of resistance to pesticides, which may threaten the efficacy of our current control programs and allow the potential for new and re-emerging vector-borne diseases. Two resistance tests run in 2018 showed no resistance to the permethrin products used at BCMC.

Supervisor Ken Misiak exposes the DC-IV probe to the adulticide fog to measure droplet size

When weather conditions are conducive to fogging (temperatures above 50°F and winds below 10 mph), nine certified technicians treat cities and townships that have either the highest mosquito populations or noted disease activity. This year saw the routine use of the permethrin product Masterline® Kontrol 4-4. Mosquitoes must come in contact with the droplets in order for the insecticide to be effective so adulticiding activities take place after sunset when most mosquito species are active and bees have returned to their hives.

For management purposes, Bay County utilizes route maps during adulticiding operations. These road maps of each township show the most efficient route to follow when adulticiding so all roads are treated without skips or re-treatment during a nightly operation. The maps also highlight addresses of medical and no spray residences. Medical residences, of which there are 91 (an 18% increase from 2017), are homes that qualify to be a part of our Medical Needs Program because at least one resident is allergic to mosquito bites or has verifiable medical needs. The medical condition must be confirmed by a medical doctor. No spray residences are homes that prefer not to be treated for mosquitoes; there were 83 in 2018.

During the 2018 season, the "Long Driveway Program" continued. This program is designed to treat inhabited properties that sit a considerable distance off the main road and do not receive adequate adult mosquito control during normal fogging operations. One hundred fifty-four such addresses were placed on route maps to be fogged during routine sweeps, an increase of 8% from 2017.

New in 2018, an online, interactive map was posted on the Mosquito Control webpage created by the Bay County GIS department. This map allowed residents to search by address, as to when the last time their area was fogged and the next intended treatment date.

Table 8 reveals that 19,157 miles were treated during adulticiding operations and 3,922 gallons of Masterline® Kontrol 4-4 were dispensed. Compared to 2017, this is 1,550 fewer gallons of control materials and 3.5% fewer miles treated. This is likely due to a dry summer where mosquito counts were not abnormally high until the end of the treatment season when overtime became prevalent.

Table 8 – Adulticiding Treatment, 2018

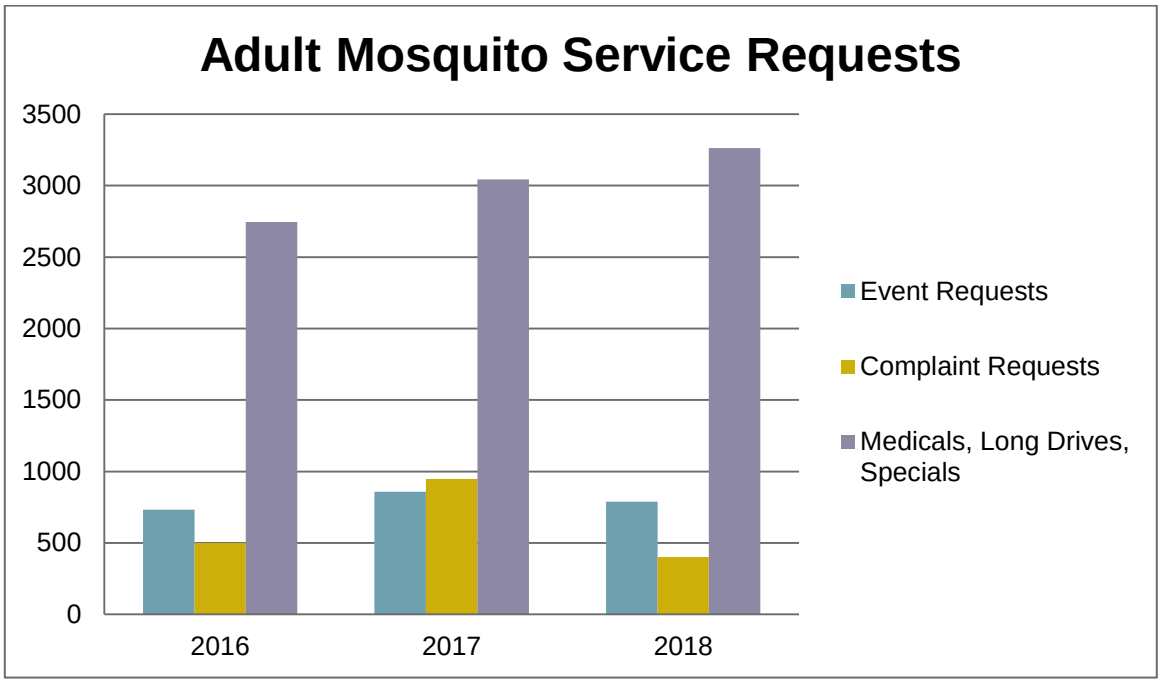
Township	Kontrol 4-4 (gallons)	Miles Treated
Bangor	329.54	1588.21
Bay City East	159.48	746.5
Bay City West	115.84	534.7
Beaver	193.01	994.39
Essexville	31.76	161.4
Frankenlust	166.92	847.14
Fraser	309.99	1443.39
Garfield	155.54	784.91
Gibson	168.89	869.9
Hampton	382.99	1889.5
Kawkawlin	306.94	1552.6
Merritt	157.22	737.5
Monitor	495.57	2327.21
Mt. Forest	175.50	894.01
Pinconning	293.39	1500.01
Portsmouth	227.43	987.2
Williams	251.69	1298.79
Total	**3921.7**	**19157.36**

