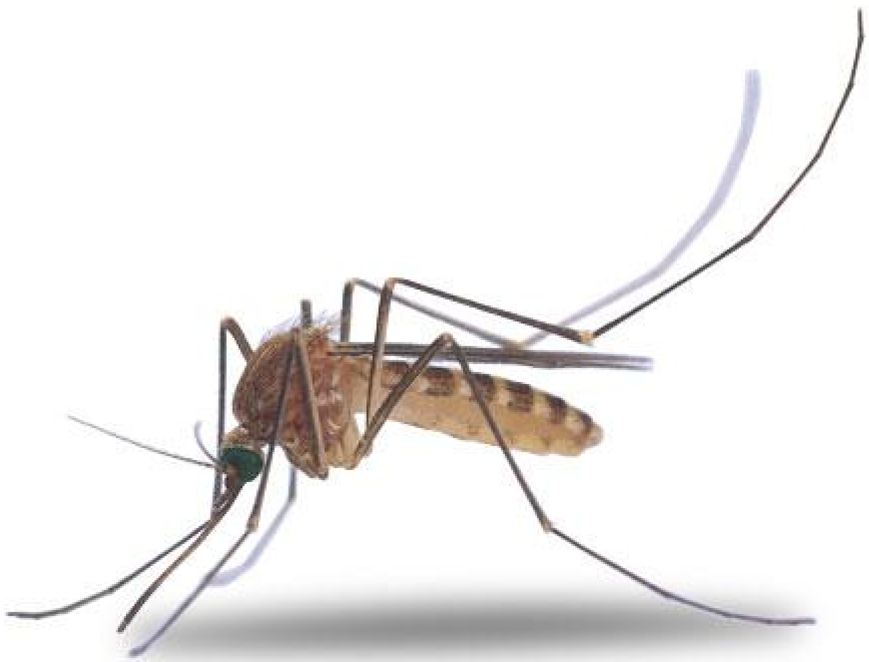
2015 Operational Review & Plans for 2016

Annual Report to the Technical Advisory Board

Metropolitan Mosquito Control District



Metro Counties Government Center ~ 2099 University Avenue West ~ St. Paul, MN 55104-3431
www.mmcd.org

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Metropolitan Mosquito Control District

Mission

The Metropolitan Mosquito Control District's mission is to promote health and well-being by protecting the public from disease and annoyance caused by mosquitoes, black flies, and ticks in an environmentally sensitive manner.

Governance

The Metropolitan Mosquito Control District, established in 1958, controls mosquitoes and gnats and monitors ticks in the metropolitan counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington. The District operates under the eighteen-member Metropolitan Mosquito Control Commission (MMCC), composed of county commissioners from the participating counties. An executive director is responsible for the operation of the program and reports to the MMCC.

Metropolitan Mosquito Control Commission 2016

Julie Braastad	Anoka County
Rhonda Sivarajah	Anoka County
Robyn West	Anoka County
James Ische	Carver County
Tom Workman	Carver County
Thomas Egan	Dakota County
Mike Slavik	Dakota County
Liz Workman	Dakota County
Jan Callison	Hennepin County
Jeff Johnson	Hennepin County
Randy Johnson	Hennepin County
Blake Huffman	Ramsey County
Mary Jo McGuire	Ramsey County
Janice Rettman	Ramsey County
Barbara Marschall	Scott County
Tom Wolf	Scott County
Gary Kriesel	Washington Co.
Fran Miron	Washington Co.

Technical Advisory Board

The MMCC formed the TAB in 1981 to provide annual, independent review of the field control programs, to enhance inter-agency cooperation, and to facilitate compliance with Minnesota State Statute 473.716.

Technical Advisory Board Members 2015-2016

Gary Montz, Chair	Mn Dept. of Natural Resources
Donald Baumgartner	US EPA
Phil Monson	Mn Pollution Control Agency
Roger Moon	University of Minnesota
John Moriarty	Three Rivers Park District
David Neitzel	Mn Department of Health
Susan Palchick	Hennepin Co. Comm. Health
Robert Sherman	Independent Statistician
Vicki Sherry	US Fish & Wildlife Service
Sarma Straumanis	Mn Dept. of Transportation
Christine Wicks	Mn Dept. of Agriculture

Metropolitan Mosquito Control District Contributing Staff

Stephen Manweiler	Executive Director
Sandy Brogren	Entomologist
Diann Crane	Assistant Entomologist
Janet Jarnefeld	Technical Services/Tick
Kirk Johnson	Vector Ecologist
Carey LaMere	Technical Services
Mike McLean	Public Affairs
Nancy Read	Technical Services Coordinator
Mark Smith	Tech. Serv./Control Materials
John Walz	Technical Services/Black Fly

METROPOLITAN MOSQUITO CONTROL DISTRICT

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Saint Paul, MN 55104-3431

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May 21, 2016

Dear Reader:

The following report is the Metropolitan Mosquito Control District's (MMCD) 2015 Operational Review and Plans for 2016. It outlines program operations based on the policies set forth by the Metropolitan Mosquito Control Commission (MMCC), MMCD's governing board of elected county commissioners.

The report has been reviewed by the Commission's Technical Advisory Board (TAB). TAB's charge is to comment on and make recommendations for improvements in the District's operations, on an annual basis. The minutes and recommendations from the TAB meeting in February 2016 are included in this report.

TAB's recommendations and report were accepted by the Commission at their April 2016 meeting. The Commission approved the MMCD 2015 Operational Review and Plans for 2016 and thanked the TAB for their work.

Please contact us if you would like additional information about the District.

Sincerely,

Stephen A. Manweiler
Executive Director

Minnesota Department of Natural Resources
500 Lafayette Road • St. Paul, MN • 55155-40

Commissioner Robyn West, Chair
Metropolitan Mosquito Control Commission
2099 University Avenue West
St. Paul, MN 55104

Dear Commissioner West,

The Technical Advisory Board (TAB) met on February 23, 2016 to review and discuss MMCD operations in 2015 and plans for 2016. Since the Board's formation in 1981, the member representatives have met at least once per year to provide independent review of field control programs and to enhance inter-agency cooperation.

After an excellent interchange of questions and information between the TAB and MMCD staff, the TAB approved the following resolutions.

1. That the TAB commends MMCD for its general practice of looking at both efficacy and environmental effects for new products. The TAB also recommends that MMCD staff preserve remaining 2014-2015 nontarget study samples, and discontinue processing until decisions are made regarding further Natular use operationally.

2. That the TAB commends MMCD for working with beekeepers in the metro area, and for MMCD's efforts to identify and follow best management practices for pollinator protection.

3. That the TAB commends the District for maintaining surveillance and control of exotic mosquitoes, including potential vectors of Zika virus.

Sincerely,

Gary Montz,
Chair, Technical Advisory Board

Research Scientist 2
MN DNR, Division of Ecological and Water Resources

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APPENDICES

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Executive Summary

The Metropolitan Mosquito Control District (MMCD or the District) strives to provide cost-effective service in an environmentally sound manner. This report presents MMCD staff efforts to accomplish that goal during 2015 through mosquito, black fly and tick surveillance, disease monitoring, mosquito and black fly control, new product testing, data management, and public information. It also presents plans for 2016 as we continue to provide an integrated mosquito management program for the benefit of metro area citizens.

Surveillance

Average rainfall in the District from the weeks of May 4 through September 21, 2015 was 24.02 inches, which is 4.56 inches above the 56-year District average of 19.46 inches. Major precipitation amounts occurred each month with July receiving the highest number of rain events. Overall, the District experienced eleven major mosquito broods this season.

Spring *Aedes* adult populations were well below average and, despite the abundant rainfall, the amount of summer *Aedes* was below the 10-year average. The cattail mosquito, *Coquillettidia perturbans,* was more numerous than the last two years, but less than average.

The average number of adult black flies captured in 2015 was 0.17, which was the lowest overall average collected in the overhead net sweep samples since the program started in 1984. At the start of the large river control program in 1996 through 2014, the average was 1.47. Prior to any *Bti* treatments on the large rivers, the average net sweep count was 14.80.

The District continued to monitor the distribution of ticks in the metro area. The average number of *Ixodes scapularis* (deer tick or black legged tick) collected per mammal (1.45) in 2015 is a new record high but it is comparable to the averages experienced in recent years. Additionally, the number of sites where *I. scapularis* occurred in 2015 is also a new record high (81 out of 100); this is the first time we detected *I. scapularis* in 80 or more sites.

Disease

District staff provides a variety of disease surveillance and control services, as well as public education, to reduce the risk of mosquito-borne illnesses such as La Crosse encephalitis (LAC), western equine encephalitis (WEE), eastern equine encephalitis (EEE), and West Nile (WNV) encephalitis, as well as tick-borne illnesses such as Lyme disease and human granulocytic anaplasmosis (HGA). WNV was confirmed in six Minnesota residents; three of these cases were recorded in the metro area. There was one LAC case recorded in Minnesota, outside the District. As part of our efforts to reduce risk of LAC, more than 24,000 used tires were collected and recycled.

MMCD continues to use public education to reduce risk of tick-borne illness. MMCD posts a “Tick Risk Meter” which is updated regularly on www.mmcd.org and on MMCD’s Facebook page. Signs are also posted in several metro-area dog parks to educate the public about tick-borne disease risk, and to remind people about MMCD’s tick identification service.

Control

MMCD's program focuses on control of mosquitoes while they are in the larval stage, and uses the insect growth regulator methoprene, the bacteria *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *B. sphaericus*, and the bacterial product spinosad. Due to the extensive rainfall and flooding of larval habitats, larvicide treatments hit a record in 2015 (326,571 acres), surpassing a record set in 2014. A cumulative total of 249,049 catch basin treatments were made in three rounds to control vectors of WNV. Adulticide acreage and related customer calls decreased in 2015.
To control black flies in the metro area, MMCD treated 48 small streams sites with *Bti* when the *Simulium venustum* larval population met the treatment threshold. MMCD made 96 treatments to large river sites when larval population of the target species met the treatment threshold.

Product and Equipment Testing

Quality assurance processes focused on product efficacy, new product evaluations, equipment, and waste reduction. Another trial was run testing Natular G for cattail mosquito control, and in this case found only a modest reduction in mosquito numbers. A follow-up to the 2014 Natular nontarget trials was done concurrently in these test sites, as directed by members of the Technical Advisory Board (TAB), and found no decrease in the main organisms of interest (scuds, isopods). Equipment calibration continued to be a priority. Due to a recent EPA label change, we conducted droplet spectrum evaluations on our barrier spray units and tested modifications to our backpacks to meet the new requirements.

Data Management and Public Information

The District values data-based decision making and is continually improving data and mapping systems. In 2015, we continued our transition to web-based data entry systems. We provide treatment data to the public through our web site, and provide data in compliance with the National Pollutant Discharge Elimination System (NPDES) and other regulatory requirements.

MMCD has also increased its efforts to contact beekeepers to document bee hive locations and ensure that mosquito control activity has minimal effect on bees.

In 2015, MMCD continued to refine its sustainability strategy. We established specific quantifiable sustainability goals in each of these areas: 1) reducing energy usage; 2) reducing waste; 3) identifying and using renewable resources; and 4) promoting social responsibility/health and wellness. The 2015 Sustainability Report is available through our website, www.mmcd.org.

Chapter 1 Mosquito Surveillance

2015 Highlights

- Rainstorms produced eleven major mosquito broods
- Warm, dry, late spring; very wet July
- Major mosquito peak occurred in July
- Identified nearly 30,000 larval samples
- Collected 19 *Culex erraticus* adults, up from 3 in 2014, down from 599 in 2012
- *Aedes albopictus* larvae found at tire recycling facility in Savage

2016 Plans

- Evaluate placement of CO_2, gravid, and New Jersey traps
- Continue to monitor and study *Ae. japonicus*
- Maintain surveillance for *Ae. albopictus* and remain aware of other potential invasive species
- Continue to refine *Cs. melanura* surveillance

Background

The Metropolitan Mosquito Control District (MMCD or the District) conducts larval and adult mosquito surveillance to determine levels of mosquitoes present, measure annoyance, and to detect the presence of disease vector species. A variety of surveillance strategies are used because different mosquito species have different habits and habitat preferences. The District strives to obtain a complete picture of the mosquito population by weekly monitoring of host-seeking, resting, egg laying, and larval mosquitoes. By knowing which species are present in an area, and at what levels, the District can effectively direct its control measures.

There are 51 known mosquito species in Minnesota, all with a variety of host preferences. Forty-five species occur in the District, 24 of which are human-biting. Other species prefer to feed on birds, large mammals, reptiles, or amphibians. Mosquitoes differ in their peak activity periods and in how strongly they are attracted to humans or trap baits (e.g., light or CO_2), therefore, we use a variety of adult mosquito collection methods to capture targeted species.

The District focuses on four major groups of human-biting mosquito species: spring *Aedes*, summer *Aedes*, *Coquillettidia perturbans,* and disease vectors. Snowmelt induces spring *Aedes* (15 species) eggs to hatch in March and April and adults emerge in late April to early May. These species have one generation each season and adults can live for three months, and lay multiple batches of eggs. Rainfall and warmer temperatures prompt the summer *Aedes* (five species) to begin hatching in early May. These species can have several generations throughout the summer and adults can live up to two weeks. *Coquillettidia perturbans*, the single generation “cattail mosquito”, develops in cattail marshes and its peak emergence is in early July. Disease vectors include *Aedes triseriatus, Culiseta melanura*, and *Culex* mosquitoes (*Cx. pipiens*, *Cx. restuans*, *Cx. salinarius*, and *Cx. tarsalis*). Adults are evident in early summer and they can produce multiple generations per year. Appendix A contains a species list and detailed descriptions of the mosquitoes occurring in the District.

2015 Surveillance

Rainfall

Rainfall surveillance is an important tool used to estimate the amount of larval production and to determine where to dispatch work crews following a rain event. Generally, an inch or more of rain can produce a hatch of floodwater mosquitoes. Rain data are collected from District-operated gauges and volunteers in the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network, a group of thousands throughout the country who input their precipitation data into one database. By joining this network we are able to share data in a timely manner. Data from 144 gauges during May through September were used for summaries in this document.

Average rainfall in the District from the weeks of May 4 through September 21, 2015 was 24.02 inches, which is 4.56 inches above the 56-year District average of 19.46 inches. Major precipitation amounts occurred each month with July receiving the highest number of rain events (Fig. 1.1).

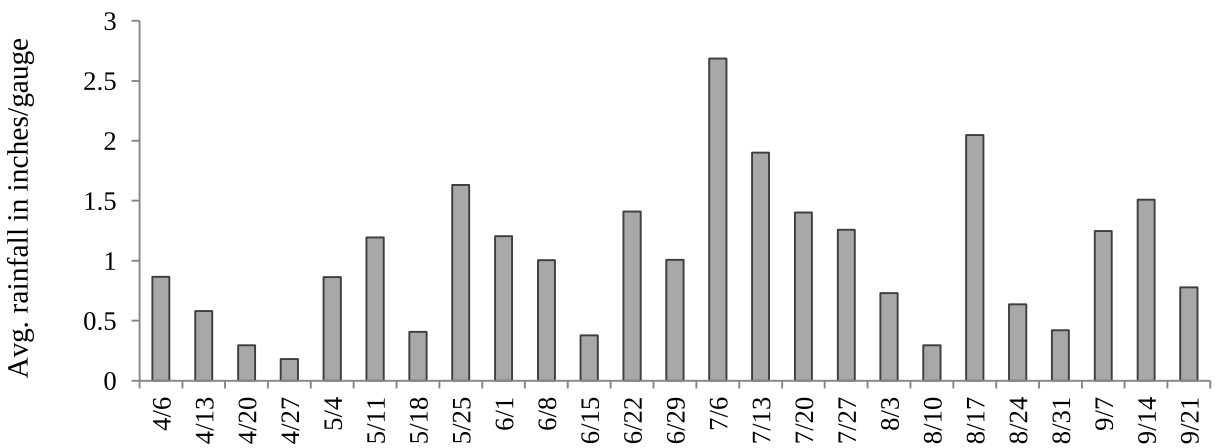


Figure 1.1 Average rainfall amounts per gauge per week (Saturday – Friday), 2015. The number of gauges varied from 95-125. Dates represent the Monday of each week.

Typically, spring *Aedes* mosquitoes larvae develop over a period of months (mid-March to early May), and summer species develop over a period of days (7-10). March and April had above average temperatures and below normal precipitation (Fig. 1.2). Water temperature and precipitation amounts influence how quickly larvae develop in sites. The dry spring conditions delayed the start of the mosquito season by two weeks. The first larval sample of the year was taken on March 30. Cool rain events in April caused spring *Aedes* and some summer *Aedes* larvae to hatch. Rain on May 8 resulted in our first summer *Aedes* hatch.

Warm weather in April and May resulted in the Freshwater Society declaring ice-out on Lake Minnetonka on April 5, earlier than the normal date of April 14, and 19 days earlier than 2014. Although July temperatures were slightly below normal, rainfall was far from it.

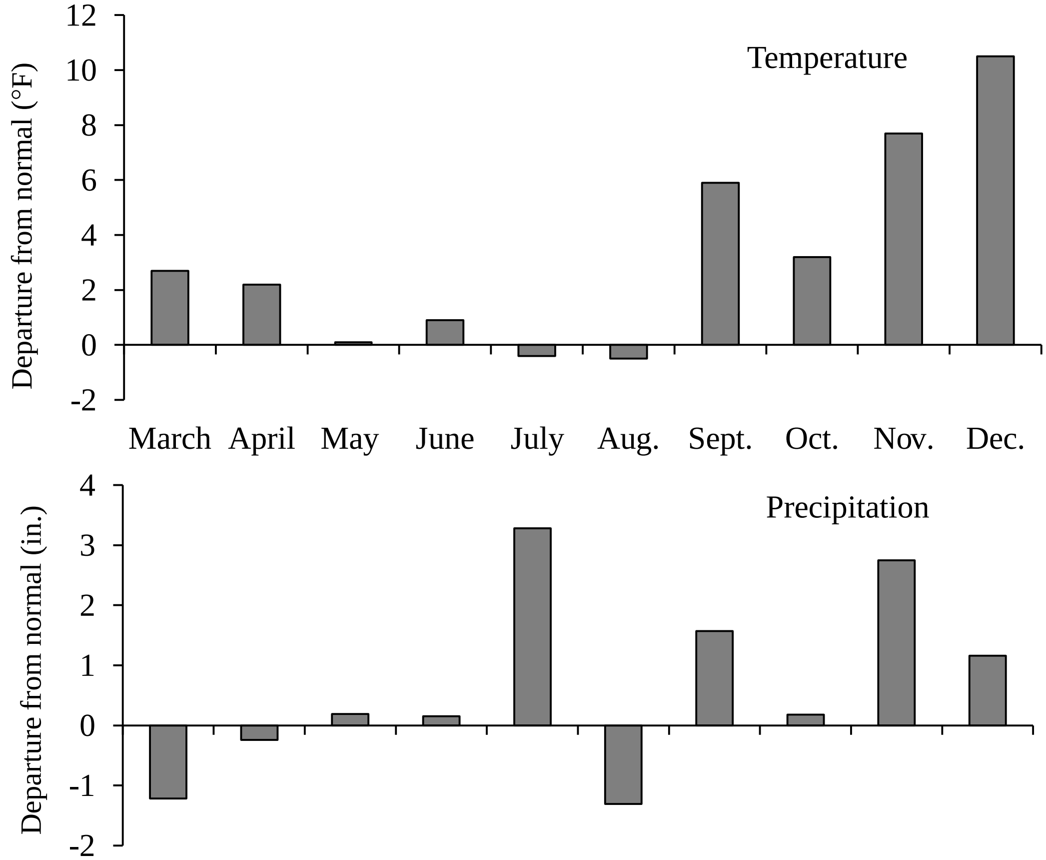


Figure 1.2 Monthly departures from normal for temperature and precipitation March-December, 2015 (source: National Weather Service, Twin Cities Station).

As is typical, there was one large spring *Aedes* brood in 2015, followed by 18 rainfall events sufficient to produce summer *Aedes* broods. Eleven large broods and seven small to medium sized broods occurred from May - September; the amount of area affected by rainfall, the amount of rainfall received, and the resultant amount of mosquito production determines brood size. Six large broods occurred between June 22 and July 28 – one brood per week for six weeks, which kept staff very busy.

Figure 1.3 depicts the geographic distribution and magnitude of weekly rainfall received in District gauges from April through September 2015. Since some weeks had multiple rain events and broods, the cumulative weekly rainfall does not identify individual rain events.

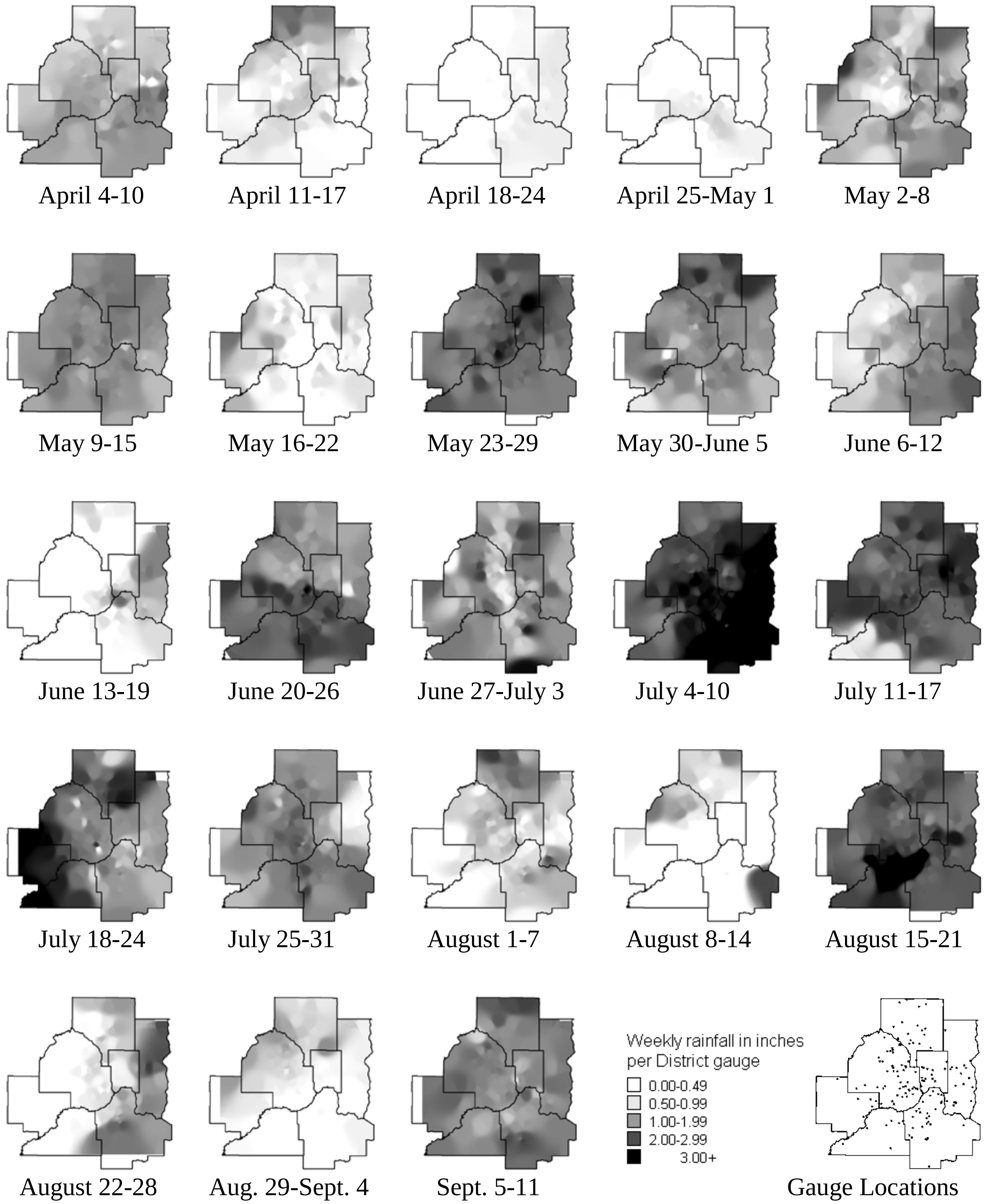


Figure 1.3 Weekly rainfall (Saturday-Friday) in inches per District gauge, 2015. The number of gauges varied from 95-125. A map of the rain gauge locations is included. Inverse distance weighting was the algorithm used for shading of maps.

Larval Collections

Larval mosquito inspections are done to determine if targeted species are present at threshold levels or to obtain species history in development sites. A variety of habitats is inspected to monitor the diverse fauna. Habitats include wetlands for *Aedes* and *Culex*, catch basins and stormwater structures for *Cx. pipiens* and *Cx. restuans*, cattail marshes for *Cq. perturbans*, tamarack bogs for *Cs. melanura*, and containers, tires, and tree holes for *Ae. triseriatus*, *Ae. albopictus*, and *Ae. japonicus*. The majority of larval collections are taken from floodwater sites using a standard four-inch dipper. The average the number of larvae collected in a minimum of 10 dips is recorded as the number of larvae per dip. Larvae are placed in sample vials, and sent to the Entomology Lab for species identification.

To accelerate the identification of samples from sites to be treated by helicopter, larvae are identified to genus only, except for *Culex* larvae, which are identified to species to differentiate vectors. Staff process lower priority samples as time permits and those are identified to species. In 2015, lab staff identified 29,573 larval samples, the second highest amount in the last 26 years (Figure 1.4).

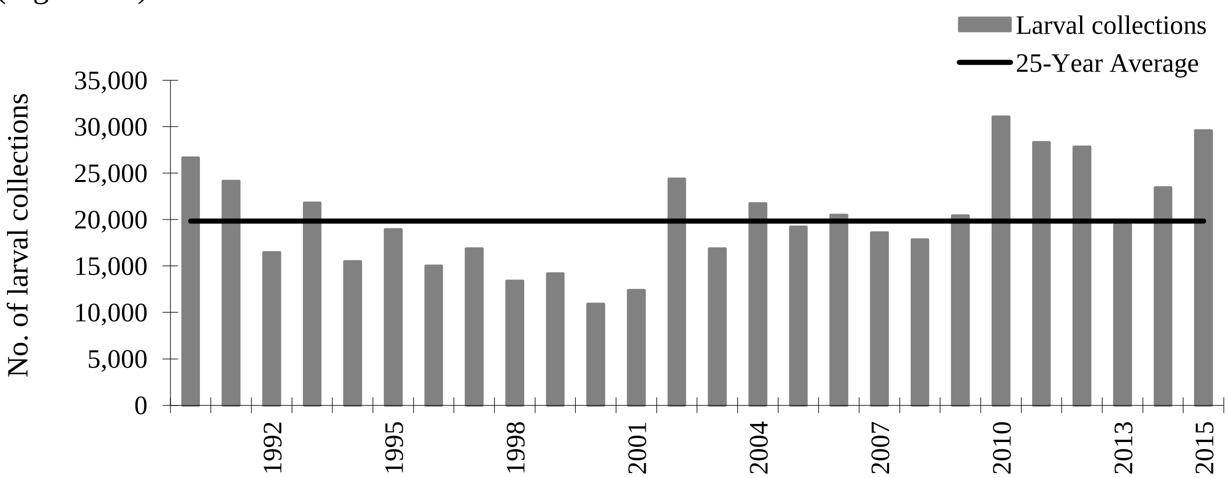


Figure 1.4 Yearly total larval collections, 1990-2015, and 25-year average.

The results of 12,501 samples identified to species, calculated as the percent of samples in which the species was present, is shown in Table 1.1. Most larval sampling takes place in natural wetlands but a significant amount of sampling is done in catch basins, stormwater structures, and other man-made features (e.g., swimming pools, culverts, artificial ponds). Those results are displayed separately (shaded column) from the natural wetlands results in Table 1.1. *Culex* mosquitoes are by far the most common species found in man-made features.

Aedes vexans is the most common species collected from natural development areas, occurring in 50.2% of the samples. The rest of the top five are *Culex territans* (20.5%), a non human-biting species; *Ae. cinereus* (12.3%), a spring and summer species; *Cx. restuans* (12.1%), a West Nile virus (WNV) vector; and *Ae. trivittatus* (6.8%), a summer species. Interestingly, staff identified *Psorophora ciliata*, a cannibalistic mosquito predator, a rare occurrence in the District. Two specimens were collected from two adjacent sites in Bayport, Washington County in July.

Table 1.1 Percent of samples where larval species occurred in wetland collections by facility and District total, and the District total for structure samples, 2015; the total number of samples processed to species is in parentheses.

	Percent of samples where species occurred by facility							
Species	North (1,648)	East (2,491)	South Rosemount (3,763)	South Jordan (1,392)	West Plymouth (1,084)	West Maple Grove (642)	Wetland Total (11,020)	Structures Total (1,481)
Aedes abserratus	0.7	0.3	0.3	0.3	0.2	0.2	0.3	
aurifer								
canadensis	0.8	1.0	2.4	1.4	0.7		1.4	0.2
cinereus	16.3	19.4	7.0	11.3	11.4	8.9	12.3	0.3
communis								
dorsalis	0.2	0.3	0.2	1.0	<	0.2	0.3	<
euedes								
excrucians	6.6	6.5	3.6	2.8	4.5	5.1	4.8	
fitchii	3.3	2.3	2.0	1.2	0.6	3.4	2.1	
flavescens			<				<	
hendersoni								<
implicatus	0.3	0.3	<		0.4		0.2	
intrudens	<						<	
japonicus	0.3	<	0.1	<	0.2	0.2	0.1	9.7
nigromaculis								
punctor	0.5	0.4	0.1		0.3	0.2	0.3	<
riparius	1.0	0.6	0.3		1.1	1.6	0.6	
spencerii		<	<				<	
sticticus	1.3	0.4	0.5	0.1	0.2	0.2	0.5	
stimulans	7.4	6.7	5.8	6.6	7.7	7.0	6.6	<
provocans	0.4	0.2	<		<	0.2	0.1	
triseriatus	0.1	<			0.2	0.2	<	2.8
trivittatus	3.9	2.9	10.6	11.6	3.6	2.6	6.8	0.3
vexans	58.8	37.6	57.4	53.8	45.7	34.6	50.2	9.6
Ae. species	36.8	30.4	31.0	23.9	19.6	44.4	30.5	5.4
Anopheles earlei								
punctipennis	1.6	1.3	0.6	0.4	1.1	0.5	0.9	1.4
quadrimaculatus	0.7	0.4	0.1	0.4	0.7	0.2	0.4	
walkeri	<	<					<	
An. species	3.9	5.0	2.3	2.7	3.6	2.6	3.4	3.7
Culex erraticus								
pipiens	2.9	0.7	1.0	1.4	4.1	1.7	1.6	28.4
restuans	11.1	11.0	12.6	12.1	17.3	8.1	12.1	70.4
salinarius	0.7	0.3	0.2	0.4	0.4	0.3	0.4	0.2
tarsalis	2.3	1.2	1.1	3.3	2.2	3.9	1.9	2.6
territans	16.9	35.2	13.4	19.6	21.6	14.3	20.5	12.2
Cx. species	2.1	2.3	4.0	5.2	5.4	3.4	3.6	45.0
Culiseta inornata	2.5	5.8	7.2	9.9	13.5	13.6	7.5	2.5
melanura								
minnesotae	0.4	2.7	0.5	<	0.2	0.5	0.9	
morsitans	<	0.3	<		0.4	0.2	0.1	
Cs. species	1.9	5.3	1.3	1.0	1.3	1.4	2.3	0.1
Or. signifera			<				<	<
Ps. ciliata		<					<	
columbiae								
ferox	<	<	0.6	0.3	<		0.3	
horrida		<	<	<			<	
Ps. species	<	0.6	0.6	0.7	<	0.2	0.5	
Ur. sapphirina	2.2	2.9	1.0	1.7	2.0	0.8	1.8	0.2

< = percent of total is less than 0.1%

Adult Mosquito Collections

As stated earlier, the District employs a variety of surveillance strategies to target different behaviors of adult mosquitoes. Sweep nets are used to survey the mosquitoes attracted to a human host. We use carbon dioxide-baited (CO_2) traps with small lights to monitor host-seeking, phototactic species. New Jersey (NJ) light traps monitor only phototactic mosquitoes. Large hand-held aspirators are used to capture mosquitoes resting in the understory of wooded areas in the daytime. Gravid traps with liquid bait are used to attract and capture egg-laying *Culex* and *Aedes* species and ovitraps are used to collect eggs of container-inhabiting vector species (i.e., *Ae. triseriatus, Ae. japonicus, Ae. albopictus*). The information obtained from sampling is used to direct control activities and to monitor vector populations and disease activity (i.e., specimens collected are tested for disease). Treatment thresholds are discussed in Chapter 3: Mosquito Control.

Monday Night Network The sweep net and CO_2 trap data reported here are weekly collections referred to as the Monday night network. Employees took two-minute sweep net collections and/or set overnight CO_2 traps in their yards every Monday night from May - September. To achieve a District-wide distribution of CO_2 traps, other locations such as parks or wood lots are chosen for surveillance as well. Figure 1.5 shows the sweep net and CO_2 trap locations and their uses [i.e., general monitoring, virus testing, eastern equine encephalitis (EEE) vector monitoring]. CO_2 traps were operated once weekly for 19 weeks, starting the same week as the sweeps and continuing two weeks later.

Most of the mosquitoes collected are identified to species, but in some cases, species are grouped together to expedite sample processing. *Aedes* mosquitoes are grouped by their seasonal occurrence (spring, summer). Others are grouped because species-level separation is very difficult (e.g., *Ae. abserratus/punctor*, *Cx. pipiens/restuans*). Generally, the most abundant species captured in sweep nets and CO_2 traps are the summer *Aedes*, *Cq. perturbans*, and spring *Aedes*. *Culex tarsalis*, unlike the other *Culex* species that prefer birds as hosts, is also attracted to mammals, and is important in the transmission of WNV to humans.

Sweep Nets CO_2 Traps

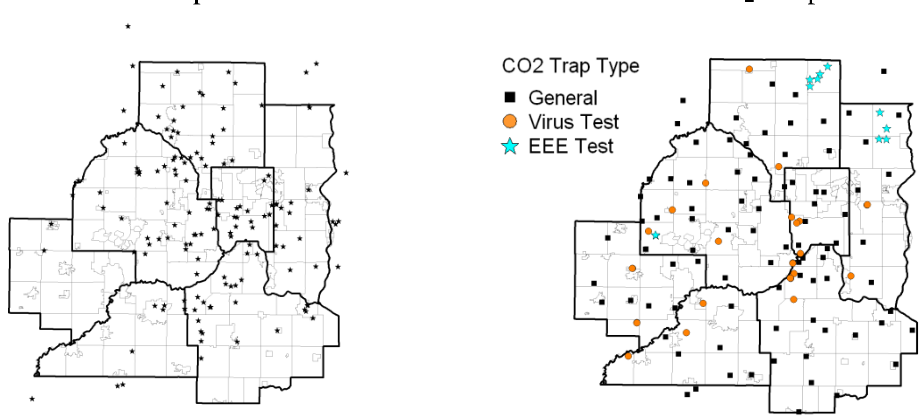


Figure 1.5 Locations of weekly sweep net and CO_2 traps locations used to monitor general mosquito populations and disease vectors (virus test and EEE test), 2015.

Sweep Net The District uses sweep net collections to monitor mosquito annoyance to humans during the peak mosquito activity period, which is 35-40 minutes after sunset for most mosquito species. The number of collectors varied from 63-120 per evening.

In 2015, staff took 1,674 collections containing 2,828 mosquitoes. The average number of summer *Aedes* collected in the evening sweep net collections was the lowest of the past four years, but still above the 10-year average (Table 1.2). Populations of *Cq. perturbans* were higher than the last two years and slightly above the 10-yr average. The late spring resulted in less than half the average numbers of spring *Aedes* adults. *Culex tarsalis,* which are infrequently collected in sweep net samples, were at average levels.

Table 1.2 Average number of mosquitoes collected per evening sweep net collection within the District, 2011-2015 and 10-year average, 2005-2014 (±SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2011	1.54	0.38	0.23	0.007
2012	1.63	0.75	0.02	0.004
2013	1.87	0.12	0.03	0.005
2014	2.33	0.12	0.20	0.008
2015	1.27	0.29	0.05	0.006
10-yr Avg.	0.96 (±0.07)	0.26 (±0.02)	0.13 (±0.02)	0.006 (±0.0003)

CO_2 Trap CO_2 traps baited with dry ice are used to monitor host-seeking mosquitoes and the presence of disease vector species. The standard placement for these traps is approximately 5 ft off the ground, the level where *Aedes* mosquitoes fly. In 2015, we placed 132 traps at 118 locations to allow maximum coverage of the District (Figure 1.5). The "General" trap type locations are used to monitor non-vector mosquitoes. Fourteen locations have low traps paired with elevated traps placed in the tree canopy (~25 ft above ground) to collect *Culex* species, which are active where birds are resting. All *Culex* specimens collected from those locations and an additional 17 locations (5 ft elevation) are tested for WNV (Figure 1.5, "Virus Test" trap type); however, *Cx. tarsalis* from all locations are tested. Ten trap locations in the network, one also with an elevated trap, have historically captured *Cs. melanura*, and are used to monitor this vector's populations and to obtain specimens for EEE testing (Figure 1.5, "EEE Test" trap type).

A total of 1,988 trap collections taken contained 327,455 mosquitoes. The total number of traps operated per night varied from 101-109. Summer *Aedes* was the predominant species collected in CO_2 traps. Populations in 2015 were lower than any of the past four years and below the 10-year average (Table 1.3). *Coquillettidia perturbans* populations were higher than the last two years, but less than average.

Spring *Aedes* were also at the lowest level of the last four years and well below the 10-year average. *Culex tarsalis* numbers were below the 10-year average and are discussed later in the vector surveillance section of this chapter.

Table 1.3 Average numbers of mosquitoes collected in CO_2 traps within the District, 2011-2015 and 10-year average, 2005-2014 (± 1 SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2011	181.0	110.0	5.1	1.4
2012	215.8	68.0	2.3	1.0
2013	303.6	22.5	5.7	2.4
2014	255.4	22.4	7.9	1.9
2015	115.7	37.4	1.7	1.0
10-yr Avg.	153.3 (±31.3)	44.9 (±9.5)	8.6 (±1.6)	2.2 (±0.5)

Geographic Distribution The weekly geographic distributions of the three major groups of nuisance mosquitoes (i.e., spring *Aedes*, summer *Aedes*, and *Cq. perturbans*) collected in CO_2 traps are displayed in Figures 1.6, 1.7, and 1.8. The computer software extrapolates the data between collection points, so some dark areas are the result of one collection without another close by. What little populations of spring *Aedes* we had were confined to a few locations on the outer edges of the District or in localized areas (Figure 1.6). Summer *Aedes* were collected at above threshold levels in some scattered locations in June and were most numerous throughout most of the District during the last two weeks of July (Figure 1.7). After mid-August, mosquito levels remained below threshold. *Coquillettidia perturbans* populations occurred in their usual hot spots in the northern District borders and in Carver, Scott, and western Hennepin counties (Figure 1.8).

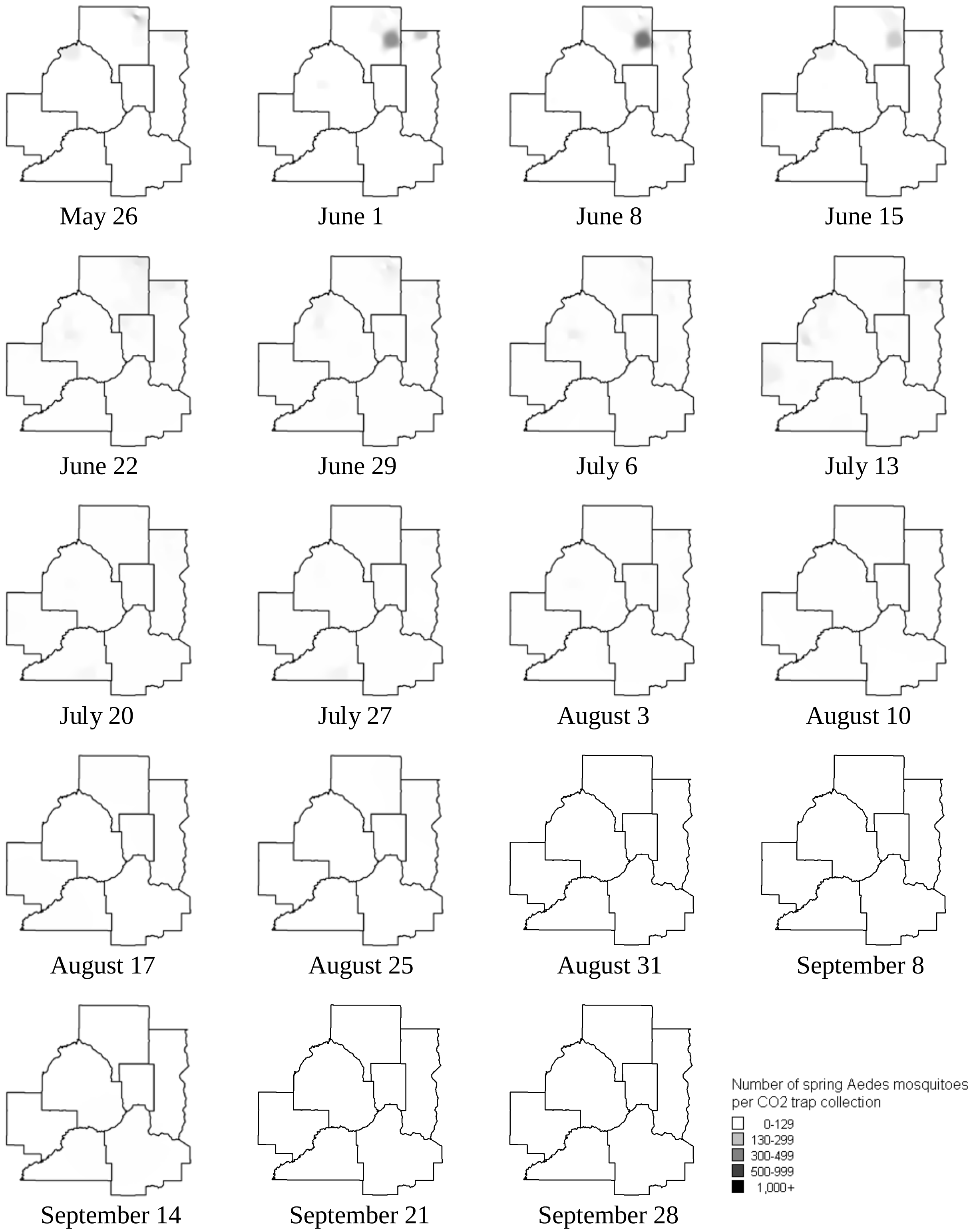


Figure 1.6 Number of spring *Aedes* in District low (5 ft) CO_2 trap collections, 2015. The number of traps operated per night varied from 101-109. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night.

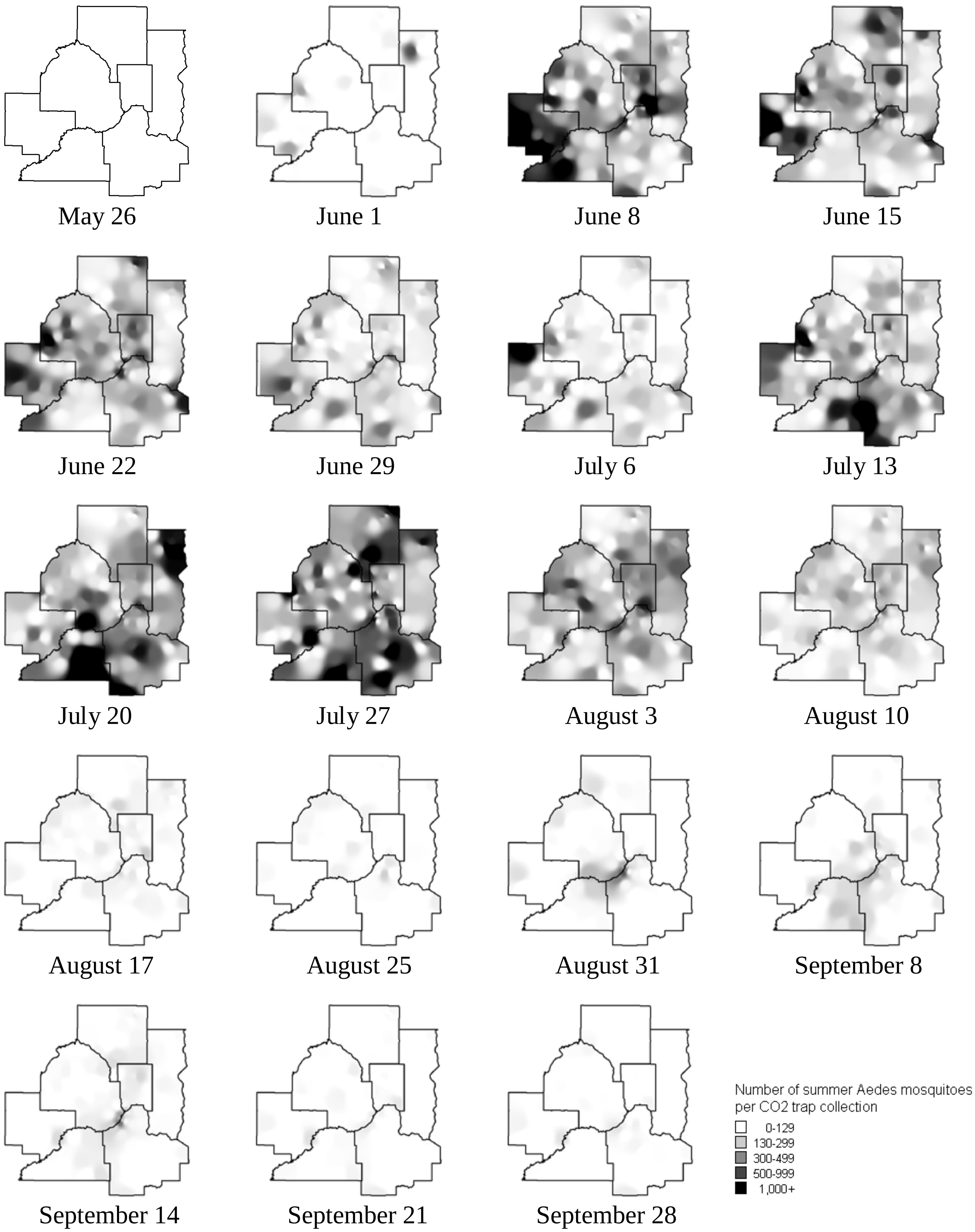


Figure 1.7 Number of summer *Aedes* in District low (5 ft) CO_2 trap collections, 2015. The number of traps operated per night varied from 101-109. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night.

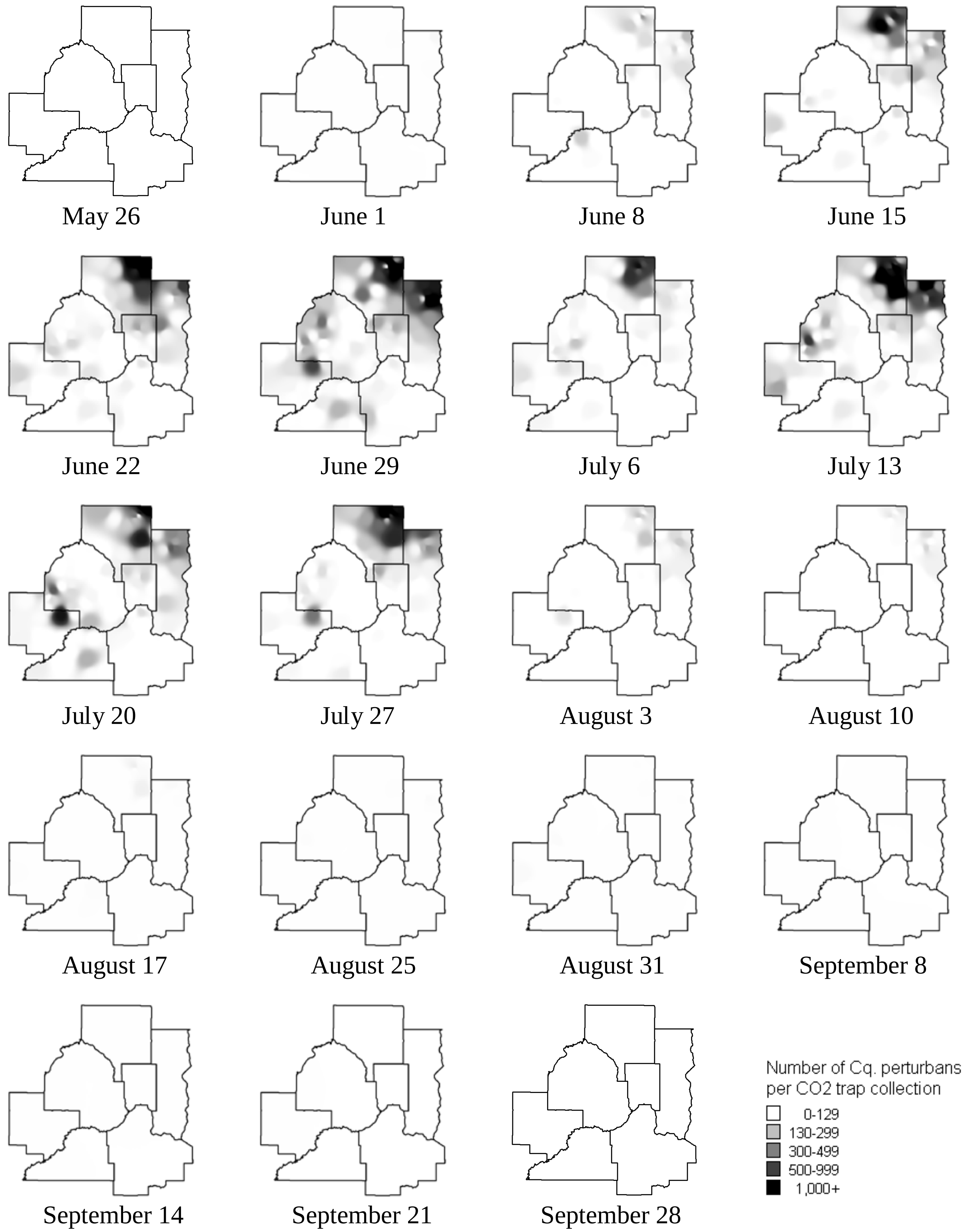


Figure 1.8 Number of *Cq. perturbans* in District low (5 ft) CO_2 trap collections, 2015. The number of traps operated per night varied from 101-109. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night.

Seasonal Distribution As described earlier, spring *Aedes,* summer *Aedes,* and *Cq. perturbans* have different patterns of occurrence during the season based on their phenology and the surveillance method used. Additionally, temperatures below 55 °F inhibit mosquito flight activity. Sampling typically begins the second week of May, but was postponed two weeks due to cool evening temperatures. There were some cool nights during the season (Fig. 1.9) that may have affected mosquito activity, especially on July 6 (Fig. 1.10).

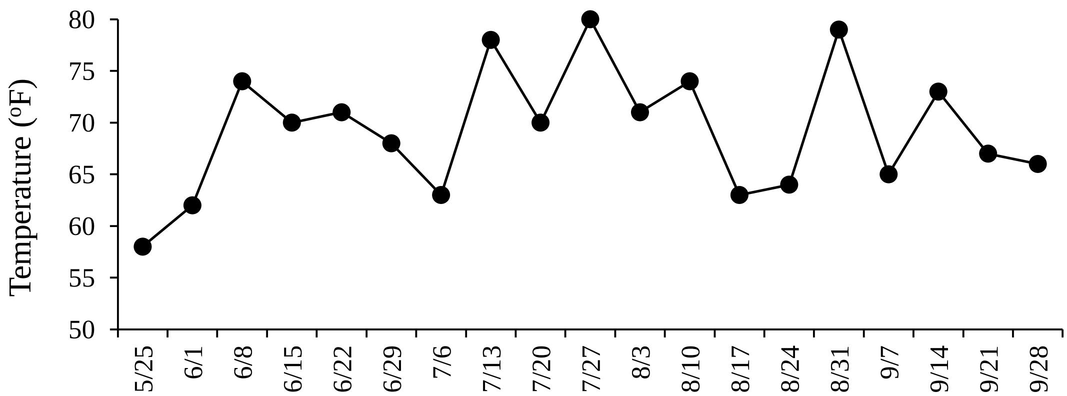


Figure 1.9 Temperature at 9:00 P.M. on Monday night surveillance dates, 2015.

Figure 1.10 shows the seasonal distribution of the three major groups of mosquitoes from mid-May through early September, detected by sweep netting and CO_2 traps. The end date for the sweep net collections is earlier than the CO_2 traps (September 14 for sweeps and September 28) due to the availability of seasonal staff to perform the sweep collections. Sweep nets and CO_2 traps detected the peak of spring *Aedes* activity differently. Typically, spring *Aedes* numbers peak in mid-June; in 2015, however, the peak number of spring *Aedes* in sweep nets occurred on July 27, the warmest Monday night of the season. Average numbers collected were very low, so whether this is a true population peak is difficult to say. Spring *Aedes* peaked in CO_2 traps on June 8, which is more typical. Spring *Aedes* populations were well below the 10-year average and, like the sweep net detections, were present only through the end of July.

Summer *Aedes* populations were relatively low for most of the summer. Sweep net samples detected peak summer *Aedes* levels on July 27 (Figure 1.10). For CO_2 traps, high numbers were detected June 8, followed by declining numbers for four weeks, and then populations began increasing July 13. A second peak occurred July 27. Overall, summer *Aedes* in CO_2 traps remained below the 10-year average, except for the last three weeks of July.

The peak for *Cq. perturbans* is typically around July 4. The peak in sweeps that occurred on June 22 was a result of two unusually high captures. The CO_2 trap peak of *Cq. perturbans* occurred on June 29. It is possible however, that the night of July 6 may have been the peak capture if temperatures had not been cool. Captures were higher the following week of July 13, remained above the 10-year average for three weeks, and diminished by mid-August.

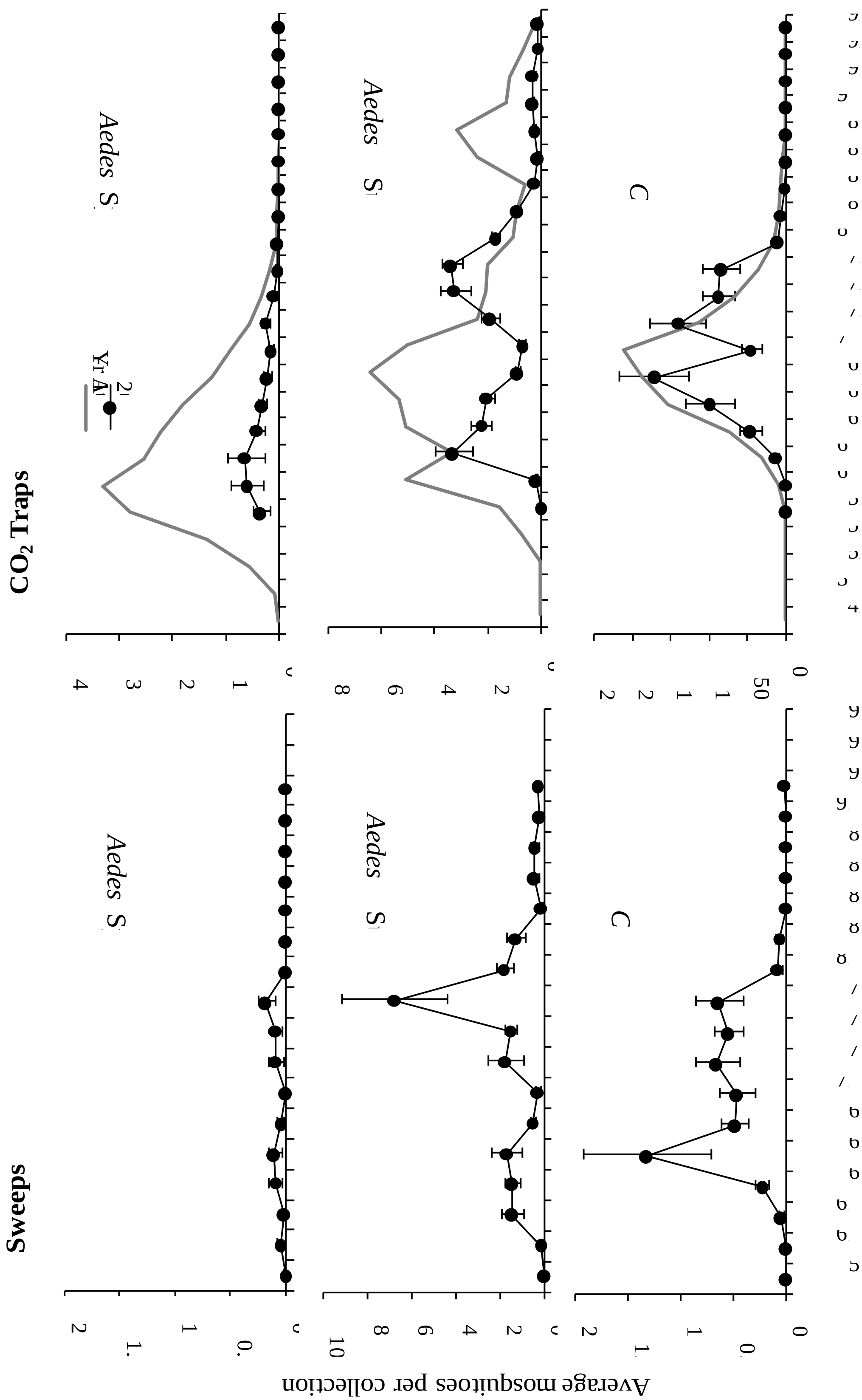


Fig. 1.10 Average number of spring *Aedes*, summer *Aedes*, and *Cq. perturbans* per sweep net, 2015 and CO_2 trap, 2015 vs. 10-year average. Weather delayed sampling until May 25 in 2015, a later start than average. Error bars equal + 1 standard error of the mean.

Coquillettidia perturbans, the cattail mosquito, is usually our second-most numerous species and have one generation per year. Adults lay their eggs in cattail marshes in July and August, the eggs hatch and larvae then overwinter; adults emerge the following June-July. Adult populations are influenced by rainfall amounts from the previous year. Higher *Cq. perturbans* captures in CO_2 traps occurred (2003, 2006, 2011, and 2012) following a year with high rainfall amounts (Fig. 1.11). However, the high rainfall in 2014 did not result in significantly higher numbers of *Cq. perturbans* populations. Drought conditions existed in the fall through winter of 2012-2014. Despite the heavy summer rains in 2014, water levels remained low in cattail marshes, reducing mosquito production in 2015. The high rain amount in 2015, especially in the fall (Fig. 1.3), helped marshes rebound from the drought and could be predictive of higher mosquito production in 2016.

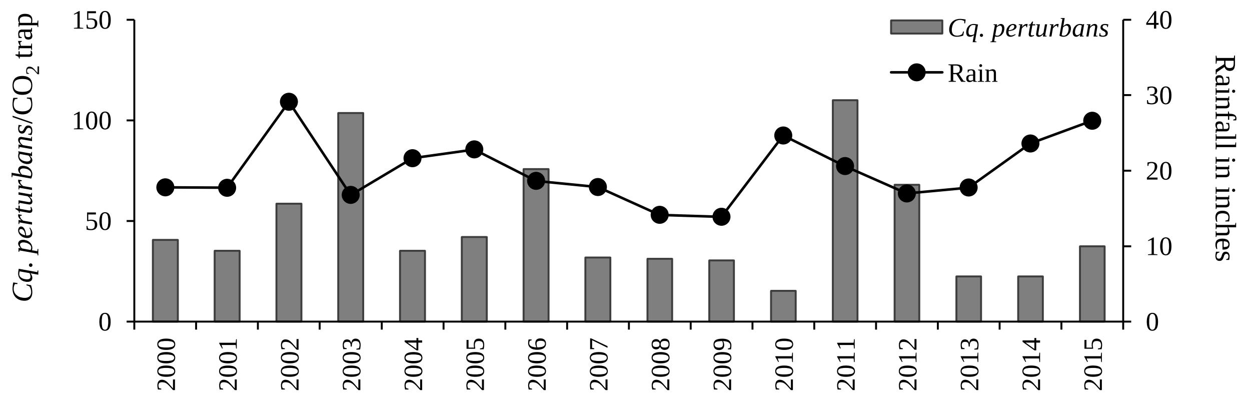


Fig. 1.11 Average number of *Coquillettidia perturbans* in CO_2 traps and average yearly rainfall per gauge, 2000-2015.

New Jersey (NJ) Traps For many years, mosquito control districts used the NJ light trap as their standard surveillance tool. The trap uses a 25-watt light bulb to attract mosquitoes and many other insects as well, making the samples messy and time-consuming to process. The number of traps used by the District has varied over the years; in the early 1980s, the District operated 29 traps. After a western equine encephalitis (WEE) outbreak in 1983, the District reduced the number to seven to alleviate the regular workload due to the shift toward disease vector processing.

The number of locations and traps has fluctuated since then. In 2015, the District reduced the number of NJ light traps by one due to lack of operator (Trap 1, St. Paul). The remaining six traps were in the following locations: trap 9 in Lake Elmo, trap 13 in Jordan, trap 16 in Lino Lakes, trap CA1 in the Carlos Avery State Wildlife Management Area, trap AV at the Minnesota Zoo in Apple Valley, and trap MN in Minnetrista (Figure 1.12).

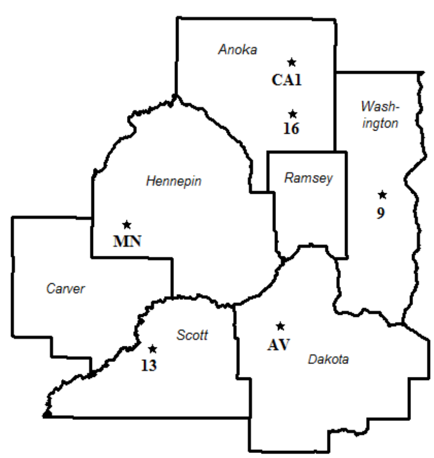


Fig. 1.12 NJ light trap locations, 2015

Trapping occurs nightly for 20 weeks from May through September and staff identify all adult female mosquitoes to species. Traps 9, 13, and 16 have operated each year since 1965. A comparison of the major species collected from 1965-2015 from those three traps is shown in Appendix B.

Results from the AV trap are not included in the following summary due to a trap malfunction. For the remaining five NJ traps, the most numerous species collected was *Ae. vexans* whose total was 72% of all female mosquitoes captured (Table 1.4). The Minnestrista trap contributed 73% and the Carlos Avery trap comprised 18% of all *Ae. vexans* captured. *Coquillettidia perturbans* ranked second and comprised 17% of the females captured. The Carlos Avery trap, placed within many acres of untreatable cattail habitat, contributed 87% of the overall *Cq. perturbans* collected. The non human-biting species, *Culex territans*, was a surprise winner of third place. Captures of *Anopheles* were higher than usual with *An*. *punctipennis* in fourth place and *An*. *walkeri* in fifth place. Sixth place belongs to the combination of *Cx. pipiens*/*Cx. restuans*. *Aedes cinereus*, which occurs in the spring and summer and is usually in the top five, came in seventh place. The spring *Aedes* species combo of *Ae. absserratus* and *Ae. punctor* is also usually in the top five but is down in tenth place at 0.31% of the female total.

The first collection of *Ae. japonicus* in a NJ light trap was in 2009 (Minnetrista). Since then, *Ae. japonicus* has increased in frequency of occurrence and has been found at all of the NJ trap locations except Jordan. In 2015, a record number of *Ae. japonicus* was collected at three NJ trap locations: Lino Lakes (2.1%), Lake Elmo (9.7%), and Minnetrista (88.2%).

Table 1.4 Total number and frequency of occurrence for each species collected in New Jersey light traps, May 9 - September 25, 2015. Trap AV results are not included due to trap malfunction.

	Trap code, location, and number of collections					Summary Statistics		
Species	9 Lake Elmo 132	13 Jordan 140	16 Lino Lakes 138	CA1 Carlos Avery 132	MN Minnetrista 134	Season Total 676	% Female Total	Avg. per Night
Ae. abserratus	0	0	0	22	1	23	0.01%	0.03
aurifer	0	0	0	0	0	0	0.00%	0.00
canadensis	0	0	0	8	0	8	0.00%	0.01
cinereus	3	0	102	336	745	1,186	0.68%	1.75
dorsalis	0	1	0	0	0	1	0.00%	0.00
excrucians	0	0	0	11	24	35	0.02%	0.05
fitchii	0	0	0	0	0	0	0.00%	0.00
implicatus	0	0	0	0	0	0	0.00%	0.00
japonicus	14	0	3	0	127	144	0.08%	0.21
nigromaculis	0	0	0	0	0	0	0.00%	0.00
punctor	0	0	1	5	1	7	0.00%	0.01
riparius	0	0	0	6	2	8	0.00%	0.01
spencerii	0	0	0	0	0	0	0.00%	0.00
sticticus	1	2	0	71	20	94	0.05%	0.14
stimulans	0	0	0	1	8	9	0.01%	0.01
provocans	0	0	0	0	0	0	0.00%	0.00
triseriatus	43	0	3	0	72	118	0.07%	0.17
trivittatus	166	13	10	52	118	359	0.20%	0.53
vexans	3,895	864	6,612	22,432	92,853	126,656	72.16%	187.36
abserratus/punctor	0	0	7	519	1	527	0.30%	0.78
Aedes species	11	4	9	268	3,154	3,446	1.96%	5.10
Spring *Aedes*	0	0	0	8	22	30	0.02%	0.04
Summer *Aedes*	0	0	1	71	1	73	0.04%	0.11
An. barberi	0	0	0	0	1	1	0.00%	0.00
earlei	0	2	0	1	1	4	0.00%	0.01
punctipennis	42	26	20	189	2251	2,528	1.44%	3.74
quadrimaculatus	238	74	47	107	220	686	0.39%	1.01
walkeri	8	3	44	1,334	38	1,427	0.81%	2.11
An. species	7	1	4	77	129	218	0.12%	0.32
Cx. erraticus	0	0	0	0	0	0	0.00%	0.00
pipiens	0	0	0	0	0	0	0.00%	0.00
restuans	86	4	59	55	256	460	0.26%	0.68
salinarius	5	2	8	22	209	246	0.14%	0.36
tarsalis	5	2	16	23	75	121	0.07%	0.18
territans	57	2	187	156	2810	3,212	1.83%	4.75
Cx. species	11	2	9	22	387	431	0.25%	0.64
Cx. pipiens/restuans	111	9	101	95	611	927	0.53%	1.37
Cs. inornata	11	3	1	5	170	190	0.11%	0.28
melanura	0	0	0	1	0	1	0.00%	0.00
minnesotae	1	3	67	32	135	238	0.14%	0.35
morsitans	0	1	5	6	10	22	0.01%	0.03
Cs. species	0	0	1	1	7	9	0.01%	0.01
Cq. perturbans	749	57	741	25,305	2,410	29,262	16.67%	43.29
Or. signifera	0	0	0	0	0	0	0.00%	0.00
Ps. ferox	0	0	0	0	0	0	0.00%	0.00
horrida	0	0	0	0	0	0	0.00%	0.00
Ps. species	0	0	0	0	0	0	0.00%	0.00
Ur. sapphirina	91	11	15	26	417	560	0.32%	0.83
Unidentifiable	13	6	26	181	2016	2,242	1.28%	3.32
Female Total	5,568	1,092	8,099	51,448	109,302	175,509	100.00%	259.63
Male Total	1,924	127	4,094	6,199	40,806	53,150		
Grand Total	7,492	1,219	12,193	57,647	150,108	228,659		

Rare Detections *Culex erraticus*, considered rare in the District, was first detected in NJ traps in 1988. This species occurred sporadically since then in low numbers and in recent years has been collected in CO_2 traps more frequently (Fig. 1.13). In 2012, we were surprised to collect them in extremely high numbers throughout the District. In 2013, we were just as surprised to collect them in such low numbers. Only three were collected in 2014, but the total in 2015 was elevated to 19. Their name is truly descriptive of their occurrence. The reason for the 2012 peak remains a mystery. *Culex erraticus* is common in southern United States, with the District at the northern edge of its range. The unusually warm spring and summer in 2012 may have resulted in favorable conditions conducive to their large population expansion. Because *Cx. erraticus* is usually extremely rare, it has not been targeted for control. It is, however, a competent vector of eastern equine encephalitis and a suspected maintenance vector of West Nile virus, so it is still a concern.

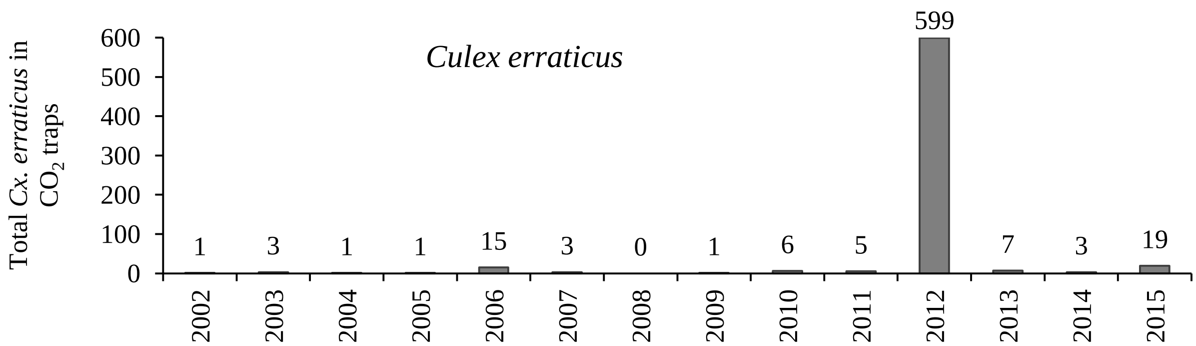


Fig. 1.13 Yearly total of *Culex erraticus* in CO_2 traps, 2002-2015.

Anopheles quadrimaculatus is notable because it is a WNV maintenance vector and capable of transmitting dog heartworm and malaria. Historically, it is rare in the District, but in recent years, it has occurred in traps throughout the District more frequently than in the past (Fig. 1.14). Since 2002, *An. quadrimaculatus* has appeared with increasing frequency, reaching the highest amount ever in 2012, down slightly in 2013, very low in 2014, and up slightly in 2015. We will continue to investigate the reasons for this fluctuation in occurrence.