ADULT MOSQUITO SERVICE REQUESTS

Localized adult mosquito control is done to reduce mosquito annoyance and disease vector populations, a process that supplements the larval control program. These adulticide applications are performed after sampling detects mosquito populations meeting threshold levels in park and recreation areas, for public events, or in response to citizen mosquito annoyance reports. Residents who wish to report mosquito issues on their property call the office and information is submitted to field staff and added to a daily service request log.

Office staff responded to 1,190 phone calls, 788 of which were event requests for backyard mosquito fogging with an additional 402 complaint phone calls for nuisance species. The lower-than-normal complaint calls were indicative of a mostly dry summer with low nuisance species. Technicians also conducted an additional 3,263 individual property treatments for adult mosquitoes, which included a combination of long driveways, medical needs, and specials (i.e., golf courses, marinas, parks). Figure 14 represents a historical profile of adult mosquito service requests. Regardless of the type of service request, all were responded to in a professional, courteous, and prompt fashion.

Figure 14 – Historical Number of Adult Service Requests from Bay County Citizens



POLLINATOR RESPONSE PLAN

As part of the national strategy to reduce the losses of honey bees and other pollinators, the State of Michigan has developed a managed pollinator protection plan (MP3) that is designed to improve and protect the health of pollinators in Michigan by reducing the risk of pesticide exposure, while recognizing that pesticides are important tools for crop, property, and human health protection.

As a community-wide public health program, Bay County Mosquito Control recognizes the importance and protection of pollinators and their role in both native plant pollination as well as agriculture, which is a large part of the Great Lakes Bay Region's economy. BCMC remains diligent in providing an Integrated Mosquito Management program that focuses on mosquito-borne disease prevention as well as quality of life while incorporating strategies to reduce pollinator risk.

The MP3 plan is a non-regulatory document that provides guidance and flexibility to growers, pesticide users, beekeepers, and other stakeholders and encourages best management practices that apply to beekeepers, growers, and pesticide applicators. BCMC follows the Michigan Mosquito Control Association's Mosquito Control and Pollinator Protection Best Management Practices as outlined below:

Best Management Practices

The following best management practices are employed by BCMC to help reduce the risk of control efforts on pollinators:

- Use of larvicide products primarily - target larval stage mosquitoes in standing water, which offers little to no risk to pollinators
- Source reduction – drain standing water when possible to eliminate mosquito larvae
- Minimize pesticide exposure by following Integrated Mosquito Management (IMM) principles and following pesticide label directions
- Ultra Low Volume (ULV) adult mosquito management that applies small amounts of material effective for small insects such as mosquitoes
- Timing of pesticide applications - ULV applications occur after sunset when honey bees and other pollinators are not foraging
- Avoid direct application of spray to flowering plants
- Monitor wind speed so insecticide off-target drift does not occur
- Communication - maintain open and frequent communication with bee keepers to help avoid unwanted impacts on pollinators
- Work with any bee keepers who would like to set up "no spray" status
- Watch MDARD's Drift Watch website for hive locations