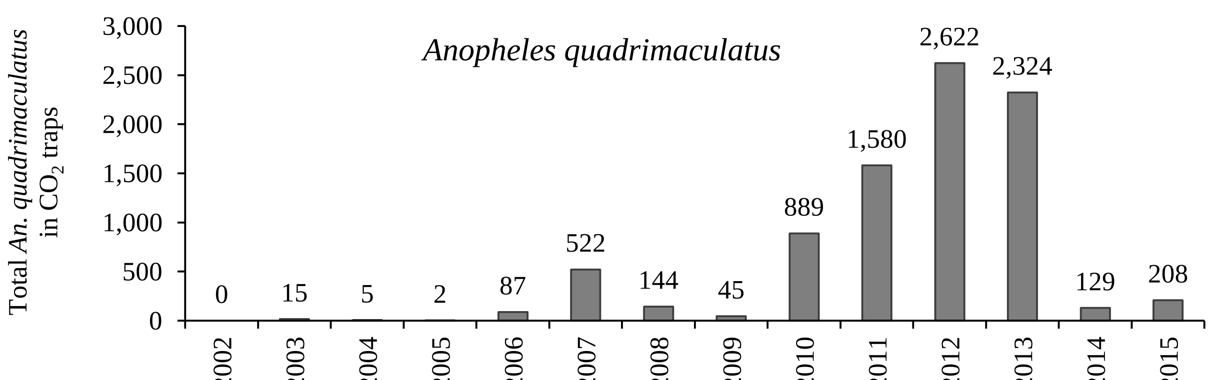


Fig. 1.14 Yearly total *Anopheles quadrimaculatus* in CO_2 traps, 2002-2015.

Targeted Vector Mosquito Surveillance

Aedes triseriatus Staff use a mechanical aspirator (pictured at left) to sample the understory for resting mosquitoes in the daytime. This method is used primarily for *Ae. triseriatus*, the La Crosse encephalitis (LAC) vector, which can be difficult to capture by other methods. The aspirator is also used to collect *Ae. japonicus* and *Ae. albopictus*, two invasive mosquito vectors. Sampling began during the week of May 26 and continued through the week of September 14.

Cool spring temperatures delayed the emergence of the season's first *Ae. triseriatus* generation until the first week of June (Figure 1.15). The peak rate of capture of 1.1 *Ae. triseriatus* per sample occurred during the week of June 22. The weekly peak rate of capture was surprisingly low as were rates of capture for most weeks during the season considering how frequently rain fell during the summer. Typically during wet years, *Ae. triseriatus* collections are higher than the multi-year average.

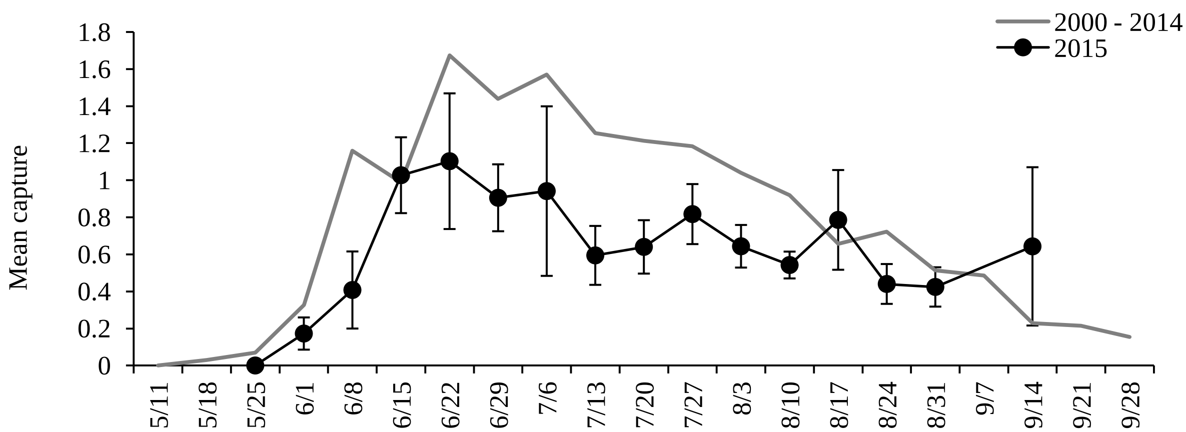


Figure 1.15 Mean number of *Ae. triseriatus* adults in 2015 aspirator samples plotted by week compared to mean captures for the corresponding weeks of 2000-2014. Dates listed are Monday of each week. Error bars equal ± 1 standard error of the mean.

Culiseta melanura *Culiseta melanura*, the enzootic vector of EEE, feeds primarily on birds. Locally, the most common larval habitat is spruce-tamarack bog or other acidic habitat. Larvae can occur in caverns in sphagnum moss supported by tree-roots. Overwintering is in the larval stage with adults emerging in late spring. There are multiple generations per year, and the late summer cohort supplies the next year's first generation. Most adults disperse a short distance from their larval habitat, although a few may fly in excess of five miles from their larval habitat.

District staff monitored adult *Cs. melanura* at 10 locations using 11 CO_2 traps. Five sites are in Anoka County, four sites are in Washington County, and one site is in Hennepin County. *Culiseta melanura* have been collected from each location in the past. Two traps are placed at the

Hennepin County location – one at ground level and one elevated 25 ft into the tree canopy, where many bird species roost at night. The first *Cs. melanura* adult was collected in a CO_2 trap on June 1 (Figure 1.16). The population remained low throughout the season with a maximum capture of 2.7 per trap on July 27.

Staff collected 60 *Cs. melanura* in 118 aspirator samples from wooded areas near bog habitats. The first aspirator collections of *Cs. melanura* occurred during the week of June 22. There were no samples collected during the weeks of July 6 through August 10. Resumption of the surveillance in mid-August recorded *Cs. melanura* levels as high as 2.0 per sample during the week of August 17 (Figure 1.17).

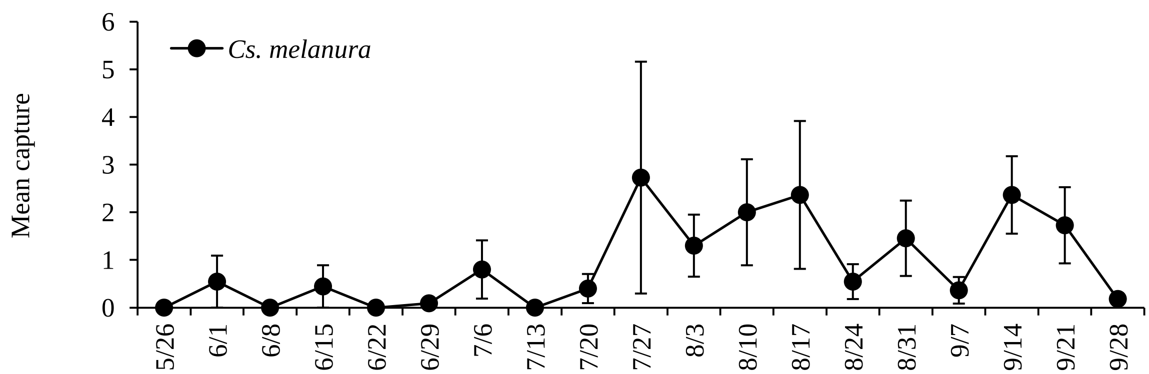


Figure 1.16 Mean number of *Cs. melanura* adults in CO_2 traps from selected sites, 2015. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

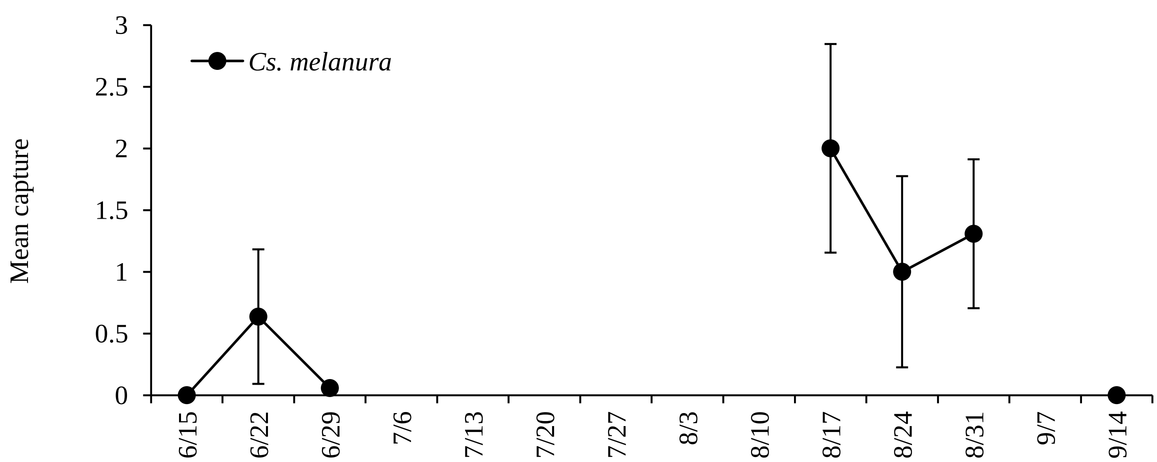


Figure 1.17 Mean number of *Cs. melanura* in aspirator collections, 2015. Error bars equal ± 1 standard error of the mean.

***Culex* Species** *Culex* species are important for the amplification and transmission of WNV and WEE virus in our area. The District uses CO_2 traps to monitor host-seeking *Culex* mosquitoes and gravid traps to monitor egg-laying *Culex* mosquitoes. Many *Culex* specimens collected in the network were tested for WNV.

Culex tarsalis is the most likely vector of WNV for human exposures in our area and as such, they are routinely tested for WNV (see Chapter 2, Table 2.3). Collections of *Cx. tarsalis* in CO_2 traps increased steadily through the week of August 3 when the mean capture peaked at a modest 6.0 per sample (Figure 1.18). Thereafter, the rate of capture decreased each week through the end of the season. As is typical, few *Cx. tarsalis* were captured by gravid trap.

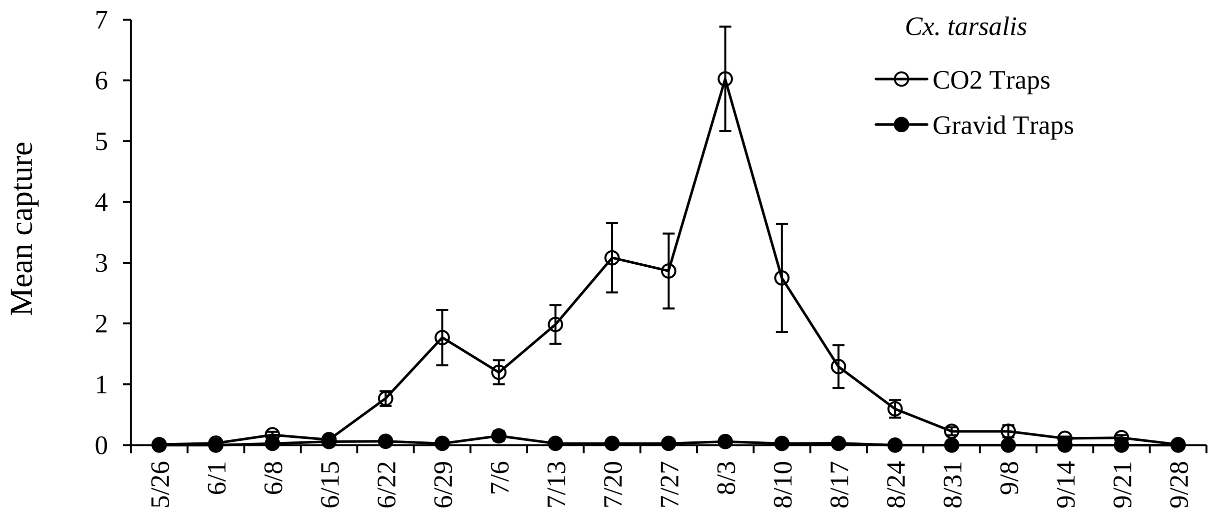


Figure 1.18 Average number of *Cx. tarsalis* in CO_2 traps and gravid traps, 2015. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

Culex restuans is another important vector of WNV in Minnesota. The species is largely responsible for the early season amplification of the virus and for season-long maintenance of the WNV cycle, as well. Low numbers of *Cx. restuans* were collected in CO_2 traps in 2015 (Figure 1.19). The CO_2 trap captures peaked on June 22 at 2.3 per trap. Gravid trap collections of *Cx. restuans* were considerably higher in June and early July of 2015 than any time during 2014. The peak capture occurred during the week of July 6 at 30.0 per trap.

Culex pipiens have been important as vectors of WNV in much of the United States. The species prefers warmer temperatures than *Cx. restuans*; therefore, populations of *Cx. pipiens* in the District tend to remain low in early to mid-summer and peak late in the summer when temperatures are typically warmer. Both gravid traps and CO_2 traps collected low numbers of *Cx. pipiens* in 2015 (Figure 1.20).

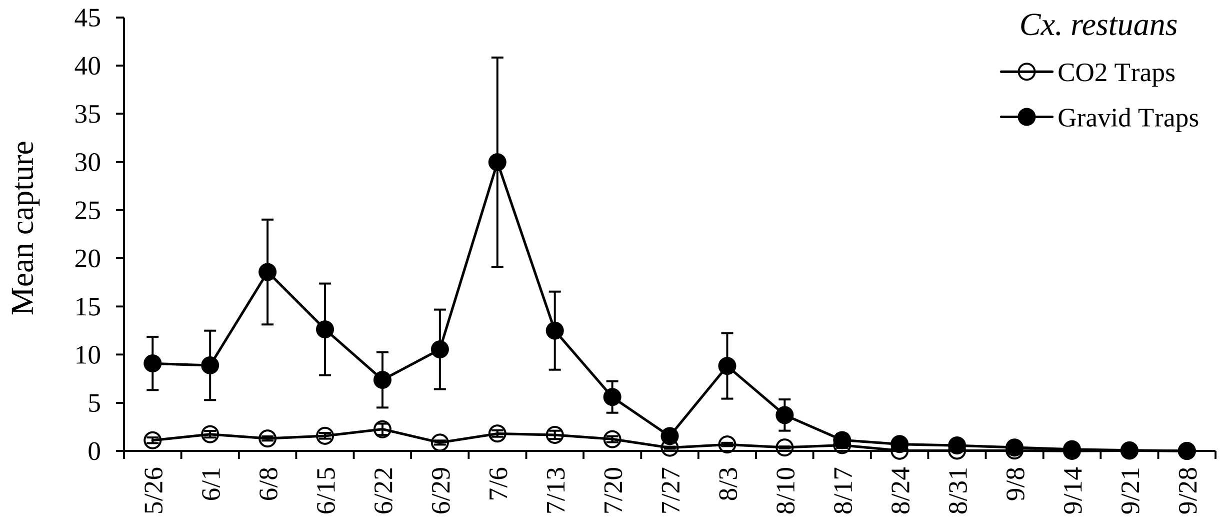


Figure 1.19 Average number of *Cx. restuans* in CO_2 traps and gravid traps, 2015. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

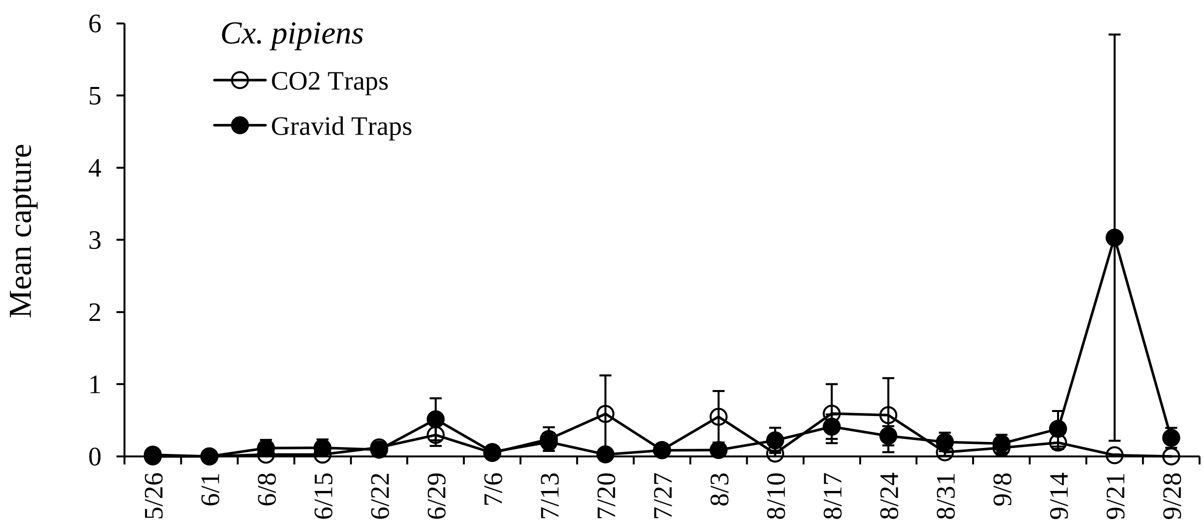


Figure 1.20 Average number of *Cx. pipiens* in CO_2 traps and gravid traps, 2015. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

When *Cx. pipiens* and *Cx. restuans* are difficult to distinguish from each other, they are grouped together and identified as *Cx. pipiens/restuans* (Figure 1.21); when only a genus level identification can be made, they are classified as *Culex* species (Figure 1.22). Both groups usually consist largely of *Cx. restuans* during the early and middle portions of the season with *Cx. pipiens* contributing more to the collections during the middle and later portions of the season.

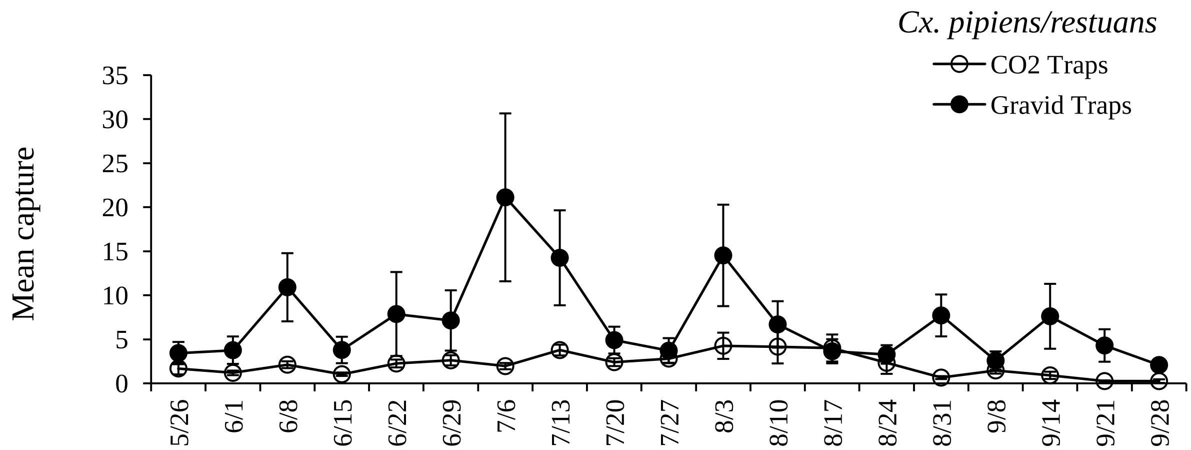


Figure 1.21 Average number of *Cx. pipiens/restuans* in CO_2 traps and gravid traps, 2015. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

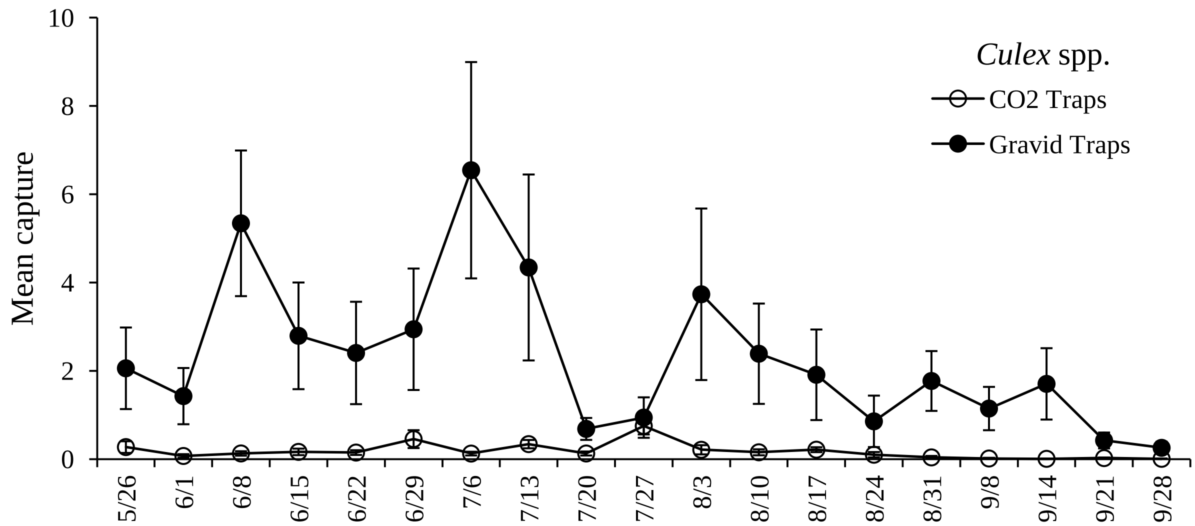


Figure 1.22 Average number of *Culex* species in CO_2 traps and gravid traps, 2015. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean

Exotic Species Each season, MMCD conducts surveillance for exotic or introduced mosquito species. There are also opportunities to collect unexpected species through a variety of surveillance techniques used to monitor local mosquito species. MMCD laboratory technicians are trained to recognize exotic species in their adult and larval forms so that the mosquitoes can be spotted in any of the tens of thousands of samples processed each year.

The two exotic species most likely to be found here are *Ae. albopictus* and *Ae. japonicus*. Both are native to Asia and have adapted to use artificial larval habitats such as tires and other containers and are thus easily transported as eggs or larvae. *Aedes albopictus*, first collected in the United States in 1985, are established in many states south and east of Minnesota and are occasionally introduced to the District in shipments of used tires or by transport of other water-holding containers. *Aedes japonicus* were first collected in the eastern United States in 1998, and were first found in the District in 2007. They are now commonly collected throughout the District.

Aedes albopictus *Aedes albopictus* were collected in four samples in 2015, all from ovitraps placed near a tire recycling facility in Savage. Specimens were reared from ovitrap samples collected July 22 and July 30 and from two traps collected on August 26. No adult or larval *Ae. albopictus* specimens were collected.

This was the thirteenth year since 1991 when *Ae. albopictus* were collected by MMCD staff. *Aedes albopictus* have been found in four Minnesota counties: Carver, Dakota, Scott, and Wright. The species has not successfully overwintered at any of the Minnesota locations where previously discovered.

Aedes japonicus Since their arrival in the District in 2007, *Ae. japonicus* have spread throughout the District and they are commonly found in areas with adequate habitat. The species is routinely collected through a variety of sampling methods. Our preferred surveillance methods when targeting *Ae. japonicus* are container/tire/tree hole sampling for larvae, and aspirator sampling of wooded areas for adults.

Aedes japonicus larvae were found in 788 samples. Most were from containers (471) and tires (155). Larvae were found in other habitats as well, including: stormwater structures/artificial ponds (128), wetlands (17), catch basins (15), and tree holes (2). We observed an increase in the frequency in which *Ae. japonicus* were found in container, tire, and tree hole habitats over 2014 (Table 1.5). *Aedes japonicus* were found in containers and tires more frequently than in any year in the past.

Table 1.5 Percentage of samples from containers, tires, and tree holes containing *Ae. japonicus* larvae, 2009 – 2015

Habitat type	2009	2010	2011	2012	2013	2014	2015
Containers	4.2%	23.5%	36.2%	39.4%	35.7%	39.2%	44.2%
Tires	2.9%	15.5%	21.3%	26.7%	21.2%	26.3%	36.0%
Tree holes	0.0%	8.8%	9.3%	4.7%	1.8%	2.0%	4.8%

Aedes japonicus adults were identified in 451 samples. They were found in 203 aspirator samples, 81 CO_2 trap samples, 73 gravid trap samples, 64 NJ trap samples, and 30 two-minute sweep samples. *Aedes japonicus* were also hatched from 25 of 58 ovitrap samples collected in 2015.

2016 Plans – Surveillance

Surveillance will continue as in past years with possible adjustments to monitor disease vector presence in the District, including refining *Cs. melanura* surveillance. We will evaluate CO_2, gravid, and New Jersey traps placement. We will find a replacement location for the NJ trap location in St. Paul.

Chapter 2 Vector-borne Disease

2015 Highlights

- There was one La Crosse encephalitis case in Minnesota
- There were no La Crosse illnesses in the District
- WNV illness confirmed in six Minnesotans, three occurred in District residents
- Two Jamestown Canyon illnesses confirmed in Minnesota, one in MMCD resident
- WNV detected in 18 District mosquito samples
- Collected and recycled 24,127 tires
- Record 81 of 100 sites *I. scapularis* positive
- Average *I. scapularis* per mammal (1.45), a new record high
- *Amblyomma americanum* 2 reports MMCD, 0 reports MDH
- Signs posted in dog parks to educate & facilitate tick collections from the public
- 2015 tick-borne cases not available (source MDH)
- Tick Risk Meter estimates posted weekly at mmcd.org & on Facebook

Background

District staff provides a variety of disease surveillance and control services, as well as public education, to reduce the risk of mosquito-borne illnesses such as La Crosse encephalitis (LAC), western equine encephalitis (WEE), eastern equine encephalitis (EEE), and West Nile (WNV) encephalitis, as well as tick-borne illnesses such as Lyme disease and human granulocytic anaplasmosis (HGA). Past District efforts have also included determining metro-area risk for infections of Jamestown Canyon virus (JC), babesiosis, Rocky Mountain spotted fever, and Sin Nombre virus (a hantavirus).

La Crosse encephalitis prevention services were initiated in 1987 to identify areas within the District where significant risk of acquiring this disease exists. High-risk areas are defined as having high populations of the primary vector *Aedes triseriatus* (eastern tree hole mosquito), *Aedes japonicus* (Japanese rock pool mosquito) a possible vector, or a history of LAC cases. MMCD targets these areas for intensive control including public education, larval habitat removal (e.g., tires, tree holes, and containers), and limited adult mosquito treatments. Additionally, routine surveillance and control activities are conducted at past LAC case sites. Surveillance for the invasive species *Aedes albopictus* (Asian tiger mosquito) routinely occurs to detect infestations of the potential disease vector.

Culex species are vectors of WNV, a virus that arrived in Minnesota in 2002. Since then MMCD has investigated a variety of mosquito control procedures to enhance our comprehensive integrated mosquito management strategy to prevent West Nile illness. We do in-house testing of birds and mosquitoes for WNV, and use that information along with other mosquito sampling data to make mosquito control decisions.

The District collects and tests *Culex tarsalis* to monitor WNV and WEE activity. The species is a bridge vector for both viruses, meaning it bridges the gap between infected birds and humans and other mammals. Western equine encephalitis can

2016 Plans

- Continue to provide surveillance and control for La Crosse encephalitis prevention
- Continue to improve surveillance and control of *Ae. japonicus*
- Continue catch basin larvicide treatments to manage WNV vectors
- Communicate disease prevention strategies to other local governments
- Continue surveillance for WNV and other mosquito-borne viruses
- Continue to monitor for *Ae. albopictus* and other exotic species
- Continue *Cs. melanura* surveillance and evaluate control options for EEE prevention
- Continue *I. scapularis* surveillance at 100 sampling locations
- Continue with tick-borne disease education, tick identifications, and homeowner consultations
- Continue to update the Tick Risk Meter and provide updates on Facebook
- Continue to post signs at dog parks and expand to additional locations
- Continue to track collections of *A. americanum* or other new or unusual tick species
- Continue a collaborative study testing *I. scapularis* nymphs for tick-borne disease exposure

cause severe illness in horses and humans. The last WEE outbreak in Minnesota occurred in 1983.

The first occurrence of EEE in Minnesota was in 2001. Since then, MMCD has conducted surveillance for *Culiseta melanura*, which maintains the virus in birds. A "bridge vector" such as *Cq. perturbans* can acquire the virus from a bird and pass it to a human in a subsequent feeding.

On the tick front, in 1989 the state legislature mandated the District "*to consult and cooperate with the MDH in developing management techniques to control disease vectoring ticks*." The District responded by beginning tick surveillance and forming the Lyme Disease Tick Advisory Board (LDTAB) in 1990. The LDTAB includes MMCD and Minnesota Department of Health (MDH) staff, local scientists, and agency representatives who offer their expertise to the tick-borne disease effort.

MMCD initiated tick surveillance to determine the range and abundance of the black-legged tick (*Ixodes scapularis*, also known as the deer tick) and the Lyme disease spirochete, *Borrelia burgdorferi*, within the District. To date, MMCD has mapped the current distribution of black-legged ticks (545 total sites sampled) and continues to monitor their populations in the metropolitan area. Additionally, District employees have assisted the University of Minnesota with spirochete and anaplasmosis studies. All collected data are summarized and presented to the MDH for their risk analysis.

Because wide-scale tick control is neither ecologically nor economically feasible, tick-borne disease prevention is limited to public education activities that emphasize tick-borne disease awareness and personal precautions. District employees continue to provide tick identifications upon request and are used as a tick referral resource by agencies such as the MDH and the Minnesota Department of Natural Resources (MnDNR).

As described in this and prior operational reports, the MMCD uses a variety surveillance techniques to determine the geographic distribution and estimated population levels of both mosquito and tick vectors in the metropolitan area. We continue to modify our surveillance efforts as new or different diseases and disease vectors are detected. This information is used to direct vector control and public education where needed. However, knowing the location and population levels of the vectors is only one part of the vector-borne disease cycle; understanding where vector-borne disease pathogens may be circulating is also important. Because MMCD lacks the equipment to test vectors or reservoir hosts for tick-borne and most mosquito-borne pathogens, samples are sent to MDH for testing.

In 2009, MMCD began examining ways to expand its programs to be more proactive in the area of vector-borne diseases. We contacted various agencies and held a Lyme Disease Tick Advisory Board meeting to solicit technical expertise. We would ultimately like to increase our ability to serve metro citizens given that in recent years we have received reports of rarely detected vector-borne illnesses (EEE, Powassan, Jamestown Canyon, Rocky Mountain spotted fever). Additionally, we frequently detect invasive vector species (*Ae. albopictus*, *Ae. japonicus*, *Amblyomma americanum*). *Aedes japonicus* are now established throughout the District.

2015 Mosquito-borne Disease Services

Source Reduction

Water-holding containers such as tires, buckets, tarps, and even plastic toys provide developmental habitat for many mosquito species including *Ae. triseriatus*, *Ae. albopictus*, *Ae. japonicus*, *Cx. restuans*, and *Cx. pipiens*. Eliminating these container habitats is an effective strategy for preventing mosquito-borne illnesses. In 2015, District staff recycled 24,127 tires that were collected from the field (Table 2.1). Since 1988, the District has recycled 636,339 tires. In addition, MMCD eliminated 2,595 containers and filled 268 tree holes. This reduction of larval habitats occurred while conducting a variety of mosquito, tick, and black fly surveillance and control activities, including the 1,504 property inspections by MMCD staff.

Table 2.1 Number of tire, container, and tree hole habitats eliminated during each of the past 11 seasons

Year	Tires	Containers	Tree holes	Total
2005	10,614	2,656	1,008	14,278
2006	10,513	2,059	228	12,800
2007	14,449	1,267	107	15,823
2008	16,229	1,615	93	17,937
2009	39,934	8,088	529	48,551*
2010	23,445	5,880	275	29,600
2011	17,326	3,250	219	20,795
2012	21,493	3,908	577	25,978
2013	17,812	2,410	386	20,608
2014	21,109	3,297	478	24,884
2015	24,127	2,595	268	26,990

*Intensified property inspections in response to introduction of *Ae. japonicus*

La Crosse Encephalitis (LAC)

La Crosse encephalitis is a viral illness that is transmitted in Minnesota by *Ae. triseriatus*. *Aedes albopictus* and *Ae. japonicus* are also capable of transmitting the La Crosse virus (LACV). Small mammals such as chipmunks and squirrels are the vertebrate hosts of LACV; they amplify the virus through the summer months. The virus can also pass transovarially from one generation of mosquitoes to the next. Most cases of La Crosse encephalitis are diagnosed in children under the age of 16. In 2015, there were 49 La Crosse illnesses documented in the United States.

***Aedes triseriatus* Surveillance and Control** *Aedes triseriatus* will lay eggs in water-holding containers, but the preferred natural habitat is tree holes. MMCD staff use an aspirator to sample wooded areas in the daytime to monitor the day-active adults. Results are used to direct larval and adult control activities.

The first adult *Ae. triseriatus* were collected during the week of June 1, 2015 which is later than typically observed. Thereafter, aspirator collections of *Ae. triseriatus* were atypically low given the frequency of rainfall throughout the 2015 season (see Chapter 1, Fig. 1.15).

In 2015, MMCD staff collected 1,631 aspirator samples to monitor *Ae. triseriatus* populations. Inspections of wooded areas and surrounding residential properties to eliminate larval habitat were provided as follow-up service when *Ae. triseriatus* adults were collected. Two hundred one samples met the District's adulticide treatment threshold (≥ 2 adult *Ae. triseriatus* per aspirator collection). Adulticides were applied to wooded areas in 98 of those cases. Adult *Ae. triseriatus* were captured in 403 of 1,272 wooded areas sampled. The mean *Ae. triseriatus* capture was lower than the previous five years (Table 2.2), despite the wet summer weather that typically benefits the species.

Table 2.2 *Aedes triseriatus* aspirator surveillance data, 2000 – 2015

Year	Total areas surveyed	No. with *Ae. triseriatus*	Percent with *Ae. triseriatus*	Total samples collected	Mean *Ae. triseriatus* per sample
2000	1,037	575	55.4	1,912	1.94
2001	1,222	567	46.4	2,155	1.32
2002	1,343	573	42.7	2,058	1.70
2003	1,558	470	30.2	2,676	1.20
2004	1,850	786	42.5	3,101	1.34
2005	1,993	700	35.1	2,617	0.84
2006	1,849	518	28.0	2,680	0.78
2007	1,767	402	22.8	2,345	0.42
2008	1,685	495	29.4	2,429	0.64
2009	2,258	532	24.0	3,125	0.56
2010	1,698	570	33.6	2,213	0.89
2011	1,769	566	32.0	2,563	0.83
2012	2,381	911	38.3	3,175	1.10
2013	2,359	928	39.3	2,905	1.22
2014	2,131	953	44.7	2,543	1.45
2015	1,272	403	31.7	1,631	0.72

La Crosse Encephalitis in Minnesota There was one LAC case reported in Minnesota in 2015. It was diagnosed in a resident of Waseca County. An investigation conducted by the Minnesota Department of Health (MDH) identified a location in Houston County as a potential site of exposure to the LAC virus. There were no LAC cases in the District in 2015. Since 1970, the District has had an average of 2.2 LAC cases per year (range 0 – 10, median 2). Since 1990, the mean is 1.5 cases per year (range 0 – 8, median 1).