VEHICLE MAINTENANCE AND MILEAGE

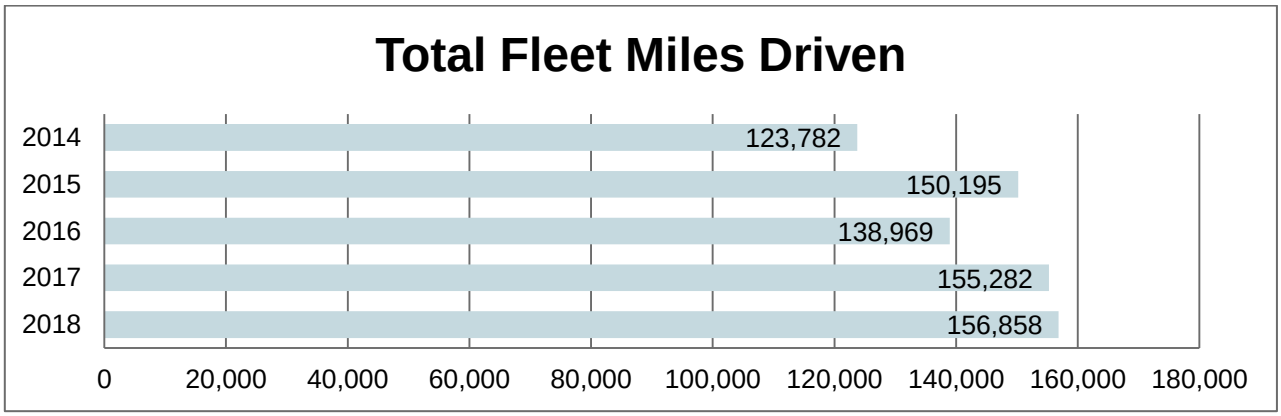
Bay County Mosquito Control's state-certified mechanic maintains the 33-vehicle fleet as well as four Bay County Animal Control vehicles, several Veterans Affairs vehicles and a Gypsy Moth vehicle, which are billed for parts and labor. Besides vehicles, the shop maintains forklifts, ULV foggers, ditch truck sprayers, and various types of equipment (Figure 15). From time to time, specialized equipment is designed and fabricated.

During the 2018 season, as Figure 16 shows, 156,858 miles were driven, which is much below the 27-year average of 181,319 miles and represents 1% more miles driven than in 2017. Two new four-wheel drive trucks and a Chevrolet Traverse were added to the fleet, replacing 3 outdated vehicles sold online through www.1bid.us.

Figure 15 – Vehicle and Equipment Repair

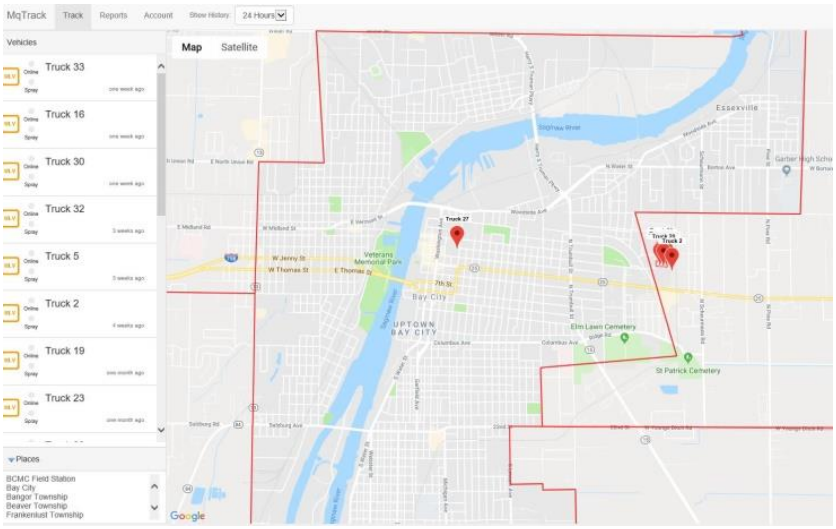
Vehicle and Equipment Repair	
Brake systems – 13	Emission repair - 5
Fuel systems – 2	Exhaust repair – 2
Front end repairs – 6	Vehicle prep – 5
Truck oil changes – 32	Maintenance/Service – 9
Electrical systems – 39	ULV repair/oil – 32
Drive lines – 10	Ditch trucks – 5
New tires – 18	CDC traps/battery packs – 29
Used tire repair – 9	Light traps – 5
Engine repair – 12	Truck wash bay – 1
Air conditioning – 10	Air compressor – 1
Body repair – 14	Pumps – 3