While *Ae. triseriatus* is known as the primary vector of LAC, the role *Ae. japonicus* might play in the LAC cycle is less understood. *Aedes japonicus* is a competent vector of LAC virus in laboratory settings. In 2015, MMCD submitted 73 pools of *Ae. japonicus* to MDH to be tested for LAC virus as well as WNV. All results were negative.

Eastern Equine Encephalitis (EEE)

Eastern equine encephalitis is a viral illness of humans, horses and some other domestic animals such as llamas, alpacas, and emus. The EEE virus circulates among mosquitoes and birds and is most common in areas near the habitat of its primary vector, *Cs. melanura*. These habitats include many coastal wetlands, and in the interior of North America, tamarack bogs and other bog sites. The first record of EEE in Minnesota was in 2001 when three horses were diagnosed with the illness, including one from Anoka County. Wildlife monitoring by the Minnesota Department of Natural Resources (MnDNR) has routinely detected antibodies to the EEE virus in wolves, moose, and elk in northern Minnesota.

In 2015, the EEE virus was reported to CDC by 17 states. There were five human illnesses diagnosed: three in New York and one each in Louisiana and Maine. There were veterinary reports of EEE illnesses in domestic animals, primarily horses, from 10 states. The nearest reports of EEE activity to the District were veterinary reports of illness in southwest Michigan.

***Culiseta melanura* Surveillance** *Culiseta melanura* are relatively rare in the District and are restricted to a few bog-type larval habitats. The greatest concentration of this type of habitat is in the northeast part of MMCD in Anoka and Washington counties. Still, *Cs. melanura* specimens are occasionally collected in other areas of the District.

The *Cs. melanura* population remained low in 2015 with a season total of only 199 adult females collected by CO_2 trap from designated surveillance locations (see Chapter 1, Figure 1.5). Twenty-three pools containing 180 *Cs. melanura* were submitted to MDH for viral analysis. All results were negative.

Western Equine Encephalitis (WEE)

Western equine encephalitis circulates among mosquitoes and birds in Minnesota. Occasionally, the virus causes illness in horses and less frequently in people. *Culex tarsalis* is the species most likely to transmit the virus to people and horses. In both 2004 and 2005, the virus was detected in *Cx. tarsalis* specimens collected in southern Minnesota. The virus has not been detected in Minnesota since then. *Culex tarsalis* collections rose steadily through June and July and peaked during the first week of August (see Ch 1, Fig. 1.18). One hundred seventy-five samples were tested for West Nile virus in the MMCD lab using the RAMP® test. Additionally, 25 samples were submitted to MDH to be tested for WEE and WNV. The results of all tests of *Cx. tarsalis* were negative.

Jamestown Canyon Virus (JC)

MDH confirmed two JC illnesses in Minnesota in 2015. The first was in a Dakota County resident who became ill in early June. While a Dakota County exposure cannot be ruled out in this case, an exposure in Stearns County is possible since the individual spent time outdoors there prior to becoming ill. The other Minnesota case occurred in a Carlton County resident who became ill in mid-June. Nationally, there were seven JC illnesses confirmed.

West Nile Virus (WNV)

West Nile virus circulates among many mosquito and bird species. It was first detected in New York in 1999 and has since spread through the continental U.S., much of Canada, Mexico, Central America, and South America. The virus causes many illnesses in humans and horses each year. West Nile virus was first detected in Minnesota in 2002. It is transmitted locally by several mosquito species, but most frequently by *Cx. tarsalis*, *Cx. pipiens,* and *Cx. restuans*.

WNV in the United States Each of the 48 contiguous states documented West Nile virus transmission in 2015. The U.S. Centers for Disease Control and Prevention received reports of 2,060 West Nile illnesses from 44 states and the District of Columbia. There were 119 fatalities attributed to WNV infections. California had the greatest number of cases with 730. Nationwide screening of blood donors detected WNV in 332 individuals from 38 states. Of the 332 presumptively viremic blood donors, 41 eventually developed clinical illnesses and are also included in the confirmed cases reported to CDC.

WNV in Minnesota MDH reported six WNV illnesses from five Minnesota counties. There were no WNV fatalities in Minnesota in 2015. There were seven presumptively viremic blood donors reported from Minnesota. Additionally, there were two reports of WNV illness in horses from two Minnesota counties and one report of a WNV illness in a domestic duck. Eighteen mosquito samples from three counties and two wild birds from two counties also returned positive results for WNV.

West Nile in the District There were three WNV illnesses reported in residents of the District, two in Scott County and one in Anoka County. One of the Scott County cases was likely exposed outside of Minnesota. Since WNV arrived in Minnesota, the District has experienced an average of 9.4 WNV illnesses each year (range 0 – 25, median 8). When cases with suspected exposure locations outside of the District are excluded, the mean is 7.1 cases per year (range 0 – 17, median 6).

Surveillance for WNV Cool and dry spring conditions resulted in a slow start to the mosquito season, and consequently suppressed WNV transmission in the early part of the 2015 mosquito season. The first detection of WNV in the District was from a mixed pool of

Cx. pipiens/Cx. restuans collected in a Ramsey County gravid trap on July 1. The first WNV detection in a bird was from an American crow collected in Washington County on July 21.

Several mosquito species from 42 CO_2 traps (13 elevated into the tree canopy) and 36 gravid traps were processed for viral analysis each week. In addition, we processed *Cx. tarsalis* collected by any of the CO_2 traps in our Monday night network for viral analysis. MMCD tested 689 mosquito pools using the RAMP® method, 18 of which were positive for WNV. We also submitted 137 mosquito pools to MDH for WNV analysis by PCR, one of which was positive for WNV. Table 2.3 is a complete list of mosquitoes MMCD processed for WNV analysis.

Table 2.3 Number of MMCD mosquito pools tested for West Nile virus and minimum infection rate (MIR) by species, 2015

Species	Number of mosquitoes	Number of pools	WNV+ pools	MIR per 1,000
Aedes japonicus	386	74	0	0
Culex pipiens	263	11	0	0
Culex restuans	2,981	81	1	0.34
Culex salinarius	103	18	0	0
Culex tarsalis	2,144	200	0	0
Culex species	3,362	170	7	2.08
Culex pipiens/restuans	5,767	249	11	1.91
Culiseta melanura	180	23	0	0
Total	15,186	826	19	1.25

The first WNV positive result of 2015 was from a pool of *Cx. pipiens/restuans* collected by a gravid trap in St. Paul on July 1. All 19 mosquito pools returning positive results for WNV in 2015 were *Cx. restuans*, mixed pools of *Cx. pipiens* and *Cx. restuans* or pools identified as *Culex* species. Even though 200 pools of *Cx. tarsalis* were tested for WNV, the virus was not detected in the bridge vector species.

Fourteen of the 19 WNV positive mosquito samples were collected in Ramsey County. Four WNV positive samples were collected in Hennepin County and one was collected in Anoka County. Sixteen of the 19 WNV positive samples were collected by gravid traps; three were collected by CO_2 traps.

The lack of a summer heat wave in 2015 along with a two week cool period in August resulted in a low level of WNV circulation. The WNV infection rate in *Culex* vectors tested remained at or near zero until the first week of August (Figure 2.1). The infection rate increased from 2.28/1,000 mosquitoes tested at the beginning of August to 7.95/1,000 mosquitoes during the week of August 24. Cool temperatures during the last two weeks of August caused the infection rate to drop during the first two weeks of September after which the infection rate increased for the remainder of the season. The season peak occurred during the last week of sampling at 12.05/1,000 mosquitoes tested.

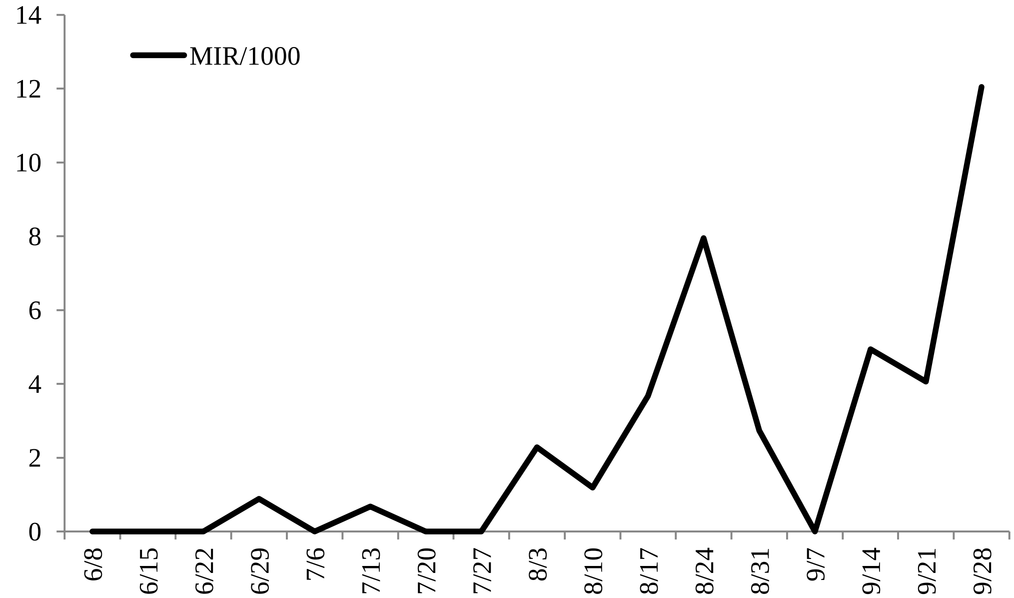


Figure 2.1 Weekly minimum WNV infection rates (MIR) per 1,000 *Culex* specimens tested in 2015. Dates listed are the Monday of each sampling week.

Two birds tested by MMCD in 2015 were positive for WNV by RAMP® test. They were both American crows collected during the week of July 20. The first was found on July 21 in Birchwood Village and the second was found in Minneapolis on July 22. The District modified its bird surveillance plan in 2013 for more efficient use of reported information. We determined that we would stop collecting birds after the first WNV positive result. Seventy-five reports of dead birds were received by telephone, internet, or from employees in the field. Seven of the reports were of dead blue jays, 39 were American crows. All other reports were of non-corvids.

Larval *Culex* Surveillance

Culex mosquitoes lay rafts of eggs on the surface of standing water in both natural and man-made habitats. Detecting *Culex* mosquitoes can be challenging since larvae will not be present in a wet habitat unless adult, egg-laying females have been recently active, the area was wet and attractive for oviposition, and the characteristics of the site allow for survival of newly hatched mosquitoes. *Culex* are also less abundant than other types of mosquitoes in our area. Furthermore, in large wetlands larvae can disperse over a wide area or they may clump together in small, isolated pockets. They are generally easier to locate in small habitats (i.e., catch basins, stormwater management structures, etc.) where greater concentrations of larvae tend to be more evenly dispersed.

Stormwater Management Structures and Other Man Made Habitats Since 2006, MMCD field staff have been working to locate stormwater structures, evaluate habitat, and provide larval control. A classification system was devised to categorize potential habitats. Types of structures include culverts, washouts, riprap, risers (pond level regulators), underground structures, swimming pools, ornamental ponds, and intermittent streams.

Staff made 5,947 inspections of 4,262 structures in 2015. Mosquito larvae were found in 952 of the 3,725 habitats that were wet on the date of inspection. Inspectors collected 701 larval samples from stormwater structures and other constructed habitats. *Culex* vectors were found in 81.6% of the samples, which is similar to previous seasons (Table 2.4). *Culex pipiens* were collected more frequently from stormwater structures in 2015 than in 2014. *Culex restuans*, *Cx. salinarius* and *Cx. tarsalis* were observed about as frequently as they have been in most other years.

Table 2.4 Frequency of *Culex* vector species in samples collected from stormwater management structures and other constructed habitats 2011 – 2015

	Yearly percent occurrence				
Species	2011 (N=1,567)	2012 (N=1,080)	2013 (N=877)	2014 (N=814)	2015 (N=701)
Cx. pipiens	13.7	39.8	29.8	15.6	24.4
Cx. restuans	65.3	53.1	66.0	64.6	71.0
Cx. salinarius	0.1	0.6	0.5	0.6	0.4
Cx. tarsalis	3.8	3.4	3.9	5.4	2.4
Any *Culex* vector spp.	76.6	74.5	78.6	74.1	81.6

Mosquito Control in Underground Stormwater Structures Many stormwater management systems include large underground chambers to trap sediments and other pollutants. There are several designs in use that vary in dimension and name, but collectively they are often referred to as BMPs from *Best Management Practices for Stormwater* under the US Environmental Protection Agency's National Pollution Discharge Elimination System (NPDES). MMCD has worked with city crews to survey and treat underground BMPs since 2005.

In 2015, we continued the cooperative mosquito control plan for underground habitats. Twenty-one municipalities volunteered their staff to assist with material applications (Table 2.5). Altosid® XR briquets were used at the label rate of one briquet per 1,500 gallons of water retained. Briquets were placed in 714 underground habitats.

Prolific mosquito development has been documented in local underground BMPs. The majority of mosquitoes found in BMPs are *Culex* species and successfully controlling their emergence from underground habitats will remain an objective in MMCD's comprehensive strategy to manage WNV vectors. We plan to continue working with municipalities to limit mosquito development in stormwater systems.

Table 2.5 Cities that assisted in treating underground stormwater habitats in 2015; 714 structures were treated and a total of 1,054 briquets were applied

City	Structures treated	Briquets used	City	Structures treated	Briquets used
Arden Hills	6	6	Mendota Heights	35	43
Blaine	6	21	New Brighton	5	8
Bloomington	88	105	New Hope	6	12
Brooklyn Park	4	15	Plymouth	150	335
Crystal	5	14	Prior Lake	56	56
Eagan	20	20	Richfield	13	25
Eden Prairie	12	20	Roseville	11	14
Edina	28	56	Savage	12	22
Fridley	10	35	Spring Lake Park	2	2
Lino Lakes	10	10	Woodbury	40	40
Maplewood	195	195			

Larval Surveillance in Catch Basins Catch basin larval surveillance began the week of May 18 and ended the week of September 7 (Figure 2.2). Despite frequent rainfall throughout the summer, larvae were found during 510 of 716 catch basin inspections (71.2%) in 2015.

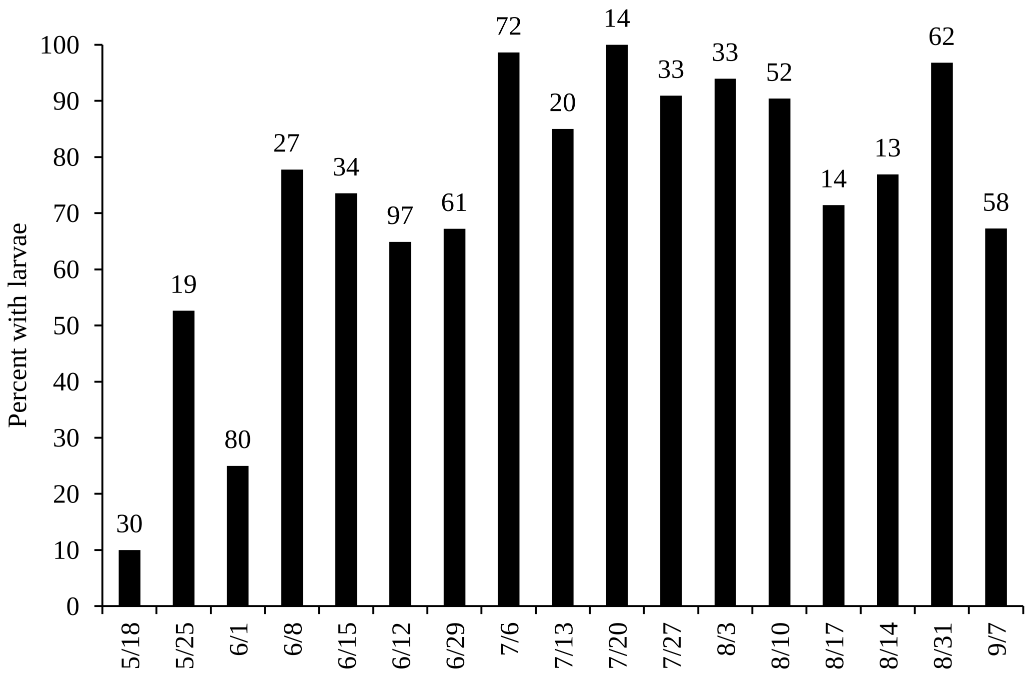


Figure 2.2 Percent of catch basins inspected with mosquitoes present in 2015. Bars are labeled with the number of inspections occurring during the week.

Mosquito larvae were identified from 512 catch basin samples. *Culex restuans* were found in 70.7% of catch basin larval samples (Figure 2.3). *Culex pipiens* were found in 42.8% of samples. At least one *Culex* vector species was found in 98.6% of samples. *Culex restuans* were the predominant species in catch basins through mid-July. By mid-August and through the remainder of the season, *Cx. pipiens* were encountered more frequently.

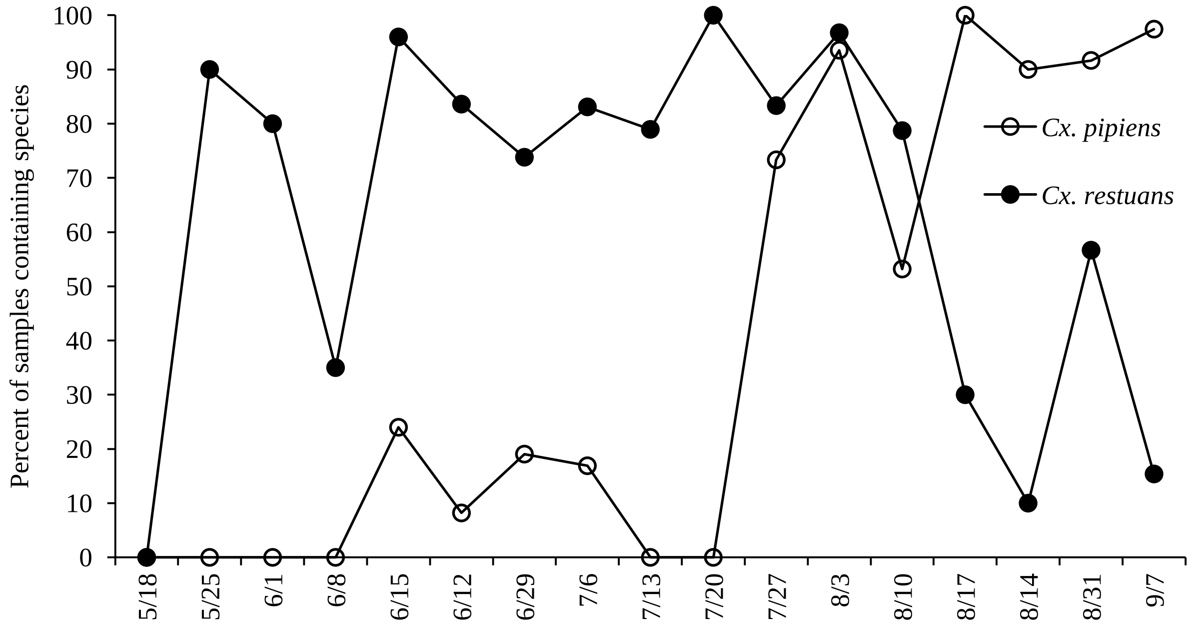


Figure 2.3 Occurrence of *Cx. pipiens* and *Cx. restuans* in catch basin larval samples by week.

2016 Plans – Mosquito-borne Disease

District staff will continue to provide mosquito surveillance and control services for the prevention of La Crosse encephalitis. Preventive measures include *Ae. triseriatus* adult sampling, adult control and, especially, tree hole and container habitat reduction. Eliminating small aquatic habitats will also serve to control populations of *Ae. japonicus*.

The District will continue to survey aquatic habitats for *Culex* larvae for use in design and improvement of larval control strategies. The WNV and WEE vector *Cx. tarsalis* will remain a species of particular interest. Cooperative work with municipalities within the District to treat underground stormwater structures that produce mosquitoes will continue. District staff will continue to target *Culex* larvae in catch basins in our efforts to reduce WNV amplification.

MMCD will continue to conduct surveillance for WNV, JC, and EEE vectors and for other mosquito-borne viruses in coordination with MDH and others involved in mosquito-borne disease in Minnesota. We plan to work with other agencies, academia, and individuals to improve vector-borne disease prevention in the District, as well as to serve as a resource for others in the state.

2015 Tick-borne Disease Services

Background

Infected deer ticks (*Ixodes scapularis*), also known as black-legged ticks, can transmit two important diseases in our area. Lyme disease, a bacterial infection caused by the bacterium *Borrelia burgdorferi*, can most notably affect the joints, nervous system, and heart. Human anaplasmosis (HA) is caused by the bacterium *Anaplasma phagocytophilum.* Other rare diseases transmitted by deer ticks include babesiosis and Powassan virus. The Metropolitan Mosquito Control District's Lyme Disease Program identifies and monitors the distribution of deer ticks within the seven-county Twin Cities metropolitan area, ranks the deer tick activity throughout the season, and provides education in preventing tick-borne illness for District residents.

Lyme Disease and Human Anaplasmosis

Our tick surveillance began to detect increases in the metro *I. scapularis* population in 1998, with obvious expansion beginning in 2000. Since then we have continued to document record-setting collection seasons on an ongoing basis. In parallel, but with a two year lag (since 2000), the Minnesota Department of Health (MDH) has been documenting ongoing record-setting human tick-borne disease case totals. Pre-2000, the highest Lyme case total was 302 but since 2000 the Lyme totals have ranged from 463 to 1,431 cases, and now typically average >1,000 per year. Human anaplasmosis cases have also been on the rise. After averaging roughly 15 cases per year through 1999, the total HA case numbers ranged from 78 to 186 from 2000 – 2006 then increased into the range of the 300s. The all-time high, statewide Lyme disease case record (1,431) was set in 2013 with the all time high HA record of 782 set in 2011. There were 896 Lyme and 448 HA cases in 2014. Case totals from 2015 are not yet available.

Ixodes scapularis Distribution

The District continued to sample the network of 100 sites set up in 1991-1992 to monitor potential changes in tick distribution over time. As in previous years, the primary sampling method involved capturing small mammals from each site and removing any attached ticks from them. Collections from the northeastern metropolitan area (primarily Anoka and Washington counties) have consistently detected *I. scapularis* since 1990, and in 1998 *I. scapularis* was detected in Hennepin and Scott counties for the first time. We collected at least one *I. scapularis* from all seven counties that comprise our service area for the first time in 2007. Since then we have continued to detect *I. scapularis* with greater frequency and they appear to be prevalent now in many wooded areas south of the Mississippi river. The 2015 report will be available on our website (www.mmcd.org) in June. Following are some 2015 highlights.

The average number of *I. scapularis* collected per mammal (1.450) in 2015 is a new record high but it is comparable to the averages we have come to expect in recent years (as shown in Table 2.6: 2000 – 2002, 2004, 2005, 2007, 2009, 2010, 2012, 2014 and 2015 were all $\geq$ .806).

While it has been typical to tabulate a yearly positive site total in the 50s since 2000, our overall positive site total of 81 for 2015 was a new record high, the first time we have tabulated a site total of 80 or more. The previous high of 75 sites was in 2014, and the 70 sites for 2010 was the first time we had a site total of 70 or more. As has occurred in all years since 2007 except 2011, we collected at least one *I. scapularis* from all seven counties. *Ixodes scapularis* was collected at 51 sites located north of the Mississippi River (Anoka, Washington, and Ramsey counties), and at 30 sites south of the Mississippi River (Dakota, Hennepin, Scott, and Carver counties). Maps are included in our yearly Lyme tick distribution study, posted online at www.mmcd.org in June.

Table 2.6 Total number of mammals trapped and tick species collected by life stage and year, and the number of *I. scapularis* collected per mammal 1990-2015. The number of sites sampled was 250 in 1990, 270 in 1991, 200 in 1992, and 100 from 1993 to present.

			Dermacentor variabilis		*Ixodes scapularis*			
Year	No. mammals	Total ticks collected	No. larvae	No. nymphs	No. larvae	No. nymphs	No. other species[b]	Ave. *I. scap* / mammal
1990 [a]	3651	9957	8289	994	573	74	27	0.177
1991	5566	8452	6807	1094	441	73	37	0.092
1992	2544	4130	3259	703	114	34	20	0.058
1993	1543	1785	1136	221	388	21	19	0.265
1994	1672	1514	797	163	476	67	11	0.325
1995	1406	1196	650	232	258	48	8	0.218
1996	791	724	466	146	82	20	10	0.129
1997	728	693	506	66	96	22	3	0.162
1998	1246	1389	779	100	439	67	4	0.406
1999	1627	1594	820	128	570	64	12	0.390
2000	1173	2207	1030	228	688	257	4	0.806
2001	897	1957	1054	159	697	44	3	0.826
2002	1236	2185	797	280	922	177	9	0.889
2003	1226	1293	676	139	337	140	1	0.377
2004	1152	1773	653	136	901	75	8	0.847
2005	965	1974	708	120	1054	85	7	1.180
2006	1241	1353	411	140	733	58	11	0.591
2007	849	1700	807	136	566	178	13	0.876
2008	702	1005	485	61	340	112	7	0.644
2009	941	1897	916	170	747	61	3	0.859
2010	1320	1553	330	101	1009	107	6	0.845
2011	756	938	373	97	261	205	2	0.616
2012	1537	2223	547	211	1321	139	5	0.950
2013	596	370	88	42	147	92	1	0.401
2014	1396	2427	580	149	1620	74	4	1.213
2015	1195	2217	390	91	1442	291	3	1.450

[a] 1990 data excludes one *Tamias striatus* with 102 *I. scapularis* larvae and 31 nymphs
[b] other species mostly *Ixodes muris.* 1999—second adult *I. muris* collected

Additional Updates – 2015

Posting Signs, Dog Parks Since the initial suggestion of the Technical Advisory Board (TAB) in 2010, we have visited dog parks and vet offices as part of our outreach. Signs have been posted in approximately 21 parks with additional signs posted in active dog walking areas, including at Stubbs Bay Park, Luce Line Trail Entrance. We have also worked on expanding placements into additional metro locations.

Distributing Materials to Targeted Areas Brochures, tick cards, and/or posters were dropped at roughly 270 locations (city halls, libraries, schools, child care centers, retail establishments, vet clinics, parks) across the metro as well as distributed at fair booths and city events, with many more mailed upon request.

***Amblyomma americanum* (Lone Star Tick) Found in the Metro** *Amblyomma americanum* is an aggressive human biter and can transmit human monocytic ehrlichiosis (HME), among other potential pathogens. Both the tick and HME are more common to the southern US, but the range of *A. americanum* is known to be moving northward. *Amblyomma* ticks have been submitted to MMCD from the public on a rare, sporadic basis and this species was first collected by MMCD in 1991 via a road kill examination of a white-tailed deer (*Odocoileus virginianus*). However, in 2009, for the first time in a number of years, the public submitted *Amblyomma* to MDH and MMCD (Minneapolis and Circle Pines). This trend continued in 2010 with *Amblyomma* submitted to MMCD from Eagan, Mound, and the Orono/Lake Minnetonka areas of the metro. In 2011 the MDH had submissions of adults from Shakopee, Lindstrom, and an unconfirmed location in Hennepin County. In 2012, three more *Amblyomma* were submitted to the MDH: Eden Prairie or Burnsville, Bloomington, and Rice County. MMCD did not receive any *Amblyomma* in 2011 or 2012. In 2013, the MDH did not receive any reports but MMCD received three *Amblyomma* (Afton, Scandia, and western Wisconsin). We notified the Wisconsin Department of Health and mailed the western Wisconsin tick to them. In 2014, MMCD did not receive any reports but the MDH received one report from the Zumbrota, MN area. In 2015, MMCD received one adult male and one nymph from the Elk River area, and one additional adult female (unknown location) was collected by a dog groomer in collaboration with the Jordan facility.

Bot Fly Collections From 2009-2015 MMCD provided Dr. Roger Moon (UM-St. Paul) with larval bot flies we collected from *Peromyscus leucopus*. In addition to analyzing trends for this lesser studied bot fly species, from 2013 – 2015 MMCD collected bot fly pupae for Dr. Moon. In his first attempt in 2014, Dr. Moon successfully reared some bot fly pupae into adults. It is a rare event to see this particular bot fly species alive as an adult and we are happy to report that a flying live adult was viewed, in person, by MMCD staff! Dr. Moon has reared a sub set of these bot fly pupae into adults in each year they were provided to him.

Tick Identification Services/Outreach

The overall scope of tick-borne disease education activities and services were maintained in 2015 using methods and tools described in previous TAB reports, including weekly updates to our Tick Risk Meter on our website and via MMCD's Facebook page.

2016 Plans for Tick-borne Services

Metro Surveillance

The metro-based *I. scapularis* distribution study that began in 1990 is planned to continue unchanged.

Tick Identification Services/Outreach

Education / Social Media We plan to maintain our tick-borne disease education activities and services (including tick identifications and homeowner consultations) using previously described methods and tools, including weekly website updates of our Tick Risk Meter and occasional use of social media. Since our *I. scapularis* collections and the MDH's human tick-borne disease case totals remain elevated, we will continue to stock local parks and other locations with tick cards, brochures and/or posters and signs. We will also distribute materials at local fairs and the Minnesota State Fair, set up information booths at events as opportunities arise, and continue to offer an encompassing slide presentation.

Signs We will continue to post at dog parks and other appropriate locations. As in past years, signs will be posted in the spring and removed in late fall after *I. scapularis* activity ceases for the year.

***Amblyomma americanum* / New or Unusual Tick Species** MMCD and MDH continue to discuss possible strategies that would enable both agencies to detect possible establishment of *A. americanum* in Minnesota. MMCD will continue to monitor for this tick in our surveillance and to track collections turned in by the public as part of our tick identification service. Both MMCD and MDH plan to maintain our current notification process of contacting the other agency upon identifying an *A. americanum* or other new or unusual tick species.

Additional Projects

Collaborative Study: Testing Nymphal Deer Ticks In 2015, MMCD provided *I. scapularis* nymphs to PhD student Steve Bennett (UM-St Paul) to be tested for exposure to several tick-borne disease agents. Nymphs from 1990 through 2014 are being tested and any changes over time will be documented.

Chapter 3 Mosquito Control

2015 Highlights

- Larvicide treatments in 2015 (326,571 acres) were higher than the record set in 2014 (318,427 acres)
- A cumulative total of 249,049 catch basin treatments were made in three rounds to control vectors of WNV
- 22,553 fewer acres worth of adulticides were applied in 2015 than in 2014

2016 Plans

- Test MetaLarv™ S-PT to control spring *Aedes* as a prehatch
- Increase September VectoLex® CG treatments as part of our cattail mosquito control program
- Repeat tests of Natular ™ G applied earlier in May to evaluated potential control of *Cq. perturbans*
- Work closely with MPCA to fulfill the requirements of a NPDES permit
- Continue tests of Onslaught® and other alternate barrier adulticides; specifically target vector mosquitoes
- Continue to increase vector surveillance and control in response to the observed geographic expansion of *Ae. japonicus* within the District

Background

The mosquito control program targets the principal summer pest mosquito *Aedes vexans*, several species of spring *Aedes*, the cattail mosquito *Cq. perturbans*, and several known disease vectors (*Ae. triseriatus, Culex tarsalis, Cx. pipiens, Cx. restuans, Cx. salinarius*) and *Aedes japonicus*, another potential vector species.

Due to the large size of the metropolitan region (2,975 square miles), larval control was considered the most cost-effective control strategy in 1958 and remains so today. Consequently, larval control is the focus of the control program and the most prolific mosquito habitats (over 79,000 potential sites) are scrutinized for all human-biting mosquitoes.

Larval habitats are diverse. They vary from very small, temporary pools that fill after a rainfall to large wetland acreages. Small sites (ground sites) are three acres or less, which field crews treat by hand if larvae are present. Large sites (air sites) are treated by helicopter only after certain criteria are met: larvae occur in sufficient numbers (threshold), larvae are of a certain age (instar), and larvae are the target species (human biting or disease vector).

The insect growth regulator methoprene and the soil bacterium *Bacillus thuringiensis* var *israelensis* or *Bti*, are the primary larval control materials. These active ingredients are used in the trade-named materials Altosid® and MetaLarv™ (methoprene) and VectoBac® (*Bti*). Other materials included in the larval control program are *B. sphaericus* (VectoLex® CG) and *Saccharopolyspora spinosa* or “spinosad” (Natular™ G30).

To supplement the larval control program, adulticide applications are performed after sampling detects mosquito populations meeting threshold levels, primarily in high use park and recreation areas, for public events, or in response to citizen mosquito annoyance reports. Special emphasis is placed on areas where disease vectors have been detected, especially if there is also evidence of virus circulation.

Four synthetic pyrethroids are used: resmethrin, permethrin, sumithrin and etofenprox. Sumithrin (Anvil®) and two formulations of natural pyrethrins, Pyrenone® and Pyrocide®, can be used in agricultural areas. A description of the control materials is found in Appendix C. Appendix D indicates the dosages of control materials used by MMCD, both in terms of amount of formulated (and in some cases diluted) product applied per acre and the amount of active ingredient (AI) applied per acre. Appendix E contains a historical summary of the number of acres treated with each control material (2007-2015). Pesticide labels are located in Appendix F.

The District uses priority zones to focus service in areas where the highest numbers of citizens benefit (Figure 3.1). Priority Zone 1 (P1) contains the majority of the population of the Twin Cities metropolitan area and has boundaries similar to the Metropolitan Urban Service Area (MUSA, Metropolitan Council). Priority Zone 2 (P2) includes sparsely populated and rural parts of the District. We consider small towns or population centers in rural areas as satellite communities and they receive services similar to P1. Citizens in P1 receive full larval and adult vector and nuisance mosquito control. In P2, the District focuses on vector control and provides additional larval and adult control services as appropriate and as resources allow.

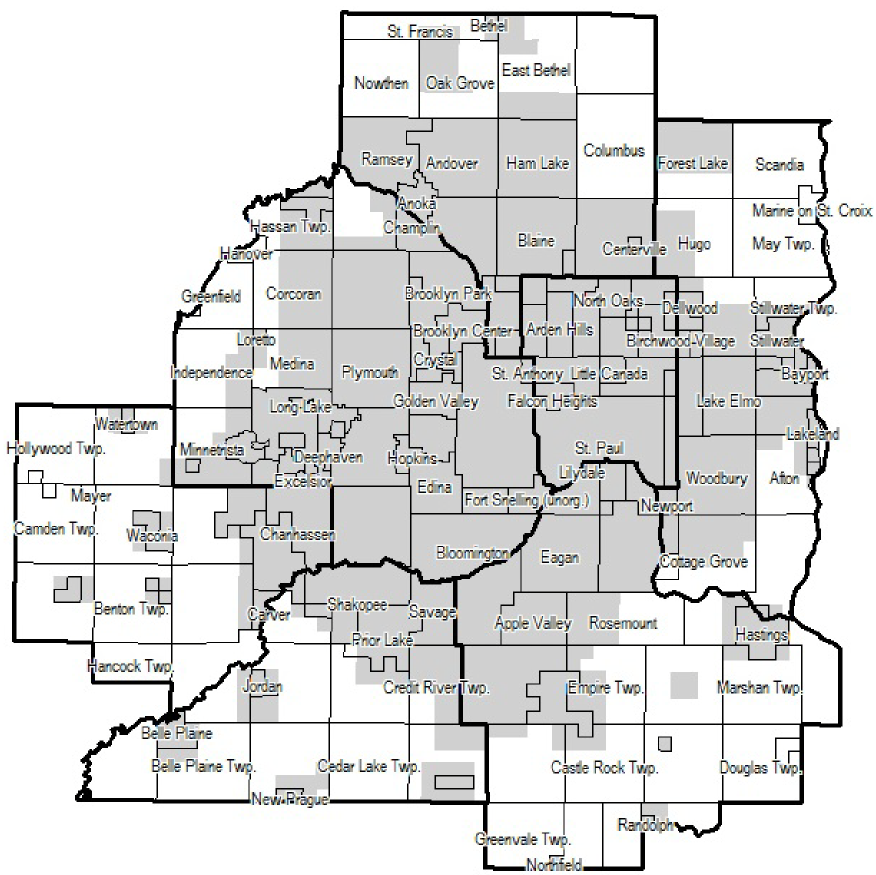


Figure 3.1 Priority Zones 1 (shaded) and 2 (white), with District county and city/township boundaries, 2015.