Figure 16 – Historical Vehicle Mileage



FLEET TRACKING

Velocity Systems, LLC of Big Rapids, MI continued implementing a fleet tracking system in 2018. The MqTrack™ system monitors and maps vehicle positioning and collects application rate measurements. The system uses an on-board computer and GPS to track position and rate information as application operations are performed. Live tracking is provided for up-to-the-minute location of vehicles and progress monitoring. Although this system has been implemented for a few years, Velocity Systems continues to work on glitches encountered in the system.



SCRAP TIRE DRIVES

Scrap tire drives are a method of source reduction, the removal or elimination of breeding sources that currently are or have the potential to breed mosquitoes. Two community tire drives were held this season. The first was held on June 2 at the BCMC field station and staff recycled 1,055 tires; an additional 906 tires were recycled during the second late-summer tire drive on August 4.

In 2018, BCMC applied for and received a Scrap Tire Cleanup Grant for up to $8,000 from the Michigan Department of Environmental Quality. The purpose of the grant was to assist property owners and local units of government with the proper removal of abandoned scrap tires and scrap tires at collection sites. The goal of the program was to use available funding to maximize reduction of the public health and environmental concerns associated with scrap tire collection sites, while improving the urban renewal and economic development opportunities.

Semi-trailers were filled at the drop-off location; trailers were then hauled back to Environmental Rubber Recycling where tires were recycled at the Flint facility.

EDUCATION AND OUTREACH

BCMC's outreach program seeks to educate and inform the public about mosquito and West Nile virus prevention methods through presentations, advertising, and media coverage. Presentations are provided to school classrooms and local community groups designed to discuss life cycle, habitats, surveillance, control methods and mosquito-borne diseases. A great deal of education takes place every day through hundreds of personal contacts in the field and calls to the office. Periodic interviews by newspaper, television, and radio allow discussion of news affecting the public, such as spring aerial treatment, summer programs, homeowner property inspections for water elimination, West Nile encephalitis, and scrap tire drives. Press releases are also issued, as needed, if a mosquito-borne disease is detected in the county. Staff training is also held on a regular basis to update staff on various topics including safety, disease activity, and policies and procedures. Brochures and handouts are developed and distributed at various locations and BCMC's website is updated regularly. An updated scrap tire video was also created and available for viewing on Bay County TV (https://www.youtube.com/baycountymi).

We participated in a variety of community events and school classroom presentations throughout the year where an educational booth was set up that included brochures, live mosquitoes, bug boxes, mosquito repellent distribution, and staff present to answer questions on activities and services. In particular, we participated in the Public Health and Wellness Fair for Bay County seniors coordinated by the Bay County Department on Aging, Pollinator Protection meetings, and STEM life cycle presentations were provided to all Bay City Public School first grade classrooms and to two kindergarten classrooms at Bangor Lincoln Elementary.

MEMBERSHIP/CERTIFICATION/MEETINGS

Membership in professional organizations remains vital in accessing updated and new information and maintaining good working relationships with peers. Membership with the non-profit Michigan Mosquito Control Association (MMCA), American Mosquito Control Association (AMCA), and The Entomological Society of America (ESA) are maintained. All are beneficial due to conferences, publications, networking, and legislative advocacy.