2015 Mosquito Control

Larval Mosquito Control

Thresholds *Bti* treatments in large sites treated by helicopter (i.e., "air sites") are only done when larval numbers meet treatment thresholds, as measured by taking 10 dips with a standard 4-inch diameter dipper. P1 and P2 areas have different thresholds to help focus limited time and materials on productive sites near human population centers (Table 3.1). Spring *Aedes*, which tend to be long-lived, aggressive biters, have lower thresholds. After mid-May, when most larvae found are summer floodwater species, thresholds are increased. If *Aedes* and *Culex* are both present in a site and neither meet threshold, the site can be treated if the combined count meets the threshold.

Table 3.1 Larval thresholds (average number of larvae per ten dips) in priority zone (P1 and P2) by species group

	Priority zone	
Species group	P1	P2
Spring *Aedes*	0.5	1.0
Summer*	2.0	5.0
*Culex*4**	2.0	2.0

*Summer = Summer *Aedes* or *Aedes* + *Culex* 4
***Culex* 4 = *Cx. restuans, Cx. pipiens, Cx. salinarius, Cx. tarsalis*

Season Overview The 2015 season started slowly. Staff detected the first spring *Aedes* larvae on March 30. *Bti* treatments to control spring *Aedes* began on April 28 (three days later than in 2014). The mosquito species composition switched to *Aedes vexans* (summer floodwater) on May 8; after that time the summer threshold was used.

Treatments with materials formulated for application prior to flooding and egg hatch ("prehatch materials") are applied to sites with a history of larvae present. The first "prehatch" treatments were applied in mid-May with a second in mid-June. Methoprene larvicides (MetaLarv S-PT, Altosid pellets) were applied in late May and very early June to control the cattail mosquito.

Precipitation was below average through June. The entire District received weekly significant rain in July through mid-August with periodic rain in September. By the end of June 2015, about 95,000 acres worth of *Bti* had been applied (Figure 3.2), much less than the 190,000 acres worth applied by the end of June 2014. We applied an additional 117,000 acres of *Bti* to control summer floodwater mosquitoes in July resulting from nearly weekly rains. On July 13, 2015 we lowered our aerial *Bti* dosage from 8 to 5 lb/acre to conserve remaining control materials while maintaining good control (Table 5.1). Rain events continued until mid August when they became more isolated. Significant rainfall in August and September stimulated enough larval floodwater mosquito development to justify 59,000 acres of aerial *Bti* treatments. On September 18, we treated 4,003 acres of cattail sites in which cattail mosquito larvae recently were detected by inspectors with VectoLex. These late summer treatments will decrease the cattail treatment pressure in late spring 2016, when weather and concurrent floodwater mosquito broods can complicate treatment efforts.

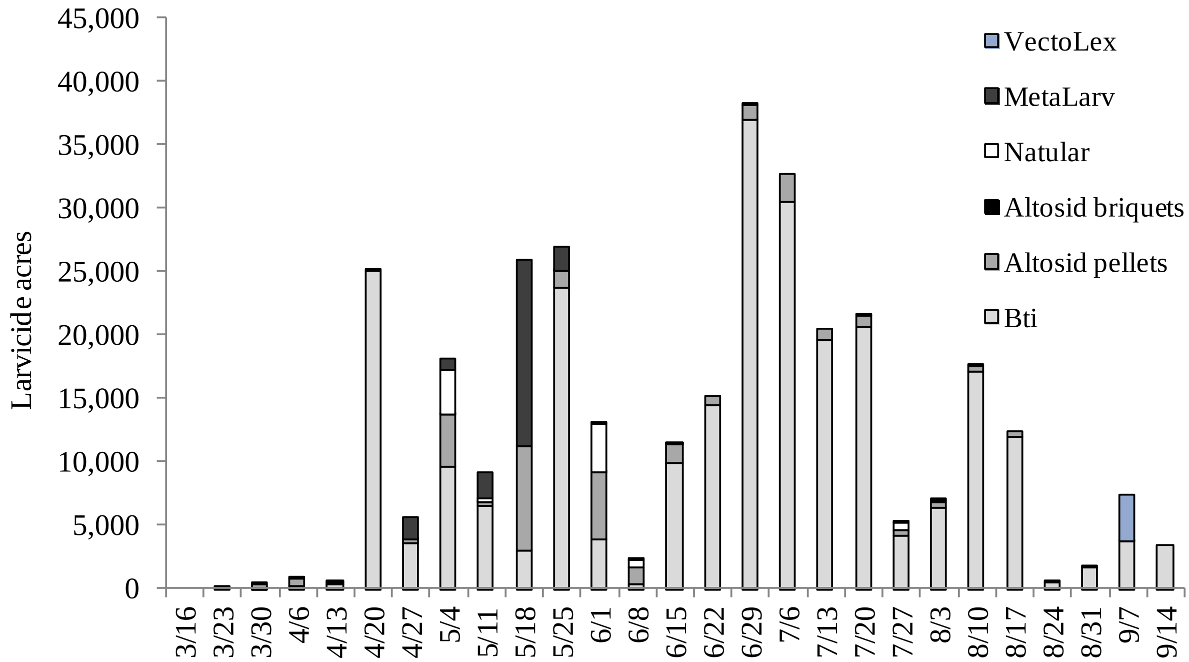


Figure 3.2 Acres treated with larvicide and each week (March-September 2015). Date represents start date of week.

While the mosquito season began as late in 2015 as in 2014, intense mosquito production again continued throughout the season in 2015 (22 weeks: April 28 through September 22, 2015, compared to 21 weeks: April 22 through September 17, 2014). This resulted in one large brood of spring *Aedes* and eleven large and seven small-medium broods of *Ae. vexans* (a typical season has four large broods). Total larval control material use in 2015 was higher than 2014 (Table 3.2).

Stormwater catch basin treatments to control *Culex* mosquitoes began in early June and ended in early September. Most catch basins were treated three times with Altosid pellets (3.5 grams per catch basin) from June through mid-September (Table 3.2).

We continued to work with Minnesota Pollution Control Agency (MPCA) to satisfy the requirements of our National Pollution Discharge Elimination System (NPDES) permit. We submitted our 2014 treatment report to MPCA in early 2015. Our report contained site-specific larval surveillance and larvicide treatment records and GIS-encoded locations of sites (more details included in Chapter 6). We plan to submit a similar report of 2015 activities in early 2016.

Table 3.2 Comparison of larval control material usage in wetlands (including stormwater structures other than catch basins) and in stormwater catch basins for 2014 and 2015 (research tests not included).

	2014		2015	
Material	Amount used	Area treated	Amount used	Area treated
Wetlands and Structures				
Altosid briquets (cases)	256.40	193 acres	257.63	188 acres
Altosid pellets	84,056.60 lb	26,179 acres	108,162.84 lb	31,494 acres
Altosid XR-G	520.00 lb	52 acres	0.00 lb	0 acres
MetaLarv S-PT	48,491.51 lb	18,073 acres	66,488.27 lb	21,126 acres
Natular G30	74,981.13 lb	14,950 acres	51,172.80 lb	8,840 acres
VectoLex CG	43,999.79 lb	3,064 acres	60,039.49 lb	3,777 acres
VectoBac G	1,730,131.00 lb	255,916 acres	1,827,601.82 lb	258,148 acres
Larvicide subtotals		318,427 acres		326,571 acres
Catch basins				
Altosid briquets (cases)	1.99	437 CB[1]	2.05	450 CB[1]
Altosid pellets	1,984.39 lb	239,829 CB	1,933.07 lb	248,599 CB
CB subtotals		240,266 CB		249,049 CB

[1]CB=catch basin treatments

Adult Mosquito Control

Thresholds Adult mosquito control operations are considered when mosquito levels rise above established thresholds for nuisance (*Aedes* spp. and *Cq. perturbans*) and vector species (Table 3.3). Staff conducted a study in the early 1990s that measured people's perception of annoyance while simultaneously sampling the mosquito population (Read et.al., 1994). Results of this study are the basis of MMCD's nuisance mosquito thresholds. The lower thresholds for vector species are designed to interrupt the vector/virus transmission cycle.

Table 3.3 Thresholds levels by sampling method for important nuisance and vector species detected in MMCD surveillance. *Aedes* spp. and *Cq. perturbans* are considered nuisance mosquitoes; all other species listed are disease vectors.

		Total number of mosquitoes			
Species	Date implemented	2-min sweep	CO_2 trap	Aspirator	2-day gravid trap
Aedes triseriatus	1988			2	
Aedes spp. & *Cq. perturbans*	1994	2*	130		
*Culex*4***	2004	1	5	1**	5
Ae. japonicus	2009	1	1	1	1
Cs. melanura	2012		5	5	

*2-minute slap count may be used
**Aspirator threshold only for *Cx. tarsalis*
****Culex* 4 = *Cx. restuans*, *Cx. pipiens*, *Cx. salinarius*, *Cx. tarsalis*

Season Overview In 2015, adult mosquito levels rose at the end of May and remained higher until early July; at those times, counts over threshold were fairly widespread (Figure 3.3). In 2015, MMCD applied 23,498 fewer acres worth of adulticides than in 2014 (Table 3.4, Appendix E). Figure 3.3 shows weekly adulticide acres treated (line). The peaks in mid-June through mid-July reflect a response to primarily widespread *Ae. vexans* emergence and increasing numbers of *Culex* (WNV vectors). The proportion of traps over the vector threshold was highest in early July with lower levels through the rest of the season. A greater proportion of ULV and barrier treatments later in the summer targeted vector mosquitoes. Customer calls related to mosquito annoyance peaked in June and July (982 and 1,051, respectively) and decreased thereafter.

Table 3.4 Comparison of adult control material usage in 2014 and 2015

	2014		2015	
Material	Gallons used	Acres treated	Gallons used	Acres treated
Permethrin	1,735.77	8,887	1,090.01	6,093
Resmethrin	526.22	44,890	239.21	19,767
Sumithrin*	735.48	31,381	645.30	27,183
Etofenprox	0.00	0	81.10	10,380
Pyrocide*	62.91	5,338	42.24	3,605
Total		90,526		67,028

* Products labeled for use in agricultural areas

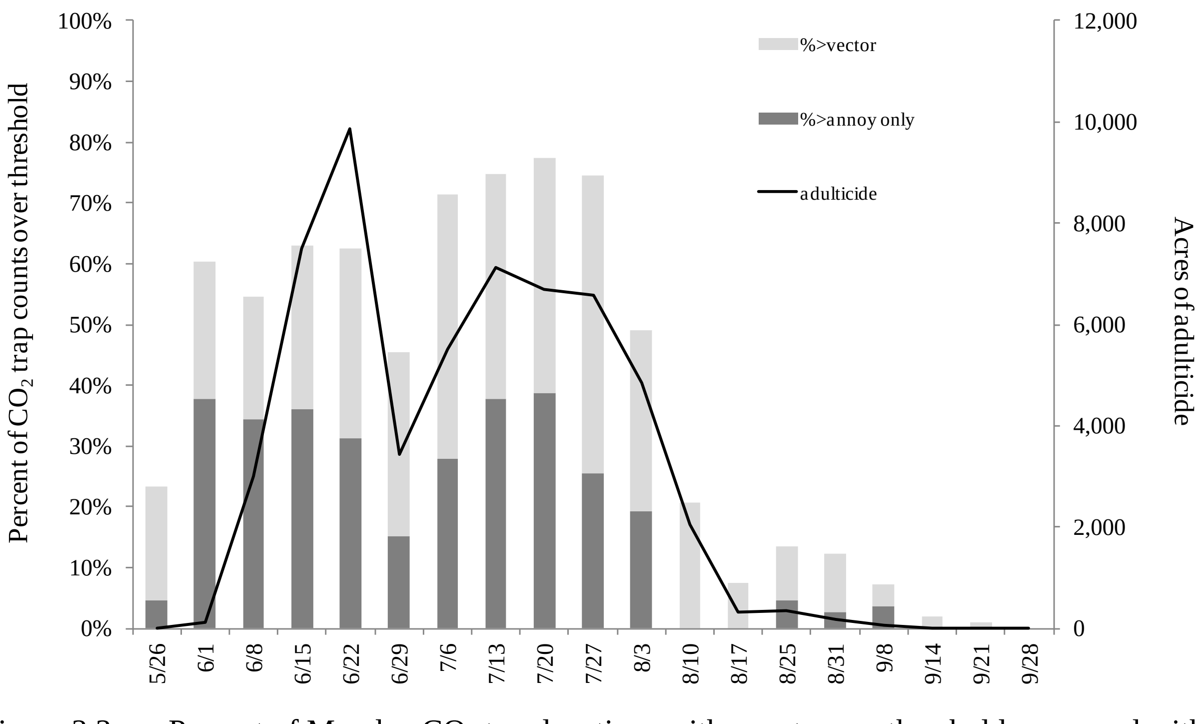


Figure 3.3 Percent of Monday CO_2 trap locations with counts over threshold compared with acres of adulticides applied in 2015 (solid line). Dark bars indicate the percentage of traps meeting annoyance mosquito thresholds and lighter bars represent the percentage of traps meeting the vector thresholds (*Culex*4, *Ae. triseriatus*, *Ae. japonicus*) on each sampling date. Date is day of CO_2 trap placement.

References

Read, N., J.R. Rooker, and J. Gathman. 1994. Public perception of mosquito annoyance measured by a survey and simultaneous mosquito sampling. J. Am. Mosq. Control Assoc. 10(1): 79-87.

2016 Plans for Mosquito Control Services

Integrated Mosquito Management Program

In 2016, MMCD will review all aspects of its integrated mosquito management program to ensure that budgetary resources are being used as effectively as possible with the goal of maximizing mosquito control services per budget dollar and complying with all NPDES-related permit requirements. Further discussion regarding the Clean Water Act's NPDES permit requirements is in Chapter 6. Our control materials budget in 2016 will be maintained at the same level as 2015.

Larval Control

Cattail Mosquitoes In 2016, control of *Cq. perturbans* will use a strategy similar to that employed in 2015. MMCD will focus control activities on the most productive cattail marshes near human population centers. Altosid briquet applications will start in early March to frozen sites (e.g., floating bogs, deep water cattail sites, remotely located sites). Largely because of control material prices, a greater proportion of acres will be treated with Altosid pellets and MetaLarv S-PT to minimize per-acre treatment costs. Beginning in late May, staff will apply MetaLarv S-PT (3 lb/acre) and Altosid pellets (4 lb/acre) aerially. Ground sites will be treated with Altosid pellets (4 lb/acre) and MetaLarv S-PT (3 lb/acre). Staff will increase (compared to previous years) late summer VectoLex CG applications (15 lb/acre) into our cattail mosquito control program based upon site inspections completed between mid-August and mid-September.

Floodwater Mosquitoes The primary control material will again be *Bti* corn cob granules. Larvicide needs in 2016, mainly *Bti* (VectoBac G), Altosid pellets, Natular G30, and MetaLarv S-PT, are expected to be similar to the five-year average larvicide usage (275,374 acres). As in previous years, to minimize shortfalls, control material use may be more strictly rationed during the second half of the season, depending upon the amount of the season remaining and control material supplies. Regardless of annoyance levels, MMCD will maintain sufficient resources to protect the public from potential disease risk.

Staff will treat ground sites (<3.0 acres) with methoprene products (Altosid pellets, Altosid briquets, MetaLarv S-PT), Natular G30 or *Bti* corncob granules. During a wide-scale mosquito brood, sites in highly populated areas will receive treatments first. The District will then expand treatments into less populated areas where treatment thresholds are higher. We will continue with the larval treatment thresholds used in 2015 (Table 3.1).

Each year staff review ground site histories to identify those sites that produce mosquitoes most often. This helps us to better prioritize sites to inspect before treatment, sites to pre-treat with Natular G30 or methoprene products before flooding and egg hatch, and sites not to visit at all. The ultimate aim is to provide larval control services to a larger part of the District by focusing on the most prolific mosquito production sites.

Vector Mosquitoes Employees will routinely monitor and control *Ae. triseriatus*, *Ae. japonicus, Ae. albopictus, Cs. melanura*, *Cx. tarsalis*, *Cx. pipiens*, *Cx. restuans,* and *Cx. salinarius* populations (See Chapter 2).

MMCD has expanded control to four *Culex* species since the arrival of WNV in 2002. Ground and aerial larvicide treatments of wetlands have been increased to control *Culex*. Catch basin treatments control *Cx. restuans* and *Cx. pipiens* in urban areas. Most catch basins will be treated with Altosid pellets. Catch basins selected for treatment include those found holding water, those that potentially could hold water based on their design, and those for which we have insufficient information to determine whether they will hold water. Treatments could begin as early as the end of May and no later than the third week of June. We tentatively plan to complete a first round of pellet treatments by June 25 with subsequent Altosid pellet treatments every 30 days.

We intend to continue working cooperatively with cities to treat underground stormwater management structures (see Chapter 2) and slowly expand the kinds of structures we treat with larvicides beyond pond level regulators.

Intensive surveillance for *Ae. japonicus* and *Cs. melanura* will continue in 2015 to determine abundance and common larval habitats and refine potential larval control methods.

Adult Mosquito Control

Staff will continue to review MMCD's adulticide program to ensure effective resource use and minimize possible non-target effects. Adulticide requirements in 2016 are based on 2015 use. We will continue to focus efforts where there is potential disease risk, as well as provide service in high-use park and recreation areas and for public functions, and respond to areas where high mosquito numbers are affecting citizens.

Additional plans are:

- to use Anvil (sumithrin) as needed to control WNV vectors in agricultural areas because the updated label now allows applications in these areas;
- to evaluate possible adulticide use in response to *Ae. japonicus* and *Cs. melanura*;
- to phase out Scourge (resmethrin), which has not been re-registered, and replace with Anvil and Zenivex (etofenprox); and
- to ensure all employees who may apply adulticides have passed applicator certification testing for both restricted and non-restricted use products.

Chapter 4 Black Fly Control

2015 Highlights

- Treated 48 small streams sites with *Bti* when the *Simulium venustum* larval population met the treatment threshold; a total of 41.2 gallons of *Bti* was used for these treatments
- Made 96 *Bti* treatments on the large rivers when the larval population of target species met the treatment threshold; a total of 4,309.5 gallons of *Bti* was used for these treatments; 96 treatments was a record number
- Monitored adult populations using overhead net sweeps and CO_2 traps; the average black fly/overhead sweep was 0.17, the lowest number since the black fly program started in 1984
- Completed Mississippi River non-target invertebrate monitoring report for samples collected in 2013
- Mississippi River non-target invertebrate sampling was conducted at the three long-term monitoring stations

2016 Plans

- Monitor larval black fly populations in small streams and large rivers; apply *Bti* when treatment thresholds are met
- Monitor adult populations by the overhead net sweep and CO_2 trap methods
- Process Mississippi River non-target monitoring samples

Background

The goal of the black fly control program is to reduce pest populations of adult black flies within the MMCD to tolerable levels. Black flies develop in clean flowing rivers and streams. Larval populations are monitored at 170 small stream and 28 large river sites using standardized sampling techniques during the spring and summer. Liquid *Bti* is applied to sites when the target species reach treatment thresholds in accordance with MMCD's permit from the Minnesota Department of Natural Resources (MnDNR).

The small stream treatment program began in 1984. The large river program began with experimental treatments and non-target impact studies in 1987. A full-scale large river treatment program did not go into effect until 1996. The large river treatment program was expanded in 2005 to include the South Fork Crow River in Carver County. Large river and small stream monitoring/treatment locations are shown in Figure 4.1.

2015 Program

Small Stream Program: *Simulium venustum* Control

Simulium venustum is the only human-biting black fly species that develops in small streams in the MMCD area that is targeted for control. It has one generation in the spring.

In April and May, 215 larval monitoring samples were collected from the small streams within the MMCD to determine larval abundance using the standard grab sampling technique developed by the MMCD. The treatment threshold was 100 *S. venustum* per sample. A total of 48 sites on 18 streams met the threshold and were treated once with VectoBac® 12AS *Bti*. A total of 41.2 gallons of VectoBac was used for the treatments (Table 4.1) in 2015. In comparison, the average annual amount of *Bti* used to treat the small stream sites during 1996-2014 was 27.2 gallons.

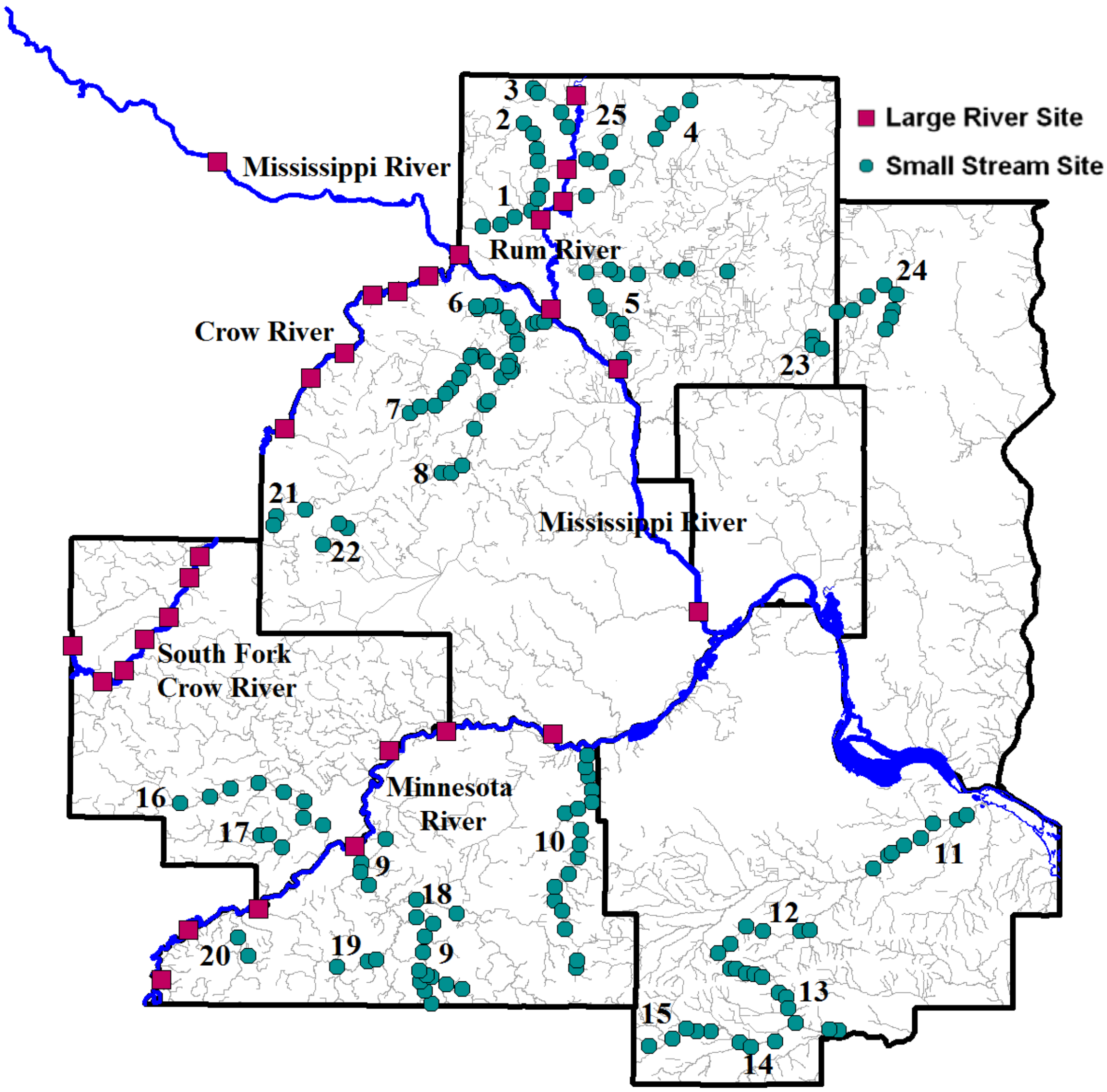


Figure 4.1 Large river and small stream black fly larval monitoring/treatment locations, 2015. Note: the large river site located outside the District on the Mississippi River is for monitoring only. Since 1991 more than 450 of the more than 600 original small stream treatment sites were eliminated from the annual small stream sampling program due to the increased treatment threshold as well as our findings from years of sampling that some sites did not produce any, or very few, *S. venustum.* Periodically historical sites that were eliminated from the permit are sampled to confirm if larval populations are present or absent. Requests are made to add new sites if larval monitoring confirms elevated *S. venustum* populations. The numbers on the map refer to the small stream names listed below:

1=Trott	6=Diamond	11=Vermillion	16=Bevens	21=Pioneer
2=Ford	7=Rush	12=Vermillion So. Branch	17=Silver	22=Painter
3=Seelye	8=Elm	13=Chub No. Branch	18=Porter	23=Clearwater
4=Cedar	9=Sand	14=Chub	19=Raven W. Br.	24=Hardwood
5=Coon	10=Credit	15=Dutch	20=Robert	25=Ditch 19

Table 4.1 Summary of *Bti* treatments for black fly control by the MMCD in 2014 and 2015

	2014			2015		
Water body	No. sites treated	Total no. treatments	Gallons of *Bti* used	No. sites treated	Total no. treatments	Gallons of *Bti* used
Small Stream Totals	26	26	26.7	48	48	41.2
Large River						
Mississippi	2	8	1,090.0	2	10	1070.3
Crow	1	2	55.0	3	13	165.0
South Fork Crow	5	8	140.0	6	14	50.3
Minnesota	7	29	2,795.1	7	38	2,887.6
Rum	4	17	243.9	4	21	136.3
Large River Totals	19	64	4,324.0	22	96	4,309.5
Grand Total	45	90	4,350.7	70	144	4,350.7

Large River Program

MMCD targets three large river black fly species for control with *Bti*. *Simulium luggeri* larvae occur mainly in the Rum and Mississippi rivers, although they also occur in smaller numbers in the Minnesota and Crow rivers. Depending on river flow, *S. luggeri* is abundant from mid-May through September. *Simulium meridionale* and *Simulium johannseni* larvae occur primarily in the Crow, South Fork Crow, and Minnesota rivers. These species are most abundant in May and June, although *S. meridionale* populations may remain high throughout the summer if river flow is also high.

The large river black fly larval populations were monitored weekly between May and mid-September using artificial substrate samplers (Mylar tapes) at the 28 sites permitted by the MnDNR on the Rum, Mississippi, Crow, South Fork Crow, and Minnesota rivers to determine if the treatment threshold was met. The treatment threshold for *S. luggeri* was an average of 100 larvae/sampler at each treatment site location. The treatment threshold for *S. meridionale* and *S. johannseni* was an average of 40 larvae/per sampler at each treatment site location. These were the same treatment thresholds used since 1990.

A total of 500 larval monitoring samples were collected from the 28 permitted sites in 2015. The treatment threshold was met in 96 of these samples at 22 of the permitted sites and the associated sites were treated with *Bti*. Ninety-six treatments was a record number since operational treatments began in 1996. A total of 4,310 gallons of VectoBac 12AS *Bti* was used in the 96 treatments in 2015 (Table 4.1). In comparison, the average annual amount of *Bti* used on the large river treatments between 1997 and 2014 was 3,083 gallons. Efficacy of VectoBac 12AS is measured by the average larval mortality 250 m downstream from the *Bti* application point. In 2015, the average larval mortality was 100% on the Mississippi River, 98% on the Minnesota River, 95% on the Rum River, 94% on the Crow River, and 97% on the South Fork Crow River. The reason that more *Bti* was used in 2015 compared to the average annual amount likely was related to the consistently stable flows in the large rivers, particularly the Rum, Mississippi, and

Minnesota rivers from late spring through the summer. In fact, a record number of treatments were done in 2015, with 38 treatments on the Minnesota River alone. The stable river levels throughout the season allowed for uninterrupted sampling and treatment opportunities.

Adult Population Sampling

Daytime Sweep Net Collections The adult black fly population was monitored at 53 standard stations using the District's standard black fly over-head net sweep technique that was established in 1984. Samples were taken once weekly from early May to mid-September, generally between 8:00 A.M. and 10:00 A.M. The average number of all species of adult black flies captured in 2015 was 0.17 (Table 4.2), which was the lowest overall number of black flies collected in the overhead net sweep samples since the program started in 1984. The overall average number of adult black flies captured per sample from the start of the District's operational large river larval black fly control program in 1996 through 2014 was 1.47 (±0.75 S.D.). Between 1984 and 1986 before any *Bti* treatments were done on the large rivers the average net sweep count was 14.80 (± 3.04 S.D.).

Table 4.2 Mean number of black fly adults captured in over-head net sweeps in samples taken at standard sampling locations throughout the MMCD between mid-May and mid-September; samples were taken once weekly beginning in 2004 and twice weekly in previous years.

Large River *Bti* Treatment Status[1,2,3,4]	Time Period	Mean ± S.D.			
		All species[5]	*Simulium luggeri*	*Simulium johannseni*	*Simulium meridionale*
No treatments	1984 to 1986	14.80 ± 3.04	13.11 ± 3.45	0.24 ± 0.39	1.25 ± 0.55
Experimental treatments	1987 to 1995	3.63 ± 2.00	3.16 ± 2.05	0.10 ± 0.12	0.29 ± 0.40
Operational treatments	1996 to 2014	1.47 ± 0.75	1.17 ± 0.74	0.02 ± 0.02	0.16 ± 0.13
	2015	0.17 ± 0.74	0.08 ± 0.49	0.00 ± 0.00	0.05 ± 0.40

[1]1988 was a severe drought year and limited black fly production occurred.
[2]The first operational treatments of the Mississippi River began in 1990 at the Coon Rapids Dam.
[3]1996 was the first year of operational treatments (treatment of all MnDNR-permitted sites) on the large rivers.
[4]Expanded operational treatments began in 2006 when permits where received from the MnDNR for treatments on the So. Fork Crow River.
[5]All species includes *S. luggeri, S. meridionale, S. johannseni,* and all other species collected.

The most abundant black fly collected in the overhead net-sweep samples in 2015 was *S. luggeri*, comprising 48.4% of the total captured with an average of 0.08 per sample. The second most abundant black fly species captured was *S. meridionale*, comprising 27.7% of the total captured with an average of 0.05 per net sweep sample.

The highest number of black flies captured among the seven counties of the MMCD in 2015 in the net sweep samples was in Anoka County where an average of 0.61 (all species) were captured. *Simulium luggeri* was the most abundant black fly captured in Anoka County, as it has been since black fly adult monitoring began in 1984, with an average of 0.38 per sample. The second highest number of black flies captured per sample was in Hennepin County with an average of 0.20 per sample. *Simulium luggeri* was also the most abundant species captured in Hennepin County with an average of 0.13 per sample. The high number of *S. luggeri* captured in Anoka County and Hennepin County versus other areas of the MMCD is most likely due to the prime larval habitat for this species in the nearby Rum and Mississippi rivers.

Monday Night CO_2 Trap Collections Black flies captured in District-wide CO_2 traps operated weekly for mosquito surveillance (see Chapter 1) were counted and identified to family level in 2015. Because these traps are operated for mosquito surveillance, samples are not placed in ethyl alcohol making black fly species-level identification difficult. Results are represented geographically in Figure 4.2. The areas in dark gray and black represent the highest numbers collected, ranging from 250 to more than 500 per trap. The highest number of black flies was observed in June and July in parts of Carver, Hennepin, and Dakota counties (Figure 4.2).

Black Fly Specific CO_2 Trap Collections Adult black fly populations were monitored in 2015 between mid-May and mid-June with CO_2 traps at four stations each in Scott and Anoka counties, and five stations in Carver County. These sites have been monitored since 2004 with CO_2 traps when larval treatments were started on the South Fork Crow River. Black flies captured in the CO_2 traps are preserved in alcohol to facilitate species identification.

Table 4.3 lists the percentage of black flies captured in the CO_2 traps yearly since 2004. The most abundant species captured since the CO_2 trapping program began, including 2015, have been *S. johannseni*, *S. meridionale*, and *S. venustum. Simulium meridionale* was the most abundant species captured in 2015, comprising 79% of the total collected, of which 70% were from Carver County. *Simulium johannseni* was the second most abundant species captured at 18% of the total (Table 4.3). The large number of *S. johannseni* and *S. meridionale* captured in Scott and Carver counties in 2015 was likely due to the fact that the preferred larval habitat of these species is in the Crow, South Fork Crow and Minnesota rivers.

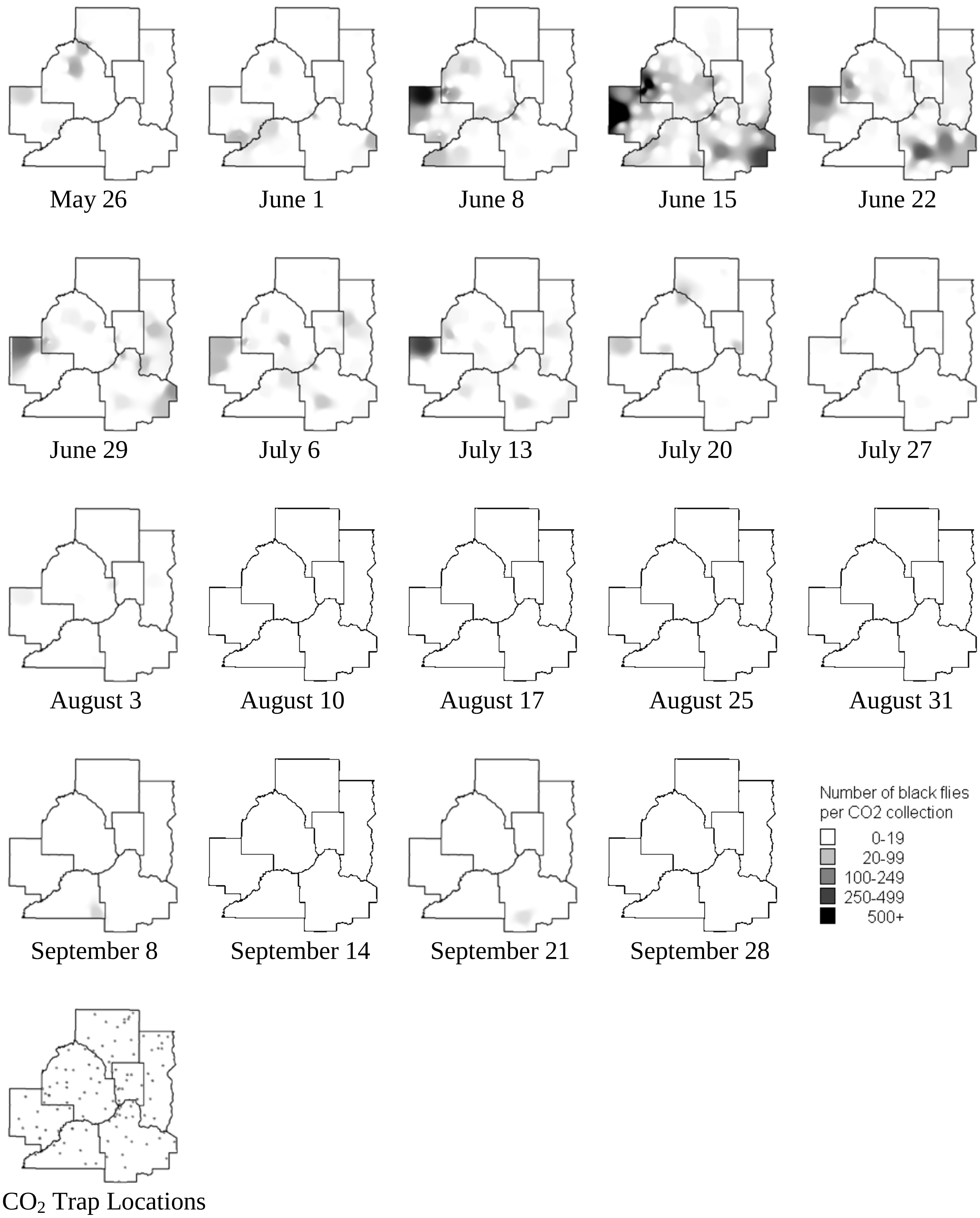


Figure 4.2 Number of black flies collected in mosquito surveillance District low (5 ft) and elevated (25 ft) CO_2 traps, 2015. The number of traps operated per night varied from 113-123. Inverse distance weighting was the algorithm used for shading of maps.

Table 4.3 Percentage of *S. venustum*, *S. johannseni*, and *S. meridionale* from the total number black flies captured in CO_2 traps set twice weekly between May and mid-June in Anoka, Scott, and Carver counties between 2004 and 2015

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Total	26,750	15,477	17,230	55,725	43,541	84,693	41,767	274,925	28,205	16,657	26,680	10,123
Simulium venustum	Anoka	0.41	0.88	7.94	3.71	1.21	0.95	2.08	0.13	0.39	2.89	1.12	2.91
	Scott	0.14	0.52	1.18	3.45	21.03	12.37	4.27	0.97	0.85	0.61	1.39	0.41
	Carver	0.07	0.26	0.63	9.51	18.70	26.60	9.22	0.88	0.07	0.31	0.91	0.19
Simulium johannseni	Anoka	0.09	0.90	0.07	0.02	0.01	0.02	0	0.04	0.15	0.23	0.28	0.11
	Scott	0.84	0.01	13.26	3.15	1.85	1.18	0.59	4.49	12.75	0.97	1.02	12.50
	Carver	7.32	31.36	34.39	14.17	10.54	2.25	26.26	83.38	28.96	3.03	73.76	5.40
Simulium meridionale	Anoka	16.36	6.01	0.26	0.10	0.06	0.04	0	0.01	0.02	0	0.11	0.05
	Scott	1.42	0.28	3.66	16.71	6.89	5.13	24.60	4.99	37.93	22.08	1.04	8.29
	Carver	73.24	59.53	37.45	48.82	39.58	51.33	32.45	4.88	18.8	69.68	20.31	70.11
All other black fly species[1]	Anoka	0.08	0.02	0.78	0.31	0.07	0.03	0.49	0.01	0.06	0.17	0.04	0.01
	Scott	0	0.20	0.34	0.02	0.04	0.10	0.02	0.05	0.02	0.01	0.01	0
	Carver	0.01	0.03	0	0.02	0.01	0	0	0.17	0	0	0.01	0.02

[1]Other black flies captured include *Simulium vittatum*, *Simulium luggeri*, *Simulium aureum*, *Simulium verecundum*, *Stegopterna mutata*, *Cnephia ornithophilia*, *Cnephia invenusta*, and *Prosimulium* spp.

Non-target Monitoring

The District has conducted biennial monitoring of the non-target macroinvertebrate population in the Mississippi River as part of its MnDNR permit requirements since 1995. The monitoring program was designed as a long-term assessment of the macroinvertebrate community in *Bti*-treated reaches of the Mississippi River. Results from the monitoring study conducted on the Mississippi River in 2013 were consistent with results from the previous monitoring studies done by the MMCD since 1995 and indicated that there have been no large-scale changes in the macroinvertebrate community in the *Bti*-treated reaches of the Mississippi River. Monitoring samples were collected from the Mississippi River in 2015. A report on the results of that study is scheduled for completion in 2017.

2016 Plans – Black Fly Program

2016 will be the 32nd year of black fly control in the District. The primary goal in 2016 will be to continue to effectively monitor and control black flies in the large rivers and small streams. The larval population monitoring program and thresholds for treatment with *Bti* will continue as in previous years. In addition, field crews will test biodegradable rope and the feasibility of using bulk control material containers for black fly treatments as a part of the broader sustainability efforts of the District. The 2016 black fly control permit application will be submitted to the MnDNR in February. Non-target invertebrate monitoring samples collected from the Mississippi River in 2015 will be processed. Program development will continue to emphasize improvement in effectiveness, surveillance, and efficiency.

Chapter 5 Product & Equipment Tests

2015 Highlights

- Both 8- and 5-lb/acre dosages of VectoBac® G *Bti* achieved good control of *Ae. vexans* in air sites
- Natular G™ applied five days before the first adult emergence, did not control cattail mosquitoes as effectively as desired. An earlier treatment may be more effective
- Permethrin and Onslaught® (barrier) controlled mosquitoes including WNV vectors for up to one week in woodlots

2016 Plans

- Increase late summer cattail treatments of VectoLex® CG to control the cattail mosquito
- Repeat tests of MetaLarv™ S-PT against spring *Aedes* to evaluate its effectiveness as a spring pre-hatch larvicide
- Continue tests of Natular™ G against spring *Aedes* and the cattail mosquito
- Continue tests of adulticides in different situations emphasizing control of vectors and effectiveness of barrier treatments

Background

Evaluation of current and potential control materials and equipment is essential for MMCD to provide cost-effective service. MMCD regularly evaluates the effectiveness of ongoing operations to verify efficacy. Tests of new materials, methods, and equipment enable MMCD to continuously improve operations.

2015 Projects

Quality assurance processes focused on product evaluations, equipment, and waste reduction. Before being used operationally, all products must complete a certification process that consists of tests to demonstrate how to use the product to effectively control mosquitoes. The District continued certification testing of two larvicides and two new adulticides. The larvicides and adulticides have been tested in different control situations in the past. Our goal is to determine that different larvicides can control two or more target mosquitoes in multiple control situations. One adulticide was tested as an alternative ULV material and the other as an alternative barrier material. These additional control materials will provide MMCD with more operational tools.

Control Material Acceptance Testing

Larval Mosquito Control Products Warehouse staff collected random product samples from shipments received from manufacturers for active ingredient (AI) content analysis. MMCD contracts an independent testing laboratory, Legend Technical Services, to complete the AI analysis. Manufacturers provide the testing methodologies. The laboratory protocols used were CAP No. 311, “Procedures for the Analysis of S-Methoprene in Briquets and Premix”, CAP No. 313, “Procedure for the Analysis of S-Methoprene in Sand Formulations”, VBC Analytical Method: VBC-M07-001.1 Analytical Method for the Determination of (S)-Methoprene by High Performance Liquid Chromatography and Clarke Analytical Test Method SP-003 Revision #2

"HPLC Determination of Spinosad Content in Natular G30 Granules."

Altosid briquets underwent a formulation change in 2013. The carrier matrix changed from a black carbon plaster-based product to a white silica-based briquet. This formulation did not alter the active ingredient release characteristics, field life, or its mode of action. The resulting change increased shelf stability and produced a product that did not chip or break as easily. Field staff appreciated that this product was less dusty and much cleaner to apply.

All 2015 samples were within acceptable values of the label claim of percent AI. The manufacturer's certificates of analysis at the time of manufacture were all within acceptable limits. Due to the high expenses of the 2015 mosquito season and the significant cost of independent laboratory evaluation, 2015 product samples have been retained and random samples will be submitted with 2016 samples to lower our overall expenditures.

Adult Mosquito Control Products MMCD requests certificates of AI analysis from the manufacturers to verify product AI levels at the time of manufacture. MMCD has incorporated AI analysis as part of a product evaluation procedure and will submit randomly selected samples of adulticide control materials to an independent laboratory for AI level verification. This process will assure that all adulticides (purchased, formulated, and/or stored) meet the necessary quality standards. In 2015, MMCD sampled but did not analyze adulticide products and saved voucher samples for reference.

Efficacy of Control Materials

VectoBac® G VectoBac G brand *Bti* (5/8 inch mesh size corncob granules) from Valent BioSciences was the primary *Bti* product applied by helicopter in 2015. Aerial *Bti* treatments began April 28 (three days later than in 2014). We applied 8 lb/acre to control spring *Aedes* and *Ae. vexans* and switched to the 5 lb/acre rate beginning on July 13 to control *Ae. vexans*. In 2015 aerial *Bti* treatments achieved an average of 83.7% control (Table 5.1), slightly less than 90.4% overall in 2014. Effectiveness was lowest later in the season when rainfall was most variable (after July 13).

Table 5.1 Efficacy of aerial VectoBac G applications in 2015 (8 lb and 5 lb/acre) (SE=standard error)

Year, dosage rate	n	Mean mortality	±SE
2015, 8 lb/acre (April 28 – May 16)	191	92.2%	1.6%
2015, 8 lb/acre (May 19 – July 9)	351	81.4%	1.8%
2015, 5 lb/acre (July 13 – Sept 19)	209	79.8%	2.4%
2015, all rates (April 28 – Sept 19)	751	83.7%	1.2 %

New Control Material Evaluations

The District, as part of its Continuous Quality Improvement philosophy, strives to continually improve its control methods. Testing in 2015 was designed to evaluate how different segments of mosquito control programs can be modified to deliver more mosquito control services to a greater part of the District area using existing resources. Much testing has focused upon controlling multiple mosquito species including potential vectors of WNV.

Larval Control

The record levels of mosquito production and need for control service significantly affected our ability to conduct control material evaluations. Largely because of low water levels in April through June, we were unable to evaluate effectiveness of Natular™ G or larvicides containing methoprene such as Valent MetaLarv™ S-PT to control spring *Aedes*. We will need to repeat those tests in 2016.

Coquillettidia perturbans **Control** *Coquillettidia perturbans* is an abundant pest that lays its eggs in mid- to late summer and overwinters as larvae attached to aquatic vegetation, primarily cattail roots. Our current control strategy includes large-scale ground and aerial treatments for this single brood mosquito in late May, just prior to its emergence. We have tested larvicides containing biorational actives (e.g., VectoLex CG) other than methoprene to determine which others we might be able to add to our control program.

Clarke Natular G: Early June Treatments In 2012, we completed a very small test of Natular G30 (10 lb/acre) to control *Cq. perturbans*. Results were disappointing (62% control) but the sample size was very small and mosquito emergence in the untreated control was low (see 2012 Operational Review and Plans for 2013 for details). Results of a repeat test in 2014 were more promising (see 2014 Operational Review and Plans for 2015 for details). We chose to test Natular G in 2015 because the per-acre cost is much lower than the same rate (5 lb/acre) of Natular G30.

In 2015, we selected ten ground cattail sites with a history of high *Cq. perturbans* emergence. Five bags of granules containing the commercial product Natular G were prepared. Five additional bags of granules that appeared to be commercial product Natular G but contained no spinosad ("blank" granules) were prepared. A double blind method was used to code these ten bags so that staff treating the sites would not know which sites were treated with blank granules and which sites received commercial Natular G (containing spinosad).

On June 1, 2015 each of these ten sites was treated with enough material from the bag designated for that site to achieve a 5 lb/acre treatment rate. Five emergence cages were placed in each of these 10 sites on June 1, 2015. All adult mosquitoes captured by emergence cages were removed twice each week beginning on June 4 and ending on July 30. Data were analyzed after sampling ended when the double blind coding was revealed.

Emergence of adult *Cq. perturbans* (in terms of mean adult emergence per cage) from sites treated with blank granules was very similar to emergence from sites treated with Natular G. (Figure 5.1, Table 5.2). However, the percentage of cages in which *Cq. perturbans* emerged was significantly lower in Natular G treated sites than in sites treated with blank granules. These results and those of tests completed in 2012 and 2014 suggest that Natular formulations have the potential to control *Cq. perturbans* (mean adult emergence per cage in 2014 was lower in treated sites). Control is not consistent when treatment occurs only a few days before adult mosquito emergence begins (both 2012 and 2015 results). Control may be better if Natular G is applied sooner before emergence.

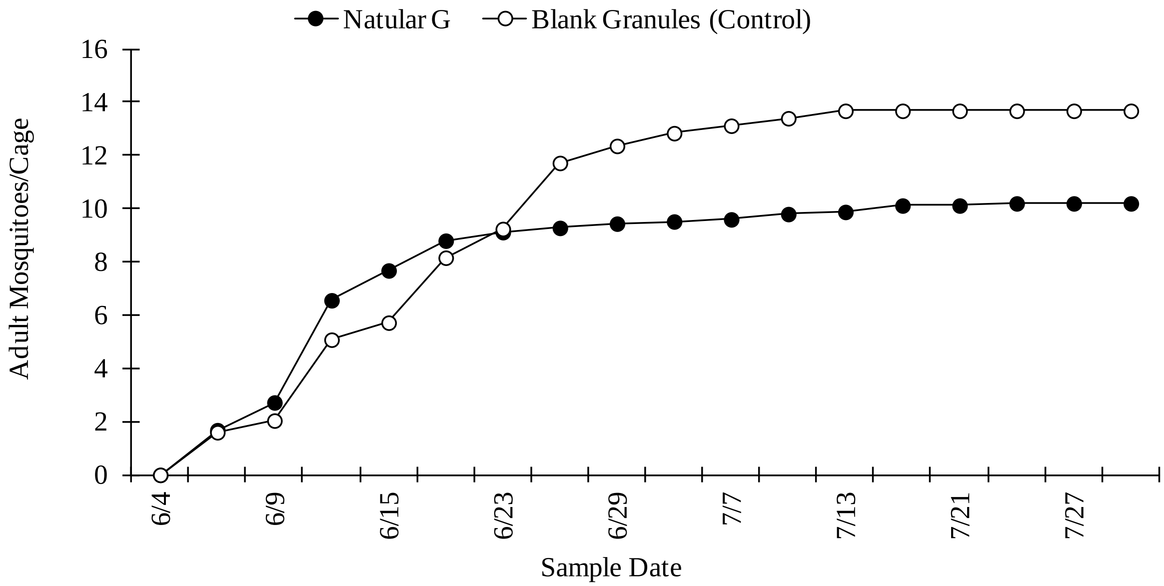


Figure 5.1 Mean cumulative emergence of *Cq. perturbans* in cages in sites treated with Natular G and blank granules (untreated sites), June – July 2015.

Table 5.2 Emergence of *Cq. perturbans* in sites treated with blank granules or Natular G, June-July 2015

Treatment	Total cages	No. positive cages	% positive cages	MCE§	% control	Fisher Exact p-value*
Blank granules (Control)	25	23	92.0	13.7	N/A	N/A
Natular G	25	16	64.0	10.2	25.4	0.016

§MCE, mean cumulative emergence per cage
*Untreated control (blank granules) compared to Natular G

Clarke Natular G: Non-Target Sampling In 2014 sampling was conducted to evaluate the potential impact of Natular G on four groups of non-target organisms (physid snails, fingernail clams (sphaeriids), fairy shrimp and amphipods) in sites treated at a 5 lb/acre rate as part of an evaluation of spring *Aedes* larval control. High levels of larval spring *Aedes* control were observed. No impacts from treatments on fingernail clams, three kinds of snails or fairy shrimp were observed; insufficient numbers of amphipods were captured to evaluate potential non-target impacts (see 2014 Operational Review and Plans for 2015 for details).

In 2015, samples designed to capture amphipods were collected from each of the ten ground cattail sites included in the efficacy study by sweeping up from the site bottom through the water column using a cattail dipper (a metal dipper with 20-micron mesh screen on the bottom). See Chapter 6 for a description of the sampling method, schedule, analyses, and results.

Adulticide Tests

Beginning in 2008, research focused upon evaluating how effectively barrier and ULV (cold fogging) treatments controlled mosquitoes, especially West Nile virus vectors. This research is partially in response to recommendations by the Technical Advisory Board that MMCD demonstrate vector-specific efficacy, especially for barrier permethrin treatments that pose the greatest potential risk to non-target organisms in treated areas.

Permethrin and Onslaught® Barrier As in previous years, tests were conducted in woodlots where operational permethrin treatments could potentially be made and all tests included untreated woodlots. All tests included CO_2 trap data. CO_2 traps (two of each per woodlot) were placed 24 hours before treatment, 30 minutes after treatment, 24 hours after treatment, and one week after treatment. Efficacy was evaluated using Mulla's equation (a correction that accounts for natural changes in the untreated control site, as well as the treatment site). The goal of all tests was to better evaluate the duration and consistency of control achieved by barrier treatments and to include vector-specific efficacy evaluations.

One test was completed August 12-19, 2015 in a pair of woodlots in Hennepin County that had a history of high adult mosquito abundance. Onslaught achieved significant control of all mosquitoes within 24 hours of treatment (Table 5.3). Control declined thereafter but was still detectable (43.5%) one week after treatment (Table 5.3). None of the CO_2 traps captured enough *Culex* vectors, *Ae. triseriatus* or *Ae. japonicus* to evaluate effectiveness.

Table 5.3 Barrier Onslaught treatment efficacy: (8/12 – 8/19): Efficacy percent calculated using Mulla's formula*

		All mosquito species		
Test 1	Collection	CO_2 trap catch§		Efficacy
Onslaught	Pre-treat	68.5	(±35.5)	---
	Post-treat	43.0	(±15.0)	80.2%
	Post-24 h	29.5	(±16.5)	76.1%
	Post-7 day	7.5	(±0.5)	43.5%
Untreated control	Pre-treat	22.5	(±10.5)	---
	Post-treat	71.5	(±12.5)	---
	Post-24 h	40.5	(±12.5)	---
	Post-7 day	4.5	(±2.5)	---

* Mulla's formula incorporates untreated control trap counts to correct for changes in the treated traps that are not due to the treatment

§ Mean (±SE), n=2 (CO_2 traps)

Between 2006 and 2013, we completed 18 barrier tests that included permethrin. Permethrin effectively controlled adult mosquitoes within 24 hours after treatment in most tests (Table 5.4).

Permethrin also effectively controlled vector mosquitoes within 24 hours after treatment in most tests where enough vectors were captured to evaluate efficacy. One week after treatment permethrin effectively controlled adult mosquitoes in only about half of those tests (Table 5.4). (see 2006, 2007, 2008, 2010 and 2011 Operational Reviews for details).

We completed ten barrier tests that included Onslaught between 2007 and 2015. The proportion of tests in which Onslaught was able to effectively control adult mosquitoes was similar to permethrin. Onslaught is able to control *Culex* vectors within 24 hours after treatment with control persisting up to one week. Insufficient data are available to evaluate effectiveness against *Ae. triseriatus* (Table 5.4) (see 2006, 2007, 2008, 2010, 2011, 2012 and 2014 Operational Reviews for details).

Table 5.4 Permethrin and Onslaught barrier tests with high efficacy (>80% control using Mulla's equation). Tests occurred from 2006-2013 for permethrin and 2007-2015 for Onslaught

		No. tests with high efficacy (% tests with high efficacy)	
Material used and number of tests*	Target mosquitoes	24-48 hours after treatment	7 days after treatment
Permethrin (2006-2013)			
18	All species	16 (89%)	7 (39%)
9	*Culex* (WNV) **	7 (78%)	4 (44%)
2	*Ae. triseriatus* (LAC)	2 (100%)	1 (50%)
Onslaught (2007-2015)			
10	All species	6 (60%)	3 (30%)
5	*Culex* (WNV) **	4 (80%)	3 (60%)
1	*Ae. triseriatus* (LAC)	0 (0%)	0 (0%)

* Number of tests in which sufficient mosquitoes of a particular species group were captured to evaluate efficacy.
** *Culex=Cx. tarsalis*, *Cx. restuans*, *Cx. pipiens*, and *Cx. salinarius*

No tests of ULV adulticides were completed successfully in 2015. In the future, we plan to continue barrier adulticide tests. Our goal is to collect as much vector-specific data (includes *Culex, Ae. triseriatus, Ae. japonicus*) as possible. We plan to explore causes of inconsistent efficacy, especially more than 24 hours after treatment, perhaps by comparing efficacy in smaller and larger scale treatments (different sized treatment areas).

Equipment Evaluations

Helicopter Swath Analysis and Calibration Procedures for Larvicides Technical Services and field staff conducted five aerial calibration sessions for dry, granular materials during the 2015 season. These computerized calibrations directly calculate application rates and swath patterns for each pass so each helicopter's dispersal characteristics are optimized. Sessions were held at the municipal airport in Le Sueur, MN. Staff completed calibrations for seven different operational and experimental control materials. In total, eight helicopters were calibrated and each helicopter was configured to apply an average of four different control materials.

An enclosed 24-foot trailer was purchased to house all the calibration gear, laboratory equipment, and blank calibration materials. Previously, we have stored equipment at multiple locations. This trailer will protect the equipment, keep it better organized, and eliminate the need for multiple vehicles to carry all of the gear and materials.

In addition, this trailer is being modified to become a mobile workstation. In the past, we needed a weather protected workspace (hanger or airport building) to conduct our work. This need for indoor space limited our ability to work at local airports/airstrips where we did not have indoor access, available electrical power or adequate buildings did not exist. This mobile workstation will improve the efficiency of our calibration operations, reduce time of commutes, shorten helicopter ferrying distance and increase the number of areas available for calibration trials.

Malvern Laser: Droplet Analysis of Ground-Based Spray Equipment Technical Services purchased a Malvern Instrument's Spraytec laser diffraction system to evaluate our adult mosquito equipment (backpacks, handheld, ATV-mounted and truck-mounted sprayers). Our previous equipment used for droplet measurement was 20 years old and was limited in the size range and quantity of droplets it could accurately measure.

The new system as described by Malvern uses "the technique of laser diffraction for measurement of the size of spray droplets. It does this by measuring the intensity of light scattered as a laser beam passes through a spray. This data is then analyzed to calculate the size of the droplets that created the scattering pattern." The system is a significant technical improvement because we can now evaluate a spray without having to impinge droplets on a probe or physically collect a subsample. The equipment's capacity to assess a larger volume of spray's droplets and sample across the entire plume provides a more accurate depiction of what the equipment is generating. Equipment can now be more accurately adjusted to improve product efficacy, reduce off-target application, maximize equipment potential and meet EPA label requirements.

Much of the work done in 2015 focused on developing new protocols, procedures, and processes for using the Spraytec system. There was a significant learning curve in understanding how to best use the equipment, which statistical features are most applicable to our spray systems, how to interpret the data output, and how to best evaluate each piece of equipment.

A difficult challenge was simply attempting to keep the lens free of droplets. When droplets coat the glass lens, the laser's software interpretation of the spray can be misleading. The attached droplets will continually be read by the laser as part of the spray and will bias the sample towards their size range. An air purge system was created that will minimize the time required to disassemble the laser components and clean the lens.

Another challenge is determining what part of the spray swath is best representative to reflect the output of the equipment. It is MMCD's goal to evaluate equipment emulating field conditions. We will continue to evaluate equipment and attempt to find that optimum area which works well within our testing parameters.

Droplet Analysis of Ground-based Spray Equipment Technical Services and the East Region staff used our 20 ft x 40 ft indoor spray booth to evaluate adulticide application equipment. This self-contained booth collects the adulticide spray droplets, which minimizes their release into the air following the calibration process, thus limiting any release of control materials into the environment. Technical Service staff optimized 42 ultra-low-volume (ULV) insecticide generators (truck-mounted, UTV-mounted, or handheld) using the KLD Model DC-III portable droplet analyzer. Staff uses this analyzer to fine-tune equipment to produce an ideal droplet spectrum of 8-24 microns. Adjusting the ULV sprayers to produce a more uniform droplet range maximizes efficacy by creating droplets of the correct size to impinge upon flying mosquitoes. In addition, more uniform swaths allow staff to better predict ULV application patterns and swath coverage throughout the District.

Permethrin Backpack Droplet Evaluations Technical Services conducted backpack droplet spectrum evaluations of our barrier spray units because a recent EPA label change during the product re-registration process significantly increased the droplet size to reduce the risk of product drifting off the targeted site. The new label requires a droplet size of 150-300 microns.

The new prototype wand that was evaluated in 2014 by Lee County, FL was retested with our Malvern Spraytec. In 2015, MMCD duplicated their results and confirmed our backpack within label parameters. Technical Services developed successful prototypes for our three backpack models and will develop templates for staff to modify all remaining backpacks to meet the droplet size requirements.

ULV Droplet Evaluations Technical Services formed a workgroup to evaluate truck-mounted, UTV-mounted, backpack and handheld ULV generators. The workgroup began by developing protocols and procedures for these larger volume sprayers. In 2016, MMCD will evaluate and optimize our adult mosquito control equipment.

Optimizing Efficiencies and Waste Reduction

Evaluation of Transportation Options for Control Materials Over the past four seasons, the District has reviewed methods for transporting pallets of control materials to helicopter landing sites. Large flatbed trucks have been the operational standard but these vehicles are expensive, can require additional licensing, and are not used extensively in the off-season. Facilities are reviewing a less expensive combination of a one-ton pickup truck and flatbed trailer. This equipment combination has more operational versatility, fewer restrictions, and can significantly reduce overall costs. In 2015, the District purchased additional trailers and heavy duty pickups for use in our air work support operations. Staff continued to incorporate the trailers operationally and found they have adequately met our needs. Staff will continue to evaluate this helicopter support system to determine its best effective use.

Recycling Pesticide Containers MMCD continued to use the Minnesota Department of Agriculture's (MDA) pesticide container recycling program. This project focuses on properly disposing of agricultural pesticide waste containers, thereby protecting the environment from related pesticide contamination of ground and water.

Field offices collected their empty, triple-rinsed plastic containers at their facility and packaged them in large plastic bags for recycling. Each facility delivered their empty jugs to our Rosemount warehouse for pickup by the MDA contractor, Consolidated Container. MMCD arranged three semi-trailer pickups during the treatment season and staff assisted the contractor with loading of the recycled packaging materials. MMCD also assists other small regional users to properly recycle their pesticide containers in conjunction with these collections.

MMCD staff collected 7,023 jugs for this recycling program. The control materials that use plastic 2.5 gallon containers are sumithrin (251 jugs), *Bti* liquid (1,744 jugs), Altosid pellets (5,001 jugs), MGK Pyrocide (17 jugs) and other materials (10 jugs).

The District purchases Permethrin 57% OS concentrate in returnable drums. The manufacturer arranged to pick up the empty containers for reuse. In addition, these drums do not have to be triple-rinsed and thus, reduces the District's overall generation of waste products.

MMCD also purchases products in 55-gallon drums and refills the 5-gallon steel cans of the same-labeled material thereby reducing the need for new packaging, thus lowering the amount of packaging waste generated by the District. In addition, the warehouse triple-rinsed and recycled numerous plastic drums and steel containers this past season. These 30- or 55-gallon drums were brought to a local company to be refurbished and reused.

The District's warehouse purchased mineral oil in 275 gallon bulk containers. Staff was able to reduce the overall number of 55-gallon drums purchased by 14 drums. These returnable containers do not have to be triple-rinsed and thus, reduces the District's overall generation of waste products.

Recycling Pesticide Pallets In 2015, MMCD produced over 2,611 empty hardwood pallets used in control material transportation. Technical Services worked with our vendors to uniquely mark their company's pallets and arrange for their return to the manufacturer for re-use. In doing so, MMCD reduces the need for the production of new pallets and helps to maintain lower control material costs for the District.

Bulk Packaging of Control Materials MMCD continued the development of reusable packaging containers into our operations. The focus is to reduce the packaging waste of the various high use materials. MMCD can produce over 40,000 empty bags in an average year. MMCD would like to eliminate a significant portion of these pesticide bags that cannot be recycled. Staff is attempting to keep these bags out of a landfill and direct them to a garbage burner to receive some public benefit of the generated waste.

There are two projects being worked on by staff to reduce packaging waste. The first project is using a large refillable tote that could be adaptable to our helicopter loading operations. This container would hold 1,600 pounds and reduce our packaging use by 40 bags per tote. In 2015, MMCD received 32 totes of Natular G granules. Staff used this tote system operationally, thus eliminating 1,280 bags from entering the waste stream.

The second project is using bulk 1,600 lb bags of *Bti* for ground work at our Maple Grove facility. The Maple Grove staff purchased a small silo to safely manage the bulk material and to dispense the insecticide into reusable 40 lb seed bags. In 2015, Maple Grove successfully utilized this system and reduced their waste by 120 bags. Staff is investigating how to implement their waste reduction into our other field facilities and to expand their ideas to other control materials.

In 2015, Technical Services worked with other vendors on reducing their packaging in our waste stream. Central Life Sciences has developed a bulk tote for Altosid pellets. This tote will greatly reduce the number of empty plastic jugs and will simplify our field operations. MMCD has formed a workgroup with Valent BioSciences to address packaging waste in all of their products and is working towards bulk systems that will successfully blend within our operations. The workgroup will be evaluating prototypes and operational systems in 2016. Overall, MMCD staff is attempting to reduce the amount of time and effort that we handle packaging after the product is used, allowing staff to focus more time on our primary missions.

Hazardous Waste Collection In 2015, MMCD worked with the MDA to provide two regional sites for hazardous waste collection. The MDA provides a day each year that the public can properly dispose of any small quantity of hazardous waste free of charge. The District's Andover and Jordan facilities were used as collection points and MDA staff managed the safe handling of these materials. MMCD will continue to support this important public service to protect the environment.

2016 Plans – Product and Equipment Testing

Quality assurance processes will continue to be incorporated into the everyday operations of the regional process teams. Technical Services will continue to support field operations to improve their ability to complete their responsibilities most effectively. A primary goal will be to continue to assure the collection of quality information for all evaluations so decisions are based upon good data. We will continue to improve our calibration techniques to optimize all of our mosquito control equipment.

In 2016, we plan to repeat tests of MetaLarv S-PT against spring *Aedes* to evaluate its effectiveness as a spring pre-hatch larvicide. We plan to repeat tests of Natular G against the cattail mosquito. We also will repeat tests of adulticides, emphasizing vector control and effectiveness of barrier treatments.

References Cited

Mir S. Mulla, R. Lee Norland, Dean M. Fanara, Husam A. Darwazeh and Donald W. McKean. 1971. Control of chironomid midges in recreational lakes. J. Econ. Ent. 64(1): 300-307.

Mulla's Formula: $$\text{Percent Efficacy} = 100 - \left(100 \times \left(\frac{\text{Cntl Pr e}}{\text{Trt Pr e}}\right) \times \left(\frac{\text{TrtPost}}{\text{CntlPost}}\right)\right)$$

CntlPre = Mean pretreatment count of untreated control
CntlPost = Mean post treatment count of untreated control
TrtPre = Mean pretreatment count of treated group
TrtPost = Mean post treatment count of treated group

Chapter 6 Supporting Work

2015 Highlights

- Completed transition to web data entry for container inspections and treatments
- With guidance from TAB subgroup, designed and carried out second year of non-target study for spinosad (Natular G)
- Continued outreach with beekeepers and worked with legislators
- Continued sustainability projects and investigations
- Citizen requests for treatments decreased, despite frequent rain events

2016 Plans

- Transition adult inspection and control data to web data entry, ending all use of PDAs
- Rewrite lab data entry and integrate with web forms
- Update wetland maps based on new metro-wide public air photos
- Continue with sustainability efforts

2015 Projects

Data System Transition

This year we continued our major project of transferring field data entry to our web-based system, and also ended up with a new mobile provider, new network hardware and configuration, and new IT staff.

Field data processes for container inspection and treatment were analyzed and new forms and reports developed which were tested and put into full use by late summer. This was our first form that uses location information from the mobile phone, in conjunction with parcel maps, to automatically fill in address information.

Data processes for adult inspection and treatment were also reviewed and those forms and reports are currently in testing. By spring of 2016 all field data will be entered using the web-based entry system and PDAs will no longer be needed. In early 2016 we are embarking on re-writing lab data entry forms to integrate better with the web-based field system and get us entirely off aging systems.

The automated aerial treatment records system rolled out in 2014 continued to work well, and again enabled us to reduce the number of staff needed at landing sites during the busiest times of the season.

Data systems require reliable hardware platforms. Problems with mobile connectivity at some of our remote sites led us to change mobile providers and totally replace our phones. The improved connectivity through the new provider has made it easier for staff to use the web-based field data entry at all locations, but did increase costs significantly. We also continue to try to keep office-based web connections and hardware up-to-date to support field operations. In conjunction with staff changes in both our IT Coordinator and Technician positions, we worked with a consultant to conduct a reanalysis of MMCD's network and related hardware and made a number of changes and upgrades intended to improve reliability, maintainability, and overall performance.

Mapping

Wetland Mapping Keeping our wetland habitat maps up-to-date is an essential task for MMCD staff members. We track about 80,000 wet areas that serve as potential larval mosquito habitat. We appreciate that Scott, Carver, and Dakota counties share their recent aerial photography through a Web Map Service at MnGeo, the state Geospatial Information Office. These services make it very easy for MMCD's staff to make use of these excellent photos. In 2016 we are participating in a metro-wide air photo collection being done by the Metropolitan Council and MnGeo, which will provide much-needed easily accessible updates for the entire region.

In addition to wetlands, MMCD staff members map locations of many stormwater structures, such as street catch basins, large culverts or separators, and pond water level regulators, which provide larval habitat for species such as *Culex* vectors of West Nile virus and for *Ae. japonicus.* Over 24,000 structures are now mapped, in addition to 280,000 catch basins.

Public Web Map MMCD continues to make wetland locations and multi-year larval treatment history available through a public web map available at www.mmcd.org. Larval treatment records are automatically updated daily. The site was developed by Houston Engineering Inc. and uses the MetroGIS Geocoder, basemap information from MetroGIS (Metropolitan Council), and aerial photos from MnGeo.

GIS Community MMCD staff continue to participate in MetroGIS, and helped celebrate the adoption of open data policies by counties in the metro in 2015. As a regional unit of government, MMCD benefits greatly from not just availability of data but also the use of standard open formats, and we continue to work to promote open standards use in products such as the state Geospatial Commons.

Climate Trends – Spring Degree Day Study

We continue to monitor trends in spring temperatures using degree-day (DD) accumulations, and and examine their relationship to control activities. The DD model used daily maximum and minimum air temperature (MSP airport) to compute a daily average. The difference between the average and the chosen base temperature of 40 °F (no larval growth per day) gave the ‘heat units’ accumulated each day for that base (DD_{base}). These were then summed from an assumed start date of January 1.

$$\text{SumDD}_{\text{to\_date, base}} = \sum_{(\text{start\_date, to\_date})} (T_{avg} - \text{baseT}) \quad \text{where } T_{avg} = [(T_{max}+T_{min})/2]$$

Figure 6.1 shows the cumulative sum of DD_{40F} from Jan 1 by week of the year (DD value at end of week), for each year from 1993-2014. Week numbers were based on standard CDC weeks (week starts on Sunday, week 1 = first week with four or more days, modified so that all dates after Jan. 1 were in week 1 or higher).