All staff members maintain certification with the Michigan Department of Agriculture and Rural Development (MDARD) in both the Core and 7F (Mosquito Control) categories. In addition to two training sessions that were held May 11 and June 11 with new and returning technicians in attendance, MDARD certification testing was offered at the field station for the second time. A presentation was also provided by Kevin Kern, MDARD, on June 13 discussing pesticide use investigations, road check inspections, and question/answer. Several staff members are also pursuing the National Environmental Health Association's e-learning vector control courses through Tulane University's Learning Management System as well as AMCA's (CDC-sponsored) training and certificate program for mosquito surveillance and control.

Full-time staff members were also present for MMCA's 32nd annual meeting at The Radisson Lansing at the Capitol on January 31-February 1, 2018 and the MMCA 2018 Mosquito Control 7F Training Session October 22, 2018 in Bay City, both of which offered continuing education credits. Staff listened to several webinars offered by the AMCA, ESA, Centers for Disease Control and Prevention, National Academies of Sciences, Engineering and Medicine, and Zingerman's. Seminars included the following: It Takes an IPM Village: IPM for a Healthier Home and Community (1-23-18), Tips for Taking Your Service to the Next Level: Wow Your Customers Over the Phone and in Writing (3-14-18), IMM in An Urban Environment (3-27-18), Managing Mosquitoes Around the Home (3-29-18), Using GIS for Mosquito Management (4-24-18), and Arbovirus Surveillance of Tomorrow (12-14-18).

BCMC's program plan was reviewed and approved in January by MDARD as part of our Comprehensive Community Outreach as mandated in Regulation 637. The Technical Advisory Committee (TAC) annual meeting was held March 7, 2018 where the 2017 annual report and 2018 program plan were presented for review and approval.

Staff also attended the 2018 American Mosquito Control Association's annual conference in Kansas City, MO. The AMCA Annual Meeting is the premier education and networking event for researchers, educators, vector control professionals, industry representatives, and students in mosquito control. Every year since 1935, hundreds gather to hear the latest research, share ideas, and form collaborations. Educational sessions and exhibit hall displays help to put attendees on the cutting-edge of the mosquito control field.

Other conferences or meetings where staff attended and/or presented included the 23rd Annual MiCAMP GIS Conference at Boyne Mountain Resort, Bangor Township Green Team Earth Day event, the State of Michigan Earth Day celebration at Constitution Hall in Lansing, Michigan State University Extension

Pollinator Health meeting at the Saginaw Valley Research and Extension Center in Frankenmuth, the Pinconning Rotary Club, and Central Life Sciences Altosid product meeting.

STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

To comply with state and federal regulations on storm water runoff from urban and suburban areas, many communities have implemented new programs to reduce the adverse impact of storm water runoff on streams, rivers, lakes, and estuaries. Compliance at BCMC is achieved by following the MI Department of Environmental Quality's Storm Water Pollution Prevention Plan (SWPPP) that began in July of 2010.

According to permit guidelines, in addition to routine monthly inspections, comprehensive inspections are completed once every six months by a certified storm water operator. The overall objective is to ensure continued use of Best Management Practices (BMPs) and good housekeeping practices as defined by the MDNR. Any leaks, spills or other exposure of significant materials shall be addressed immediately to achieve compliance with permit standards. Additionally, it is imperative to identify any potential sources of storm water contamination and reduce that potential by the greatest extent possible. Robert Kline, Chad Milkowski and Ken Misiak all hold Storm Water Industrial Site Operator certification.

The areas inspected in 2018 included the chemical storage, cold storage, wash bay, garage, and parking lot. Four indoor and three outdoor catch basins were also monitored. Minor vehicle leaks were the main issue observed during inspections. These were cleaned up with Floor-Dry™ granular absorbent or soap, water, and paper towel.

MDARD REGULATION 640 COMPLIANCE

Under MDARD Regulation 640, BCMC must annually apply for status as a registered Bulk Storage Facility. MDARD registers and inspects businesses storing large quantities of agricultural chemicals to help prevent the likelihood of contamination of Michigan's natural resources. The bulk storage program ensures commercial bulk storage facilities are constructed, installed, and maintained in a safe manner with the least possible impact on people, property, and the environment. Mosquito Control has always been found in compliance with bulk storage requirements.

MDARD PESTICIDE POSTINGS

Due to new interpretation of MDARD Regulation 637, Rule 11 by the State of Michigan, mosquito control applicators are now required to place lawn postings when a pesticide application is made to a turf or ornamental site, beginning in 2018. For community-wide mosquito control programs such as BCMC, MDARD has determined postings only need to be placed on a property when the owner has specifically contacted mosquito control to come out and perform a service. This primarily applies to placing postings for personal requests via phone or in person to check standing water or perform a yard spray.

NPDES

Water quality protection has been a long-standing concern in Michigan and an effort to protect Michigan's water resources began early in the twentieth century, with the enactment of the Michigan Water Resources Commission Act (Act 245) in 1929.

The NPDES permit process was initiated by The Federal Water Pollution Control Act amendments of 1972. The purpose of the program is to control the discharge of pollutants into surface waters by imposing effluent limitations to protect the environment. Authority to administer this program was delegated to Michigan by the Environmental Protection Agency (EPA) in October of 1973. Thus, Michigan was one of the first states to be authorized to carry out this program. Currently, authority for NPDES permit issuance rests with the Michigan Department of Environmental Quality (MDEQ).

The MDEQ has issued BCMC a Certificate of Coverage (COC) under the National Pollution Discharge Elimination System (NPDES) General Permit No. MIG030004. The COC authorizes BCMC to discharge biological pesticides and pesticide residues resulting from the application of chemical pesticides to control mosquito and other flying insect pests, in, over, or near to surface waters of the State of Michigan. The original permit expired February 1, 2017, but was reissued until February 1, 2022. This year was the sixth year BCMC was mandated to file a NPDES Annual Report, which was completed and submitted on November 20, 2018 via the MIWaters website. The annual report was approved on November 28, 2018.

The issuance of an NPDES permit or certificate of coverage does not authorize violation of any federal, state or local laws or regulations, nor does it prevent the necessity of obtaining such permits, including any other DEQ permits, or approvals from other units of government as may be required by law.