The week totals with an outlined box mark the first week with ≥ 200 DD. This number was chosen empirically from these data as an apparent indicator of when spring *Aedes* larvae have sufficiently developed to warrant aerial treatment. In 2015 that DD total was reached by the end of week 15 (April 18), a fairly typical date compared with the last 18 years. Given relatively low precipitation in April (see Chapter 1), aerial treatments for spring *Aedes* (gray boxes) began a week later, in early May.

- First week with CumDD40 > 200   - Aerial Treatments for Spring spp. (many or few)   - Treatment on CumDD40 > 200 week

Week #	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Last date in week (2015)
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	
2	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	0	0	0	
3	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	0	0	0	
4	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	0	0	0	
5	0	0	0	0	0	0	0	0	0	2	3	0	6	0	0	0	0	0	0	3	0	0	0	
6	0	0	0	0	0	0	0	0	0	2	3	0	6	0	0	0	1	0	0	3	0	0	0	
7	0	0	0	0	0	1	0	0	0	2	3	0	6	0	0	0	1	0	0	3	0	0	0	
8	0	0	0	0	0	17	0	20	0	8	3	0	6	0	0	0	1	0	0	3	0	0	0	
9	0	4	0	0	0	17	0	39	0	8	3	2	6	0	0	0	1	0	0	3	0	0	0	
10	0	4	5	0	0	17	0	104	0	8	3	2	13	4	0	0	1	4	0	18	0	0	47	
11	0	9	61	12	0	17	2	104	0	8	19	3	13	4	20	2	30	49	6	135	0	3	76	
12	3	22	69	12	0	72	8	150	0	8	55	56	13	4	54	2	54	70	7	**306**	0	3	76	**Mar 28**
13	17	32	72	12	20	95	83	184	0	16	85	81	68	27	148	2	54	174	12	358	7	3	130	**Apr 4**
14	26	41	79	12	80	158	143	**209**	23	16	104	132	187	58	156	30	64	**236**	70	450	16	14	154	**Apr 11**
15	44	100	100	37	80	**234**	181	233	66	75	146	**209**	**300**	**209**	162	34	166	356	134	497	21	87	**290**	**Apr 18**
16	106	199	129	81	100	335	**231**	268	115	**220**	**233**	292	405	318	**281**	82	**249**	461	144	554	21	102	325	**Apr 25**
17	185	**245**	184	109	162	436	350	388	**213**	243	327	385	424	416	415	173	328	576	**200**	640	63	167	440	**May 2**
18	**331**	310	**273**	158	**225**	571	486	586	367	295	439	492	508	521	566	**213**	460	646	271	786	146	196	599	**May 9**
19	474	448	385	**220**	312	753	601	710	494	356	537	611	607	629	740	321	567	719	411	913	**267**	**302**	707	**May 16**
20	564	627	515	347	372	939	754	809	699	440	664	746	725	762	914	437	765	896	554	1112	434	378	812	**May 23**
21	689	796	637	492	490	1114	899	973	778	539	775	848	869	951	1075	545	923	1146	692	1280	570	527	979	**May 30**
22	791	977	810	627	616	1210	1069	1111	910	755	939	1005	1059	1205	1274	690	1071	1341	905	1442	733	748	1148	
23	993	1152	970	753	811	1345	1290	1305	1060	913	1093	1204	1292	1417	1457	873	1202	1512	1121	1681	868	944	1356	
24	1153	1392	1192	967	1017	1558	1424	1462	1276	1117	1273	1388	1500	1633	1732	1059	1432	1721	1316	1881	1067	1111	1565	

Figure 6.1 Cumulative Degree Days (base 40 °F, 4.4 °C) from January 1, MSP Airport.

In addition to being timed to match mosquito abundance, aerial treatments are not started until a sufficient number of sites are over threshold, and cannot happen until seasonal inspectors are hired and helicopters calibrated (usually early April).

Stormwater Management, Wetland Design, and Mosquitoes

MMCD staff has worked to maintain awareness of mosquito issues within the stormwater design and regulatory community. For example:

- The "Stormwater and Mosquitoes" page on the MMCD web site (http://www.mmcd.org/resources/storm-water-management/) includes information on rain barrels, rain gardens, and wetland design.
- The web-based Minnesota Pollution Control Agency (MPCA) Stormwater Manual presents information regarding mosquito prevention at http://stormwater.pca.state.mn.us/index.php/Mosquito_control_and_stormwater_management

Evaluating Nontarget Risks

Spinosad (Natular) Nontarget Risk Information MMCD and TAB members continued steps evaluating nontarget risk for Natular products, which use the biological control material spinosad (see Appendix C). Natular is registered by the U.S. EPA as a "Reduced Risk Pesticide" and is OMRI Listed® (Organic Materials Review Institute). MMCD uses Natular G30, an extended release (30 day) formulation, as an option for larval control in summer *Aedes* sites, as it has both a different mode of action and different manufacturer than *Bti* or methoprene. We are also testing Natular G, which has a shorter active period (up to 7 days) and lower cost.

A 2014 study conducted by District staff in spring, ephemeral ponds did not identify any large-scale nontarget impacts on physid snails, fingernail clams (sphaeriids), and fairy shrimp using Natular G; however, scuds (amphipods), the other organism of interest, were not detected in that study. Staff and the TAB agreed that a second study targeting scuds should be undertaken. Since the District already was planning efficacy studies on *Cq. perturbans* with Natular G in cattail marshes (see Chapter 5), TAB members suggested the District consider adding a nontarget assessment to that test.

2015 Study: Natular G in Cattails Staff selected 10 cattail marshes in Anoka and Washington counties, five of which received active Natular G material and five received blank Natular G. The study was double-blind; applicators did not know which sites received active vs. blank material. Pretreatment samples were taken May 28, treatment occurred June 1, and post-treatment samples were taken June 4. Two random samples were taken in each marsh using a 20-micron screened dipper. Each sample consisted of five dips starting from the bottom of the site sweeping directly up through the water column. We measured water temperature and depth at each sample location in the site at the time of collection. An initial sampling was done May 21 (methods assessment), and additional follow-up samples were taken June 26 and September 9.

Lab staff processed the May 28 and June 4 samples. Few scuds were found, but more isopods (aquatic sow bugs) were found and staff removed those from the samples as well as the scuds. Staff sent Dr. Roger Moon the data to analyze to determine if any treatment effects were evident that might indicate that further sample processing would be worthwhile.

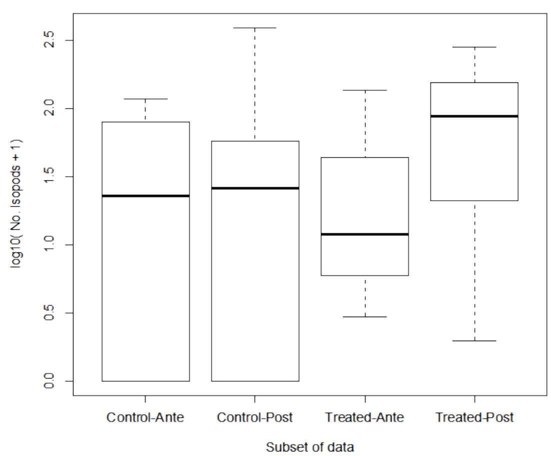
There were no measurably significant differences in amphipod (scud) populations related to treatment. Isopod populations apparently were higher in treated sites after the treatment. Based on these results, and the likelihood that MMCD would not use Natular G in cattail sites, members of the Natular subgroup have indicated that they do not believe that further sample processing is necessary (e-mail, January 12, 2016). Results of Dr. Moon's analysis follow.

Non-target effects of Natular® in cattail mosquito breeding sites, 2015

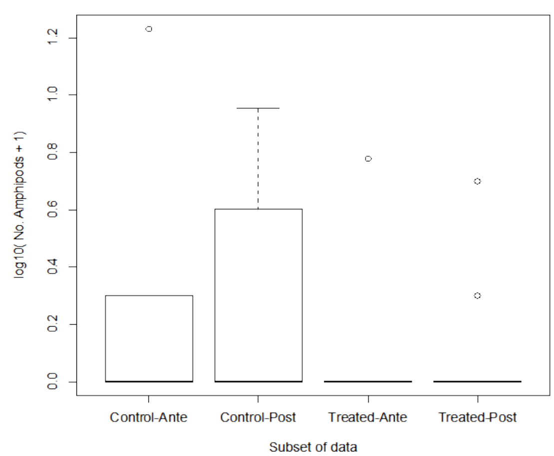
Design: MMCD staff applied blank and active granules containing Natular® at label rates in a double blind design to 10 independent cattail sites in Washington and Anoka County, *n* = 5 per treatment group. All sites were dip sampled at two randomly chosen locations on 21 and 28 May, 2015, granules were applied on 1 June, and the sites were dipped again on 4 June, three days after treatment, and again at 3 and 9 weeks later. Samples from 28 May and 4 June have been processed.

Results: Isopods and amphipods were abundant enough to be counted and analyzed. Fairy shrimp were absent. Box & whisker plots of the results (*n* = 5 sites per group, before and after applications) are shown:

Isopods

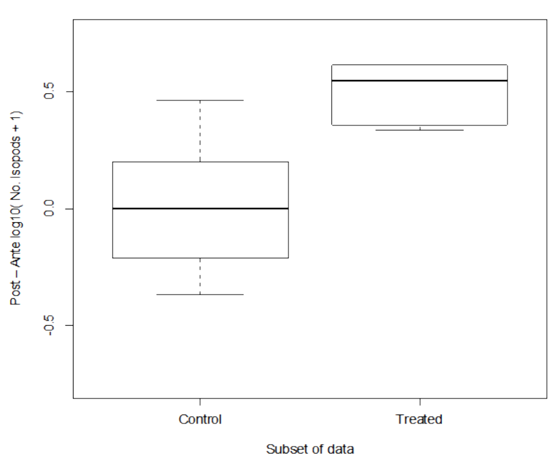


Amphipods



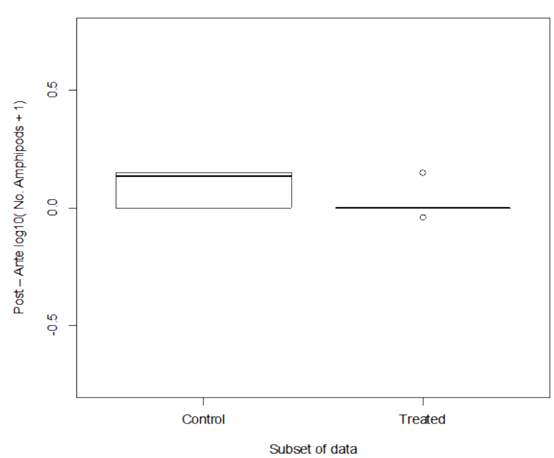
<u>Differences</u> in means per dip in each site before and after were analyzed with ANCOVA as a completely random design with two treatments (active or blank granules), plus covariates of initial mean numbers per dip, water depth and water temperature. Analysis was done in $\log_{10}$ scale to overcome unequal variances and non-normality. No covariates were significant, so they were deleted and a simpler ANOVA model was used to test for effects of treatment.

Change in Isopods per dip
(before to after treatment)



H_o: No change after treatment
F = 8.9; df = 1, 8; P = 0.017
Natular caused Isopods to increase?

Change in Amphipods per dip
(before to after treatment)



H_o: No change after treatment
F = 1.8; df = 1, 8; P = 0.22
Natular had no effect

2014 Study Progress: Natular G in Spring *Aedes* Sites While the 2014 Natular study in spring *Aedes* sites did not show any effects on fairy shrimp, fingernail clams, and three species of snails, TAB members expressed an interest in determining if any community effects exist. MMCD agreed to re-pick the samples, removing any remaining invertebrates. To date, only 10 samples have been picked and are ready to be identified. Of the remaining 50 samples, 24 have been processed and need to be checked, and 26 have yet to be picked. It takes approximately 8-12 hours to pick a sample, 6-8 hours to QA check the pick, and 2-4 hours to do the identifications. The approximate time to process the samples in the various stages of completeness is between 16 – 24 weeks. Some obstacles in the process are the amount of vegetation in the samples and the size and the sheer numbers of the copepods, ostracods, and oribatid mites in the samples. In light of the 2015 Natular study results, MMCD staff would like the TAB to re-evaluate the utility of this work.

Previous Larvicide Nontarget Earlier publications and reports on Wright County Long-term Study and other studies on *Bti* and methoprene done under the direction of the Scientific Peer Review Panel (SPRP) continue to be available on the MMCD web site, mostly as PDF files. The address is http://www.mmcd.org/non-target-studies-bti/

Pollinators and Mosquito Control With increasing public concern about the loss of pollinators (e.g. honeybees, native bees, butterflies, flies, etc.), the Metro Mosquito Control District has increased its efforts to locate honeybee hives and ensure that mosquito control activity has minimal effect on honeybees and pollinators in general. Neighboring states register hive locations through Drift Watch; Minnesota does not require bee keepers to register through this centralized system (mn.driftwatch.org/map). However, under a new law that went into effect August 1, 2015, beekeepers who want to be eligible for compensation for losses due to pesticide exposure must have registered their hives through Driftwatch. More cities are moving to allow beekeeping and many require permits. We are working to record hive locations in our database/mapping system, and exploring methods to keep the information up-to-date, given that hives may be moved frequently for different forage conditions.

The pyrethroids we use as fog or barrier spray on vegetation to control adult mosquitoes, used according to label, are relatively low risk for bees. However, knowing where and when bees are active can reduce the chance of exposure and decrease risk further. Our biological controls for mosquito larvae in wet areas pose no risk to bees.

MMCD staff members have initiated discussions with local beekeeper associations aimed at avoiding possible adverse impacts to bees and hives. We regularly update other MMCD staff about pollinator protection at staff training events as well. MMCD staff members are attending the MN Dept. of Agriculture Pollinator Summit in February to work with other stakeholders to identify challenges and possible steps to be taken to help reverse pollinator decline.

Permits and Treatment Plans

National Pollutant Discharge Elimination System Permit A Clean Water Act - National Pollutant Discharge Elimination System (NPDES) permit is required for most applications of mosquito control pesticides to water, and MPCA procedures for Pesticide NPDES Permits are described at http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-permits-and-forms/pesticide-npdes-permit/pesticide-npdes-permit-program.html. The checklist for mosquito control permits is given at http://www.pca.state.mn.us/index.php/view-document.html?gid=15671

In 2012, MMCD submitted a Pesticide Discharge Management Plan (PDMP) to the MPCA that described contact people, target pests and data sources, thresholds and management, and steps to be taken to respond to various types of incidents, submitted a Notice of Intent (NOI), and paid permit fees. This has been renewed annually.

Comprehensive treatment listings have been prepared for the MPCA in fulfillment of the permit requirements and submitted annually. The listings included site-specific treatment history and a geospatial file of treatment locations. This is the same information that MMCD makes available for public view on MMCD's web site.

US Fish & Wildlife Service – Mosquitoes and Refuges MMCD works with the US Fish & Wildlife Service (FWS) regarding mosquito surveillance on and near FWS lands within the District. If rainfall, river levels, or other nearby surveillance indicates a need for sampling, work in the Minnesota Valley National Wildlife Refuge (MVNWR) is conducted following the stipulations of a Special Use Permit updated annually by the Refuge Manager. "Emergency Response Procedures" and "Pesticide Use Proposals" for the larvicide *Bacillus sphaericus* (VectoLex) and the adulticide sumithrin (Anvil) prepared in 2009 by FWS staff allow treatment of disease vectors if "a mosquito-borne disease human health emergency exists in vicinity of the Refuge" (agreed on by MDH, FWS, and MMCD) and such treatment "is found to be appropriate".

Because of low mosquito populations in general, low vector mosquito populations, low WNV transmission, and heavy demands on staff time throughout the season, MMCD did not request permission to survey wetlands for mosquito larvae in MVNWR or in Soberg WPA (waterfowl production area) in 2015.

Adult mosquito surveillance using CO_2 traps indicated that, for traps near MVNWR, collections of *Ae. vexans* were greatest within one mile of the refuge. Collections of *Cx. pipiens* and/or *Cx. restuans* were highest at two locations near MVNWR (FS1in Fort Snelling & H291in Eden Prairie). While the distance from each of these traps to the refuge is within the flight range of these two mosquito species, most of the *Cx. pipiens* and *Cx. restuans* captured in these two areas likely developed off the refuge closer to the traps. Still, birds that move between the refuge and the surrounding area can be infected with WNV off the refuge then carry the virus back to the refuge and subsequently infect mosquitoes there. *Culex tarsalis* collections were generally low for most of the season near MVNWR. The Eden Prairie trap consistently collected more *Cx. tarsalis* than other traps in the area during most of June, July, and August. Mosquitoes collected from traps near MVNWR were tested for WNV from the beginning of June through the end of September. There were no WNV positive samples from the area in 2015. MMCD staff report these surveillance findings annually to FWS.

Public Communication

Notification of Control The District continues to post daily adulticide information on its website (www.mmcd.org) and on its "Bite Line" (651-643-8383), a pre-recorded telephone message interested citizens can call to hear the latest information on scheduled treatments. Aerial larvicide treatment schedules are also posted on the web site and on the "Bite Line" as they become available. Information on how to access daily treatment information is regularly posted on Facebook and Twitter.

Calls Requesting Service Call volume in 2015 built slowly from Memorial Day weekend and remained modest and relatively steady until falling off in mid-August. A mid-July drop in call volume tracked an observed drop in mosquito numbers during the same period (Fig. 6.2).

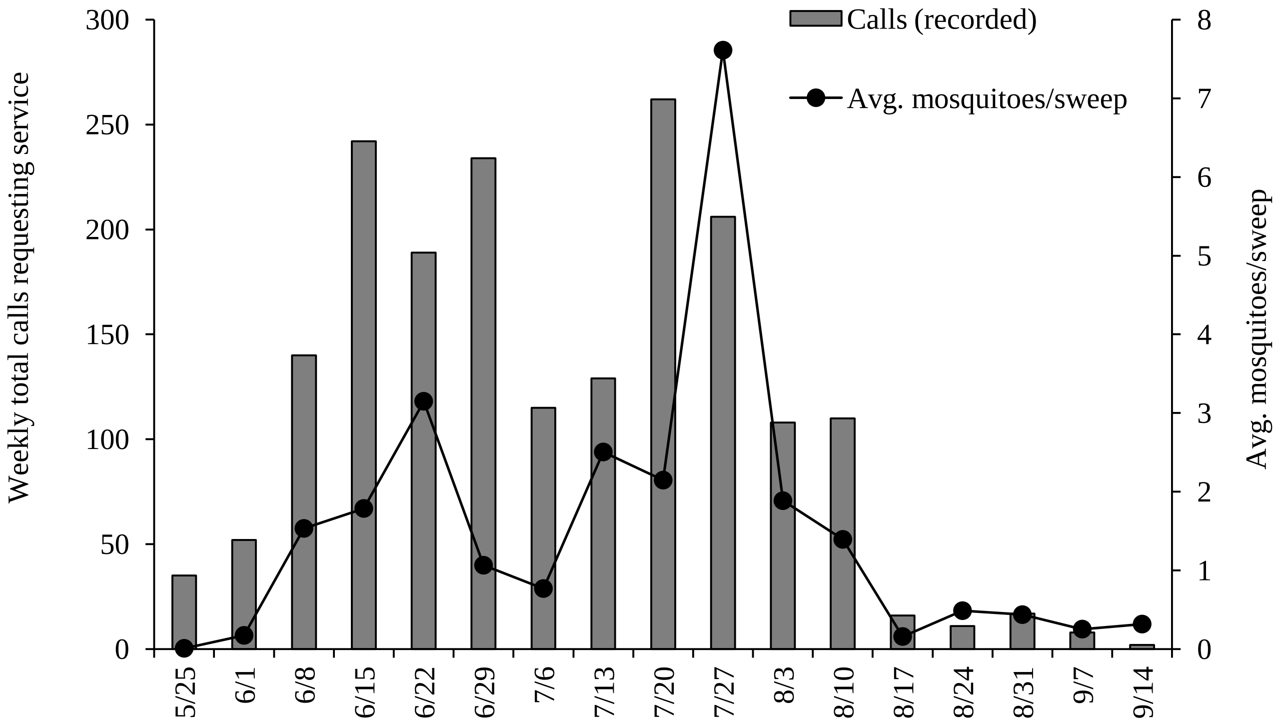


Figure 6.2 Calls requesting treatment of adults, and sweep net counts, by week, 2015.

Despite heavy rainfall and record larval treatments, total requests for adult mosquito treatment decreased in 2015 (Table 6.1). Calls requesting site checks for larval mosquitoes also decreased. Calls requesting treatment for public events held steady. Late-season emphasis on mosquito-borne disease prevention, as public awareness of WNV and LAC encephalitis risk increases, continues to drive requests to pick up and dispose of used tires, although calls requesting tire removal were lower than 2014. Requests for limited or no treatment continue to reflect a District commitment to finding and mapping bee hive locations in the metro area.

Table 6.1 Yearly citizen call totals (including e-mails), by service request type, 2004-2015

	Number of calls by year											
Service request	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Check a larval site	984	633	610	393	220	197	164	626	539	609	1,068	447
Request adult treatment	2,506	1,094	854	867	1,375	594	1,384	1,291	1,413	1,825	2,454	1,633
Public event, request treatment	135	100	72	60	109	250	78	68	61	70	93	91
Request tire removal	255	242	170	208	257	253	335	316	419	351	434	371
Request or confirm limited or no treatment	38	36	[a]171	49	66	61	55	56	54	[b]151	[c]150	147

Note: 2013 call numbers corrected since previous TAB report

[a] Years where confirmation postcards sent to confirm restricted access property status

[b] Historic restriction "calls" moved into new system

[c] Bee hive locations added into call system to track restrictions

Curriculum in Schools Main Office and regional facility staff made presentations to 5,870 students in 54 schools during 2015. MMCD continued to deliver "Mosquito Mania," a three-day curriculum for upper elementary and middle school students. This curriculum was introduced to metro-area schools during the 2005-2006 school-year. "Mosquito Mania" builds on MMCD's relationship with schools by offering a standards-based approach to the subject of mosquitoes and their relationship to the environment. We continue to monitor changes in middle-school learning standards and make the adjustments necessary to keep the curriculum relevant and useful. Nearly one quarter of students reached by MMCD's school presentations visited learning stations set up as part of multi-school field days where a variety of public agencies gave short, science-based presentations throughout the day.

Social Media As part of an ongoing effort to notify residents when and where treatment is to take place, MMCD continues to build a presence on Facebook and Twitter. Anyone can sign up to receive MMCD tweets (@metromosquito). People can also "friend" Metropolitan Mosquito Control District on Facebook. MMCD currently has 278 Twitter followers (up from 210 a year ago), and 463 "Likes" on Facebook (up from 354 in 2014).

MMCD currently uses the service "GovDelivery" to give advance notification to District residents of adult mosquito treatments. In 2016, GovDelivery will continue to manage MMCD's direct treatment notification email lists. MMCD also works with GovDelivery to make efficient use of social media to reach people who are interested in finding out more about District treatment activities. GovDelivery is also used to distribute press releases and make announcements about job openings. In 2015, there were 3,177 distinct email subscribers to our GovDelivery lists. That's up significantly from 2,503 distinct subscribers in 2014.

Sustainability Initiative

Ongoing impacts from decreasing natural resources and climate change have served to deepen MMCD's longstanding commitment to sustainability and social responsibility. In 2015, MMCD converted the sustainability steering committee into an established District team. The team's work groups address the following focus areas:

- Reducing energy usage
    a. Evaluating electricity savings through automated light switches and better windows.
    b. Documenting savings from telecommuting for meetings.
    c. Testing more fuel-efficient vehicles such as the Ford C-max hybrid (40-44 mpg) and GMC Canyon compact trucks (19-21 mpg, vs. 13-15 mpg for Ford F-150). In general these have worked well; the main issue with the C-max is that we can't carry pesticides inside the vehicle. We are hoping to order more compact trucks for 2016 but there is a very long wait time from the manufacturers.
    d. Other upcoming projects include automated shutdown settings for computers, looking at Solatubes, and reviewing insulation status for long-term building plans.
- Reducing waste
    a. We continue to make progress on shifting control material delivery to bulk containers to reduce waste, and have worked with several manufacturers. In 2015 reusable bulk totes for helicopter loading replaced 1,280 bags that would have gone in the trash.
    b. One facility found a recycler that handled 490 lb of shrink-wrap from control material deliveries, and we are looking to expand this to other offices.
    c. Composting is in active use at 4 of 7 facilities, and one facility started a garden with the product.
- Identifying and using renewable resources
    a. Group is studying solar options including some that would allow the District to use renewable energy sources without directly investing in solar power equipment, such as community solar gardens.
- Social responsibility/health and wellness
    a. Staff conducted drives to collect food, winter clothing and shoes for donation.

A guiding Sustainability document for the District is updated yearly, and can be found at www.mmcd.org/resources/technical-reports.

Professional Association Support

American Mosquito Control Association MMCD staff members continued to provide support for the national association, most notably Diann Crane's editorial assistance with the AMCA Annual Meeting Program.

North American Black Fly Association John Walz served as President and Program Chair for this group again in 2015 and Carey LaMere maintains the association's web site, http://www.nabfa-blackfly.org.

North Central Mosquito Control Association Mark Smith and Sandy Brogren serve on the Board of Directors of this regional association focused on education, communication, and promoting interaction between various regional organizations and individuals in Minnesota, North Dakota, South Dakota, Wisconsin, Iowa, and the Central Provinces of Canada. MMCD hosted the 2015 annual meeting at the University of Minnesota St. Paul campus and held an open house at our Main Office featuring many aspects of our program. The 2016 meeting is planned for Fargo, ND.

Scientific Presentations, Posters, and Publications

MMCD staff attends a variety of scientific meetings throughout the year. Following is a list of papers and posters presented during 2015 and talks that are planned in 2016. Also included are publications that have MMCD staff as authors or co-authors.

2015 Presentations & Posters

Brogren, S. 2015. Entomology training techniques: “keys” to success. Presentation: Michigan Mosquito Control Association Annual Meeting in Traverse City / Bellaire, MI.

Crane, D. 2015. Nontarget effects of Natular G in spring *Aedes* sites. Presentation: North Central Mosquito Control Association Annual Meeting in St. Paul, MN.

Herrmann, C. 2015. GoPro video of MMCD black fly control operations. Presentation: North American Black Fly Association Annual Meeting in Athens, GA.

Jarnefeld, J. 2015. Ticks and tick-borne diseases in Minnesota. Presentation: North Central Mosquito Control Association Annual Meeting in St. Paul, MN.

Johnson, K. 2015. Mosquito-borne diseases in Minnesota. Presentation: North Central Mosquito Control Association Annual Meeting in St. Paul, MN.

Lemke, L. 2015. Sustainability: the use of bulk material and the elimination of forty-pound bags in the ground treatment process. Presentation: American Mosquito Control Association Annual Meeting in New Orleans, LA.

Manweiler, S. and M. McLean. 2015. Aligning mosquito control operations and pollinator protection. Presentation: Michigan Mosquito Control Association Annual Meeting in Traverse City / Bellaire, MI and American Mosquito Control Association Annual Meeting in New Orleans, LA.

McLean, M. 2015. Protecting pollinators. Presentation: North Central Mosquito Control Association Annual Meeting in St. Paul, MN.

Read, N. and J. Jarnefeld. 2015. March of the ticks. Presentation: MN GIS/LIS Conference in Duluth, MN.

Smith, M. 2015. Pollinator protection initiatives. Presentation, Bayer Corporation Advisory Board meeting, Raleigh, NC

Smith, M. 2015. Update on pyrethroids and the re-registration process. Pesticide Applicator Training Workshop, St. Paul, MN

Smith, M. 2015. Strategic use of pre-hatch larvicides can improve your mosquito control program. Presentation: American Mosquito Control Association Annual Meeting in New Orleans, LA.

2016 Presentations & Posters

Brogren, S. 2016. Weather or not, we get mosquitoes: Seasonality of mosquito species. Presentation: North Central Mosquito Control Association Annual Meeting in Moorhead, MN.

Johnson, K. 2016. Zika: Surveillance and prevention. Presentation: North Central Mosquito Control Association Annual Meeting in Moorhead, MN.

Manweiler, S. 2016. Succession planning for sustaining a healthy, vibrant agency. Presentation: Michigan Mosquito Control Association Annual Meeting in Ann Arbor, MI.

McLean, M. 2016. Mosquito control and stagnant water. Presentation: 60th Annual Institute for Building Officials. University of Minnesota Continuing Education and Conference Center.

Nee, M. 2016. Mosquito clip art. Poster: American Mosquito Control Association Meeting in Savannah, GA.

Peterson, J. 2016. Flying into action: Helicopter larval treatments for MMCD. Presentation: American Mosquito Control Association Meeting in Savannah, GA.

Walz, J. and C. LaMere. 2016. MMCD Black Fly Program update. Presentation: North American Black Fly Association Meeting in Laughlin, NV.

APPENDICES

APPENDIX A Mosquito and Black Fly Biology and Species List

Mosquito Biology

There are 51 species of mosquitoes in Minnesota. Forty-five species occur within the District. Species can be grouped according to their habits and habitat preferences. For example, the District uses the following categories when describing the various species: disease vectors, spring snow melt species, summer floodwater species, permanent water species, the cattail mosquito, and invasive or rare species.

Disease Vectors

Aedes triseriatus Also known as the eastern treehole mosquito, *Ae. triseriatus*, is the vector of La Crosse encephalitis (LAC). Natural oviposition sites are tree holes; however, adult females will also oviposit in water-holding containers, especially discarded tires. Adults are found in wooded or shaded areas and stay within ¼ to ½ miles from where they emerged. They are not aggressive biters and are not attracted to light. Vacuum aspirators are best for collecting this species.

Aedes japonicus This non-native species was first detected in Minnesota in 2007. By 2008, they were established in the District and southeast Minnesota. Larvae are found in a wide variety of natural and artificial habitats (containers), including rock holes and used tires. Preferred sites usually are shaded and contain organic-rich water. Eggs are resistant to desiccation and can survive several weeks or months under dry conditions. Overwintering is in the egg stage. Wild-caught specimens have tested positive for the LAC (Harris, C., et al, 2015. Emerging Infectious Diseases 21:4), thus, it is another potential vector of LAC in Minnesota.

Culex tarsalis *Culex tarsalis* is the vector of western equine encephalitis (WEE) and a vector of West Nile virus (WNV). In late summer, egg laying spreads to temporary pools and water-holding containers, and feeding shifts from birds to horses or humans. MMCD monitors this species using New Jersey light traps and CO_2 traps.

Other *Culex* Three additional species of *Culex* (*Cx. pipiens, Cx. restuans,* and *Cx. salinarius*) are vectors of WNV. All three use permanent and semi-permanent sites for larval habitat, and *Cx. pipiens* and *Cx. restuans* use storm sewers and catch basins as well. These three *Culex* vector species plus *Cx. tarsalis* are referred to as the *Culex*4.

Culex erraticus *Culex erraticus* normally a southern mosquito, has been increasing in our area over the past decade. In 2012 (a very warm spring and summer period), there were very high levels of adult *Cx. erraticus* in the District, and larvae were found for the first time since 1961 in permanent water sites with no emergent vegetation and edges with willow. *Culex erraticus* is a potential vector of eastern equine encephalitis (EEE).

Culiseta melanura *Culiseta melanura* is the enzootic vector of EEE. Its preferred larval habitat is spruce tamarack bogs, and adults do not fly far from these locations. A sampling strategy developed for both larvae and adults targets habitat in northeastern areas of the District, primarily in Anoka and Washington counties. Several CO_2 trap locations are specific for obtaining *Cs. melanura*; adult females collected from those sites are then tested for EEE.

Floodwater Mosquitoes

Spring *Aedes* Spring *Aedes* mosquito (12 species) eggs inundated with snowmelt runoff hatch from March through May; they are the earliest mosquitoes to hatch in the spring. Larvae develop in woodland pools, bogs, and marshes that are flooded with snowmelt water. There is only one generation per year and overwintering is in the egg stage. Adult females live throughout the summer, can take up to four blood meals, and lay multiple egg batches. These mosquitoes stay near their oviposition sites, so localized hot spots of biting can occur both day and night. Our most common spring species are *Ae. abserratus, Ae. punctor*, *Ae. excrucians*, and *Ae. stimulans*. Adults are not attracted to light, so human (sweep nets) or CO_2-baited trapping is recommended.

Summer Floodwater *Aedes* Eggs of summer floodwater *Aedes* (15 species) can hatch beginning in late April and early May. These mosquitoes lay their eggs at the margins of grassy depressions, marshes, and along river flood plains; floodwater from heavy rains (greater than one inch) stimulate the eggs to hatch. Overwintering is in the egg stage. Adult females live about three weeks and can lay multiple batches of eggs, which can hatch during the current summer after flooding, resulting in multiple generations per year. Most species can fly great distances and are highly attracted to light. Peak biting activity is as at dusk. The floodwater mosquito, *Ae. vexans* is our most numerous pest. Other summer species are *Ae. canadensis, Ae. cinereus, Ae. sticticus,* and *Ae. trivittatus*. New Jersey light traps, CO_2-baited traps, and human-baited sweep net collections are effective methods for adult surveillance of these species.

Cattail Mosquito

Coquillettidia perturbans This summer species is called the “cattail mosquito” because it uses cattail marshes for larval habitat. Eggs are laid in rafts on the surface of the water and will hatch in the same season. Larvae of this unique mosquito obtain oxygen by attaching its specialized siphon to the roots of cattails and other aquatic plants; early instar larvae overwinter this way. There is only a single generation per year, and adults begin to emerge in late June and peak around the first week of July. They are very aggressive biters, even indoors, and can disperse up to five miles from their larval habitat. Peak biting activity is at dusk and dawn. Adult surveillance is best achieved with CO_2 traps and sweep net samples.

Permanent Water Species

Other mosquito species not previously mentioned develop in permanent and semi-permanent sites. These mosquitoes comprise the remaining *Anopheles*, *Culex*, and *Culiseta* species. These mosquitoes are multi-brooded and lay their eggs in rafts on the surface of the water. The adults prefer to feed on birds or livestock but will bite humans. The adults overwinter in places like caves, hollow logs, stumps or buildings. As previously mentioned, the District targets disease vectors (the *Culex*4 species and *Cs*. *melanura*) for surveillance and/or control.

Invasive or Rare Species

Aedes albopictus This invasive species is called the Asian tiger mosquito. It oviposits in tree holes and containers. This mosquito is a very efficient vector of several diseases, including LAC. *Aedes albopictus* has been found in Minnesota, but it is not known to overwinter here. It was brought into the country in recycled tires from Asia and is established in areas as far north as Chicago. An individual female will lay her eggs a few at a time in several containers, which may contribute to rapid local spread. This mosquito has transmitted dengue fever in southern areas of the United States. Females feed predominantly on mammals but will also feed on birds.