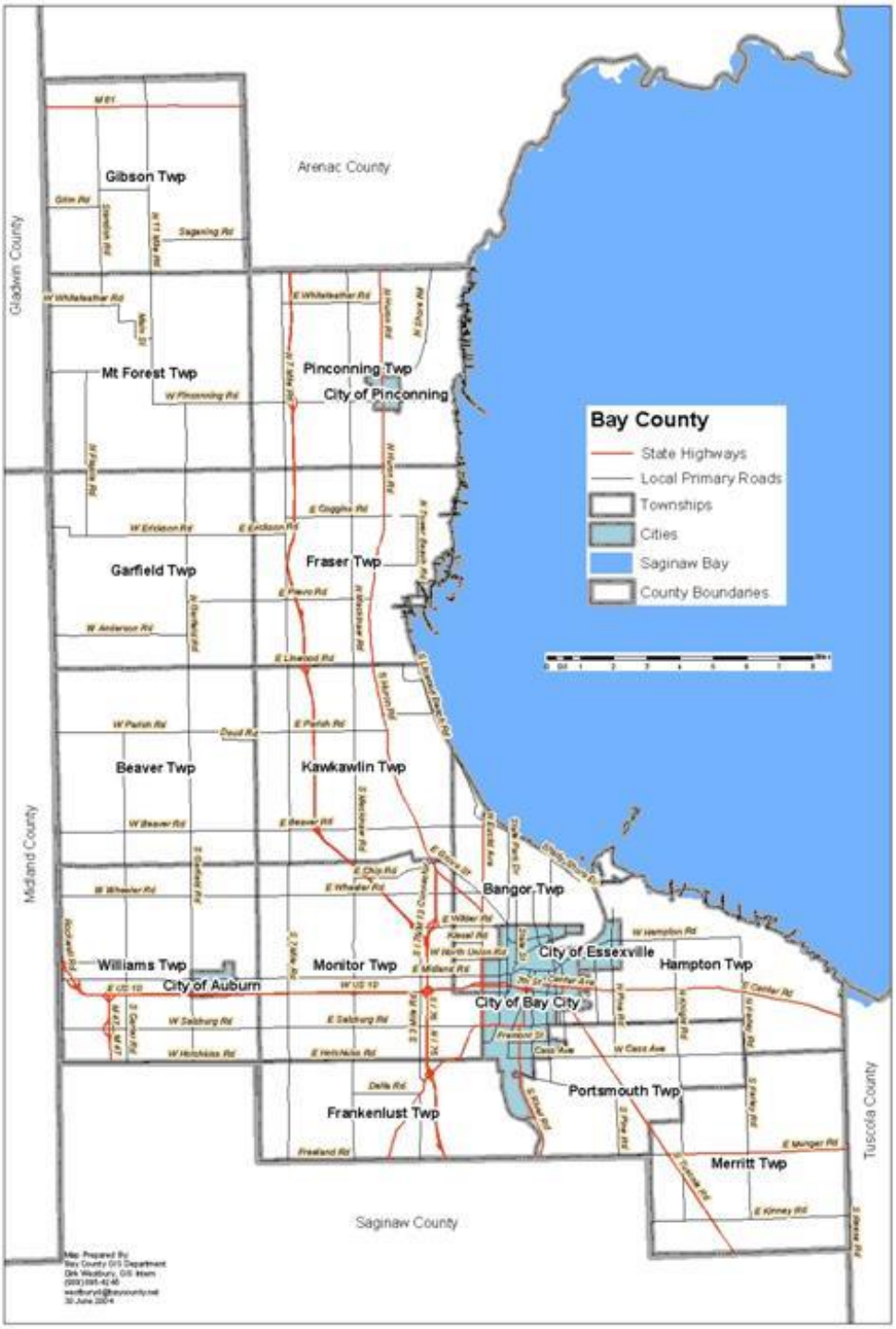
Lastly, BCMC worked with MDEQ in relation to Regulation 637 Rule 7 (Washing and Rinsing Facilities). According to the rule, wash water from equipment that may contain pesticide residue must be stored until tested and then released to the sanitary sewer. In 2018, BCMC worked with Paragon Laboratories, Livonia, MI to develop a wash water rinsate test for permethrin residue. Paragon analyzed two samples with results received on June 27 and August 24, 2018. Wash water was released the following day after notifying the Bay City Waste Water Treatment Plant, per protocol established by the MDEQ, Bay City WWTP, and BCMC.

Table 9 – Control Material List, 2018

Control Materials

Trade Name	Application Rate	Active Ingredient Dosage
AllPro® ProVect 1G	10 lb/acre	0.1 lb temephos/acre
AllPro® Provect 4E	1.5 fl oz/acre	0.048 lb temephos/acre
Agnique® MMF	0.2-1 gal/acre	0.2-1 gal alcohol-based surface film/acre
BVA2 Mosquito Larvicide Oil	1-3 gal/acre	0.97-2.91 gal petroleum distillates/acre
Bactimos Bti Briquets™	1briquet/100 sq ft	7000 *Aedes aegypti (AA*) Bti ITU/mg
VectoBac® G	3-5 lb/acre	0.273-0.4555 billion Bti ITU/acre
VectoBac® 12AS	0.25-2 pints/acre	0.605-1.21 billion Bti ITU/acre
VectoLex® FG	5-80 lb/acre	0.115-1.84 billion BsITU/acre
VectoLex® WDG	0.5-1.5 lb/acre	0.1495-0.4485 billion BsITU/acre
Natular™ 2EC	1.1-2.8 fl oz/acre	0.018-0.045 lb spinosad/acre
Natural™ XRT	1 tablet/CB	6.25% spinosad/tablet
AllPro® Sustain MBG	5-10 lb/acre	0.91-1.82 billion Bti ITU/acre
Sunspray® MLO	1-3 gal/acre	0.988-2.964 gal petroleum distillates/acre
Masterline® Kontrol 4-4	0.67 fl oz/acre	0.00175 lb permethrin/acre 0.00175 lb PBO/acre

BAY COUNTY MAP



BAY COUNTY 2018 WNV-POSITIVE BIRDS