***Psorophora* Species** Larvae of this genus develop in floodwater areas, are human-biting, and are not known to vector any disease. Four species occur in the District: *Ps. ciliata*, *Ps. columbiae*, *Ps. ferox*, and *Ps. horrida*. Although considered rare or uncommon, they have been detected more frequently since the mid-2000s. The adult *Psorophora ciliata* is the largest mosquito found in the District, and its larvae are predacious and even cannibalistic, feeding on other mosquito larvae.

Black Fly Biology

Life Cycle Females lay eggs directly onto the water or on leaves of aquatic plants and objects in rivers, streams, and other running water. Once they hatch, the larvae attach themselves to stones, grass, branches, leaves, and other objects submerged under the water. In Minnesota, black flies develop in large rivers (e.g. Mississippi, Minnesota, Crow, and Rum) as well as small streams. Most larval black flies develop under water for ten days to several weeks depending on water temperature. Larvae eat by filtering food from the running water with specially adapted mouthparts that resemble grass rakes. They grow to about 1/4 inch when fully developed; after about a week as pupae, they emerge as adults riding a bubble of air to the surface.

Female black flies generally ambush their victims from tree-top perches near the edge of an open area and are active during the day; peak activity is in the morning and early evening. Females live from one to three weeks, depending on species and weather conditions. They survive best in cool, wet weather. Studies done by MMCD show that the majority of black flies in the region lay only one egg batch.

Targeted Species (taken from Adler, P. et al, 2004)
Simulium venustum develops in smaller streams. It has one generation in the spring (April through early June), and is univoltine (one egg batch per year). Eggs overwinter and larvae begin hatching in April. Females can travel an average of 5.5-8 miles (maximum=22 miles) from their natal waterways. *Simulium venustum* is one of the most common black flies and probably one of the major biting pests of humans in North America.

Simulium johannseni develops primarily in the Crow and South Fork Crow rivers. It has one generation in the spring (April through May). Larvae develop in large, turbid, meandering streams and rivers with beds of sand and silt. Female adults feed on both birds and mammals.

Simulium meridionale develops in the Minnesota, Crow, and South Fork Crow rivers and is multivoltine with three to six generations (May- July). Adult females feed on both birds and mammals. Females will travel at least 18 miles from their natal sites and have been collected at heights up to 4,900 ft above sea level (0.932 miles).

Simulium luggeri develops primarily in the Mississippi and Rum rivers and has five to six generations a year. Eggs overwinter with larvae and pupae present from May to October. Three to five overlapping generations are produced annually. Host-seeking females can travel at least 26 miles from their natal waters and perhaps more than 185 miles with the aid of favorable winds. Hosts include humans, dogs, horses, pigs, elk, cattle, sheep, and probably moose.

Adler, Peter H., Douglas C. Currie, and D. Monty Wood. 2004. *The Black Flies (Simuliidae) of North America*. Cornell University Press.

Species Code and Significance/Occurrence of the Mosquitoes and Black Flies in MMCD

Code	Genus	species	Significance/ Occurrence	Code	Genus	species	Significance/ Occurrence
Mosquitoes							
1.	*Aedes*	*abserratus*	common, spring	27.	*Anopheles*	*barberi*	rare, tree hole
2.		*atropalpus*	rare, summer	28.		*earlei*	common
3.		*aurifer*	rare, spring	29.		*punctipennis*	common
4.		*euedes*	rare, spring	30.		*quadrimaculatus*	common
5.		*campestris*	rare, spring	31.		*walkeri*	common
6.		*canadensis*	common, spring	311.	*An.* unidentifiable		
7.		*cinereus*	common, spring-summer				
8.		*communis*	rare, spring	32.	*Culex*	*erraticus*	rare
9.		*diantaeus*	rare, spring	33.		*pipiens*	common
10.		*dorsalis*	common, spring-summer	34.		*restuans*	common
11.		*excrucians*	common, spring	35.		*salinarius*	uncommon
12.		*fitchii*	common, spring	36.		*tarsalis*	common
13.		*flavescens*	uncommon, spring	37.		*territans*	common
14.		*implicatus*	uncommon, spring	371.	*Cx.* unidentifiable		
15.		*intrudens*	rare, spring	372.	*Cx.*	*pipiens/restuans*	common
16.		*nigromaculis*	uncommon, summer				
17.		*pionips*	rare, spring	38.	*Culiseta*	*inornata*	common
18.		*punctor*	common, spring	39.		*melanura*	uncommon, local
19.		*riparius*	common, spring	40.		*minnesotae*	common
20.		*spencerii*	uncommon, spring	41.		*morsitans*	uncommon
21.		*sticticus*	common, spring-summer	411.	*Cs.* unidentifiable		
22.		*stimulans*	common, spring	42.	*Coquillettidia*	*perturbans*	common
23.		*provocans*	common, early spring	43.	*Orthopodomyia*	*signifera*	rare
24.		*triseriatus*	common, summer, LAC vector	44.	*Psorophora*	*ciliata*	rare
25.		*trivittatus*	common, summer	45.		*columbiae*	rare
26.		*vexans*	common, #1 summer species	46.		*ferox*	uncommon
50.		*hendersoni*	uncommon, summer	47.		*horrida*	uncommon
51.		*albopictus*	rare, exotic, Asian tiger mosquito	471.	*Ps.* unidentifiable		
52.		*japonicus*	summer, Asian rock pool mosq.				
53.		*cataphylla**		48.	*Uranotaenia*	*sapphirina*	common, summer
118.		*abserratus/punctor* inseparable when rubbed		49.	*Wyeomyia*	*smithii*	rare
261.	*Ae.* unidentifiable			491.	Males		
262.	Spring *Aedes*			501.	Unidentifiable		
264.	Summer *Aedes*						
Black Flies							
91.	*Simulium*	*luggeri*	treated, summer	96.	Other Simuliidae		
92.		*meridionale*	treated, summer	97.	Unidentifiable Simuliidae		
93.		*johansenni*	treated, spring				
94.		*vittatum*	non-treated, summer				
95.		*venustum*	treated, spring				

* Two *Aedes cataphylla* larvae were collected in April, 2008 in Minnetonka, MN

Genus Abbreviations for mosquitoes

Aedes=Ae.	*Orthopodomyia=Or.*
Anopheles=An.	*Psorophora=Ps.*
Culex=Cx.	*Uranotaenia=Ur.*
Culiseta=Cs.	*Wyeomyia=Wy.*
Coquillettidia=Cq.	

APPENDIX B Average Number of Common Mosquitoes Collected per Night in Long-term NJ Light Trap Locations and Average Yearly Rainfall, 1965-2015. Traps 1, Trap 9, Trap 13, and Trap 16 have run yearly since 1965; in 2015, Trap 1 was discontinued and will be relocated in 2016.

Year	Spring *Aedes*	*Aedes cinereus*	*Aedes sticticus*	*Aedes trivittatus*	*Aedes vexans*	*Culex tarsalis*	*Cq. perturbans*	All species	Avg. Rainfall
1965	0.10	0.22	0.06	0.01	107.54	8.76	1.28	135.69	27.97
1966	0.16	0.06	0.00	0.01	17.26	0.45	1.99	22.72	14.41
1967	0.31	0.27	0.25	0.03	85.44	0.96	4.93	95.5	15.60
1968	0.21	0.71	0.04	0.19	250.29	2.62	3.52	273.20	22.62
1969	0.15	0.23	0.01	0.03	20.39	0.57	3.57	30.12	9.75
1970	0.20	0.57	0.03	0.33	156.45	0.97	3.07	179.71	17.55
1971	0.87	0.42	0.12	0.11	90.45	0.50	2.25	104.65	17.82
1972	1.05	1.79	0.19	0.07	343.99	0.47	14.45	371.16	18.06
1973	0.97	0.68	0.03	0.04	150.19	0.57	22.69	189.19	17.95
1974	0.37	0.36	0.10	0.03	29.88	0.26	5.62	38.75	14.32
1975	0.28	0.63	0.44	0.17	40.10	6.94	4.93	60.64	21.47
1976	0.24	0.04	0.01	0.00	1.69	0.25	4.24	9.34	9.48
1977	0.14	0.07	0.00	0.02	21.75	5.98	7.42	34.07	20.90
1978	0.84	0.77	0.17	0.11	72.41	4.12	0.75	97.20	24.93
1979	0.29	0.21	0.03	0.48	27.60	0.29	2.12	35.44	19.98
1980	0.03	0.19	0.05	0.79	74.94	0.93	16.88	96.78	19.92
1981	0.05	0.14	0.13	0.69	76.93	1.50	4.45	87.60	19.08
1982	0.10	0.08	0.02	0.03	19.95	0.23	3.16	25.91	15.59
1983	0.15	0.08	0.02	0.04	45.01	0.67	3.44	53.39	20.31
1984	0.08	0.09	0.15	0.36	74.68	2.97	22.60	110.26	21.45
1985	0.07	0.00	0.02	0.01	21.02	0.33	4.96	28.72	20.73
1986	0.35	0.22	0.11	0.04	30.80	1.55	2.42	40.76	23.39
1987	0.00	0.09	0.01	0.17	29.91	1.18	1.52	37.43	19.48
1988	0.01	0.09	0.00	0.00	12.02	0.84	0.18	15.31	12.31
1989	0.05	0.35	0.01	0.26	13.13	1.60	0.17	21.99	16.64
1990	0.30	3.39	0.22	0.08	119.52	4.97	0.08	147.69	23.95
1991	0.11	0.56	0.15	0.26	82.99	1.17	0.45	101.33	26.88
1992	0.04	0.04	0.03	0.13	50.30	0.62	16.31	74.56	19.10
1993	0.03	0.24	0.10	1.15	50.09	0.96	10.90	72.19	27.84
1994	0.02	0.14	0.03	0.08	23.01	0.05	15.19	40.92	17.72
1995	0.04	0.28	0.02	0.29	63.16	0.42	6.79	77.71	21.00
1996	0.12	0.10	0.01	0.04	14.28	0.05	12.06	28.81	13.27
1997	0.09	0.64	0.14	0.63	39.06	0.14	2.03	45.35	21.33
1998	0.03	0.14	0.16	1.23	78.42	0.10	6.13	91.29	19.43
1999	0.01	0.28	0.09	0.11	28.24	0.06	1.74	33.03	22.41
2000	0.01	0.07	0.00	0.22	24.09	0.15	1.36	29.50	17.79
2001	0.05	0.41	0.32	0.10	20.97	0.27	1.01	26.26	17.73
2002	0.05	0.22	0.07	2.53	57.87	0.35	0.75	65.82	29.13
2003	0.04	0.15	0.43	2.00	33.80	0.13	1.59	40.51	16.79
2004	0.02	0.33	0.22	0.63	24.94	0.16	0.99	28.91	21.65
2005	0.05	0.11	0.17	0.42	22.27	0.17	0.57	25.82	22.82

Continued on next page

Year	Spring *Aedes*	*Aedes cinereus*	*Aedes sticticus*	*Aedes trivittatus*	*Aedes vexans*	*Culex tarsalis*	*Cq. perturbans*	All species	Avg. Rainfall
2006	0.05	0.08	0.14	0.01	6.73	0.08	1.85	10.04	18.65
2007	0.22	0.27	0.01	0.01	8.64	0.26	0.94	13.20	17.83
2008	0.38	0.32	0.17	0.01	8.17	0.10	2.01	12.93	14.15
2009	0.10	0.07	0.00	0.02	3.48	0.04	0.23	4.85	13.89
2010	0.07	0.08	0.06	0.17	16.18	0.23	0.36	26.13	24.66
2011	0.10	0.07	0.11	0.78	33.40	0.07	5.76	47.36	20.61
2012	0.04	0.03	0.15	0.21	21.10	0.04	4.01	30.39	17.53
2013	0.37	0.49	0.15	0.81	26.95	0.12	1.80	35.08	17.77
2014	0.12	0.32	0.19	0.44	32.42	0.20	2.18	41.72	23.60
2015*	0.02	0.26	0.01	0.46	27.73	0.06	3.77	36.00	24.02

*Trap 1 discontinued in 2015 due to operator retirement.

APPENDIX C Description of Control Materials Used by MMCD in 2015

The following is an explanation of the control materials currently used by MMCD. The specific names of products used in 2015 are given. The generic products will not change in 2016, although the specific formulator may change.

Insect Growth Regulators

Methoprene 150-day briquets — Central Life Sciences
Altosid® XR Extended Residual Briquet — EPA # 2724-421

Altosid briquets are typically applied to mosquito oviposition sites that are three acres or less. Briquets are applied to the lowest part of the site on a grid pattern of 14-16 ft apart at 220 briquets per acre. Sites that may flood and then dry up are treated completely. Sites that are somewhat permanent are treated with briquets to the perimeter of the site in the grassy areas. Pockety ground sites (i.e., sites without a dish type bottom) may not be treated with briquets due to spotty control achieved in the uneven drawdown of the site.

Coquillettidia perturbans sites are treated at 330 briquets per acre in rooted sites or 440 briquets per acre in floating cattail stands. Applications are made in the winter and early spring.

Methoprene pellets — Central Life Sciences
Altosid® Pellets — EPA# 2724-448

Altosid pellets consist of methoprene formulated in a pellet shape. Altosid pellets are designed to provide up to 30 days control but trials have indicated control up to 40 days. Applications will be made to ground sites (less than three acres in size) at a rate of 2.5 lb per acre for *Aedes* control and 4-5 lb per acre for *Cq. perturbans* control. Applications will also be done by helicopter in sites that are greater than three acres in size at the same rate as ground sites, primarily for *Cq. perturbans* control.

Methoprene granules — Valent Biosciences
MetaLarv® S-PT — EPA# 73049-475

MetaLarv S-PT consists of methoprene formulated in a sand-sized granule designed to provide up to 28 days control. Applications for control of *Cq. perturbans* and *Aedes* mosquitoes are being evaluated at 3 and 4 lb per acre.

Bacterial Larvicides

***Bacillus thuringiensis israelensis* (*Bti*) corn cob** — Valent Biosciences
VectoBac® G — EPA#73049-10

VectoBac corn cob may be applied in all types of larval habitat. The material is most effective during the first three instars of the larval life cycle. Typical applications are by helicopter in sites that are greater than three acres in size at a rate of 5-10 lb per acre. In sites less than three acres, the material is applied to pockety sites with cyclone seeders or power backpacks.

***Bacillus thuringiensis israelensis* (*Bti*) liquid** Valent Biosciences
VectoBac® 12AS EPA# 73049-38

VectoBac liquid is applied directly to small streams and large rivers to control black fly larvae. Treatments are done when standard Mylar sampling devices collect threshold levels of black fly larvae. Maximum dosage rates are not to exceed 25 ppm of product as stipulated by the MnDNR. The material is applied at pre-determined sites, usually at bridge crossings applied from the bridge, or by boat.

Bacillus sphaericus (Bs) Valent Biosciences
VectoLex® CG EPA# 73049-20

VectoLex CG may be applied in all types of larval *Culex* habitat. The material is most effective during the first three instars of the larval life cycle. Typical applications are by helicopter in sites that are greater than three acres in size at a rate of 8 lb per acre. In sites less than three acres, VectoLex is applied to pockety sites with cyclone seeders or power back packs at rates of 8 lb per acre. This material may also be applied to cattail sites to control *Cq. perturbans*. A rate of 15 lb per acre is applied both aerially and by ground to cattail sites in early to mid-September to reduce emergence the following June-July.

Natular® (spinosad) Clarke
Natular® G30 EPA# 8329-83

Natular is a new formulation of spinosad, a biological toxin extracted from the soil bacterium *Saccharopolyspora spinosad*, that was developed for larval mosquito control. Spinosad has been used by organic growers for over 10 years. Natular G30 is formulated as long release granules and can be applied to dry or wet sites.

Natular® (spinosad) Clarke
Natular® G EPA# 8329-80

Natular is a new formulation of spinosad, a biological toxin extracted from the soil bacterium *Saccharopolyspora spinosad*, that was developed for larval mosquito control. Spinosad has been used by organic growers for over 10 years. Natular G is formulated on corn cob as a short release granule designed for application (3.5 – 9 lb/acre) to wet sites.

Pyrethroid Adulticides

Permethrin Clarke
Permethrin 57% OS EPA# 8329-44

Permethrin 57% OS is used by the District to treat adult mosquitoes in known daytime resting or harborage areas. Harborage areas are defined as wooded areas with good ground cover to provide a shaded, moist area for mosquitoes to rest during the daylight hours.
Adult control is initiated when MMCD surveillance (sweep net and CO_2 trap collections) indicates nuisance populations of mosquitoes, when employee conducted landing rate collections document high numbers of mosquitoes, or when a large number of citizens complain of mosquito

annoyance from a given area. In the case of citizen complaints, MMCD staff conducts mosquito surveillance to determine if treatment is warranted. MMCD also treats functions open to the public and public owned park and recreation areas upon request and at no charge if the event is not-for-profit.

The material is diluted with soybean and food grade mineral oil (1:10) and is applied to wooded areas with a power backpack mister at a rate of 25 oz of mixed material per acre (0.0977 lb AI per acre).

Natural Pyrethrin MGK, McLaughlin Gormley King
Pyrocide® Mosquito Adulticiding Concentrate 7369 EPA#1021-1569

Pyrocide is used by the District to treat adult mosquitoes in known areas of concentration or nuisance where crop restrictions prevent treatments with resmethrin or sumithrin. Pyrocide is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand-held cold fog machines that enable applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Pyrocide is applied at a rate of 1.5 oz of mixed material per acre (0.00217 lb AI per acre). Pyrocide is a non-restricted use compound.

Esfenvalerate and Prallethrin MGK, McLaughlin Gormley King
Onslaught® FastCap Microencapsulated Insecticide EPA# 1021-1815

Onslaught (esfenvalerate, prallethrin, and the synergist PBO) is used by the District to treat adult mosquitoes in known daytime resting or harborage areas. Onslaught, a non-restricted use compound, is diluted with water (1:50) and applied to wooded areas with a power backpack mister at a rate of 25 oz of mixed material per acre (0.0026 lb AI per acre [0.0021 esfenvalerate and 0.0005 prallethrin]).

Resmethrin Bayer
Scourge® 4+12 EPA# 432-716

Scourge (resmethrin and the synergist PBO) is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Scourge is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand-held cold fog machines that enable the applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. The material is applied at a rate of 1.5 oz of mixed material per acre (0.0035 lb AI per acre). Scourge is a restricted used compound and is applied only by Minnesota Department of Agriculture-licensed applicators.

Sumithrin Clarke
Anvil® 2+2 EPA# 1021-1687-8329

Anvil (sumithrin and the synergist PBO) is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Anvil is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enable applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. The material is applied at a rates 1.5 and 3.0 oz of mixed material per acre (0.00175 and 0.0035 lb AI per acre). Anvil is a non-restricted use compound.

Etofenprox Central Life Sciences
Zenivex® E4 EPA# 2724-807

Etofenprox is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Etofenprox is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enable applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Etofenprox is applied at a rate of 1.0 oz of mixed material per acre (0.0023 lb AI per acre). Etofenprox is a non-restricted use compound.

APPENDIX D 2015 Control Materials: Active Ingredient (AI) Identity, Percent AI, Per Acre Dosage, AI Applied Per Acre and Field Life

Material	AI	Percent AI	Per acre dosage	AI per acre (lbs)	Field life (days)
Altosid® briquets [a]	Methoprene	2.10	220	0.4481	150
			330	0.6722	150
			440	0.8963	150
			1*	0.0020*	150
Altosid® pellets	Methoprene	4.25	2.5 lb	0.1063	30
			4 lb	0.1700	30
			0.0077 lb* (3.5 g)	0.0003*	30
MetaLarv™ S-PT	Methoprene	4.25	2.5 lb	0.1063	30
			3 lb	0.1275	30
			4 lb	0.1700	30
Natular™ G30	Spinosad	2.50	5 lb	0.1250	30
Natular™ G	Spinosad	0.50	5 lb	0.0250	7
VectoBac® G	*Bti*	0.20	5 lb	0.0100	1
			8 lb	0.0160	1
VectoLex® CG	*Bs*	7.50	8 lb	0.6000	7-28
			0.0077 lb* (3.5 g)	0.0006*	7-28
Permethrin 57%OS [b]	Permethrin	5.70	25 fl oz	0.0977	5
Onslaught FastCap® [c]	Esfenvalerate Prallethrin	6.40 1.60	25 fl oz	0.0021 0.0005	5
Scourge® [d]	Resmethrin	4.14	1.5 fl oz	0.0035	<1
Zenivex® E4 [e]	Etofenprox	4.00	1.0 fl oz	0.0023	<1
Anvil® [f]	Sumithrin	2.00	3.0 fl oz	0.0035	<1
Pyrocide® [g]	Pyrethrins	2.50	1.5 fl oz	0.00217	<1

[a] 44 g per briquet total weight (220 briquets=21.34 lb total weight)
[b] 0.50 lb AI per 128 fl oz (1 gal) (product diluted 1:10 before application, undiluted product contains 5.0 lb AI per 128 fl oz)
[c] 0.0135 lb AI per 128 fl oz (1 gal) (product diluted 1:50 before application, undiluted product contains 0.675 lb AI per 128 fl oz)
[d] 0.30 lb AI per 128 fl oz (1 gal)
[e] 0.30 lb AI per 128 fl oz (1 gal)
[f] 0.15 lb AI per 128 fl oz (1 gal)
[g] 0.185 lb AI per 128 fl oz (1 gal) (product diluted 1:1 before application, undiluted product contains 0.37 lb AI per 128 fl oz)
* Catch basin treatments—dosage is the amount of product per catch basin.

APPENDIX E Acres Treated with Control Materials Used by MMCD for Mosquito and Black Fly Control, 2007-2015.The actual geographic area treated is smaller because some sites are treated more than once

Control Material	2007	2008	2009	2010	2011	2012	2013	2014	2015
Larvicides									
Altosid® XR Briquet 150-day	290	294	225	174	205	165	189	193	186
Altosid® XRG	1,776	6,579	8,320	9,924	13,336	23,436	6,948	52	0
Altosid® Pellets 30-day	36,818	35,780	35,161	36,516	30,749	13,172	15,813	26,179	31,494
Altosid® Pellets catch basins (count)	161,876	195,973	219,045	227,611	234,033	226,934	246,300	239,829	248,599
MetaLarv™ S-PT	0	0	0	0	0	2,750	14,063	18,073	24,126
Natular™ G30	0	0	0	0	0	9,524	15,000	14,950	8,840
Altosid® XR Briquet catch basins (count)	6,438	40	0	0	0	458	375	437	450
VectoLex® CG granules	27	6	0	0	0	0	2,330	3,064	3,777
VectoMax® CG granules	0	182	5	0	0	0	0	0	0
VectoBac® G *Bti* corn cob granules	118,128	122,251	151,801	250,478	201,957	207,827	150,280	255,916	258,148
VectoBac® 12 AS *Bti* liquid (gal used) Black fly control	1,395	2,063	2,181	2,630	3,817	3,097	3,878	4,349	4,351
Adulticides									
Permethrin 57% OS Permethrin	3,897	8,272	4,754	8,826	7,544	8,578	9,020	8,887	6,093
Scourge® 4+12 Resmethrin/PBO	24,102	64,142	12,179	27,794	24,605	8,078	37,204	44,890	19,767
Anvil® 2 + 2 Sumithrin/PBO	5,608	35,734	7,796	26,429	29,208	27,486	36,000	31,381	27,183
Pyrenone® Adulticide	0	2,214	943	2,560	0	0	0	0	0
Pyrocide® Adulticide	0	299	0	0	0	0	0	5,338	3,605
Zenivex® Etofenprox	0	0	0	0	0	0	0	0	10,380

APPENDIX F Graphs of Larvicide, Adulticide, and ULV Fog Treatment Acres, 1984-2015

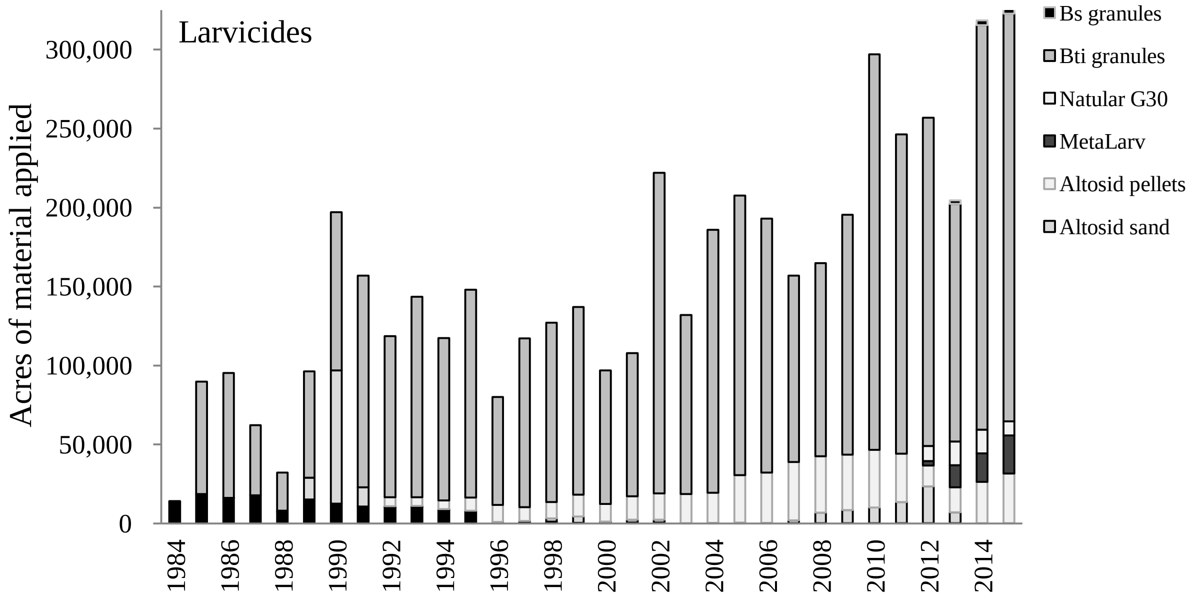


Figure F.1 Summary of total acres of larvicide treatments applied per year since 1984. For materials that are applied to the same site more than once per year, actual geographic acreage treated is less than that shown.

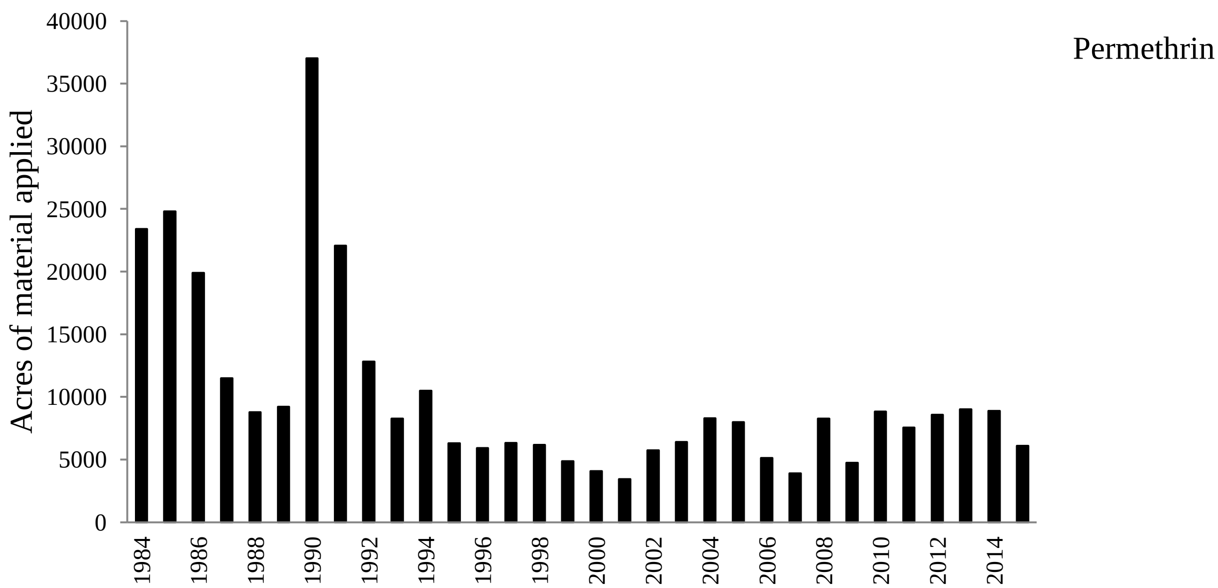


Figure F.2 Summary of total acres of permethrin treatments applied per year since 1984. This material may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

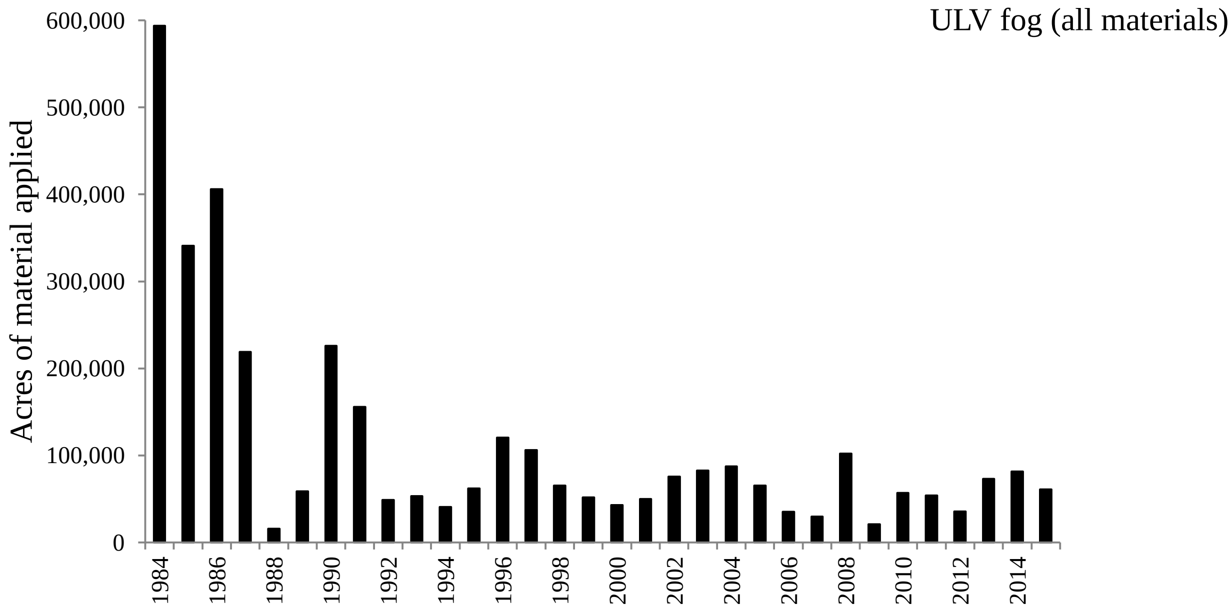


Figure F.3 Summary of total acres of ULV fog treatments applied per year since 1984. These materials may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

Appendix H MMCD Technical Advisory Board Meeting Notes

February 23, 2016

TAB Members Present:
Don Baumgartner, US EPA (remote link)
Phil Monson, MN Pollution Control Agency
Gary Montz, MN Dept. of Natural Resources, Chair
Roger Moon, University of Minnesota
John Moriarty, Three Rivers Park District
David Neitzel, MN Department of Health
Susan Palchick, Hennepin County Public Health
Robert Sherman, Independent Statistician
Vicky Sherry, US Fish and Wildlife Service
Sarma Straumanis, MN Department of Transportation
Christine Wicks, MN Dept. of Agriculture

MMCD Staff in Attendance: Stephen Manweiler, Arleen Schacht, Nancy Read, Sandy Brogren, Diann Crane, Janet Jarnefeld, Kirk Johnson, Mike McLean, Mark Smith, Molly Nee, Paul Youngstrom

Guests: Franny Dorr (MDH), Elizabeth Schiffman (MDH), Jenna Bjork (MDH), Charlie Schroeder (North Star Capital Management)

(Initials in the notes below designate discussion participants)

Welcome and Call to Order

Chair Gary Montz called the meeting to order at 12:30 p.m. All present introduced themselves. Gary then introduced MMCD Executive Director, Stephen Manweiler.

Zika Update

Kirk Johnson started with an update on Zika virus, given the intense media attention, and its implications for MMCD. Zika is a flavivirus related to West Nile virus, dengue viruses and yellow fever virus; there are two strains, African and Asian. The Asian strain appears to be the one in the current Western Hemisphere outbreak. *Aedes aegypti* is the primary vector, but there is some evidence of *Ae. albopictus* transmission in Gabon in 2007. Most infections are asymptomatic. There is no known vertebrate host other than humans and other primates. Of symptomatic infections, most are mild. There are rare indications of Guillain Barre syndrome, and some evidence of birth defects including microcephaly and blindness. There are also rare known cases of sexual transmission, which is different than other mosquito-borne viruses. Effort is being taken to protect the US blood supply if there is local transmission. There are 82 confirmed Zika cases in the US from travelers, many waiting testing. The concern is that asymptomatic carriers might be present. The chance of local transmission in the US depends on the presence of effective vectors. *Aedes aegypti* is only present in the southern US and *Ae. albopictus* is present farther north. As the year progresses, Zika-infected travelers may encounter active mosquito populations. The CDC is currently conducting a nationwide survey to determine the current ranges of these *Aedes* species.

We want to make sure that MMCD staff members are a source of accurate information, and we will coordinate our message with the MDH. The chance of transmission in the District is extremely low. We plan to maintain our current practices, removing container habitat, conducting surveillance for exotic (non-native) mosquitoes, especially *Ae. albopictus*, and responding promptly to any introductions. If we see any evidence of local transmission we will start by looking for container habitats for known vectors, and by testing other species for possible transmission. Given the high populations of some other *Aedes* species, even a low transmission rate would be a concern.

SP – who is testing other species for Zika? – KJ – MDH or other cooperators, we don't have internal capacity. DN – most human testing is done at CDC now, trying to get more state labs to have that capacity. There is limited ability to test mosquitoes. KJ – Lee County has a PCR lab, not sure of other Florida labs. If we see that Zika is just staying in southern US, we probably don't have as much to worry about, if we see it move farther north, it would indicate *Ae. albopictus* or another species other than *Ae. aegypti* is responsible.
BS – Does this mosquito bite more than once? SP – *Aedes aegypti* is a good vector because it tends to take many small meals (sips).
GM – our desk gets calls, if they get calls about Zika, where should we forward them? KJ – we can take those calls if needed. DN – if they have a question about health, call MDH, if it's about mosquitoes, call MMCD. KJ – we get questions about is it safe to travel to these places, we refer to CDC info. DN – we use Zika as an opportunity to remind people of the many diseases they should be prepared for. RDM – Dept of State issues some alerts.
DB – are you planning on having Minnesota-tailored info on your web site? It would be good to add. KJ – We're working on that, would be happy to share. DB – I'm concerned about the overreaction that is already happening and increased pesticide use by private and commercial applicators. To the general public, a mosquito is a mosquito – we could get more misters, structural applicators getting into mosquito control. SP – this is an opportunity to get people to focus on cleaning up containers – focus the energy on something positive. KJ – agree.
Gary suggested we hold further discussion until later, keep on time.
[SP had to leave at this time.]

MMCD Overview: Personnel Changes
Stephen discussed some of the major events of 2015. This year was a record year for larval control, with consistently low adult mosquito and black fly adult numbers. In 2015 we used $400,000 of emergency funds to cover extra expenses, mostly helicopter expenses. We have had a lot of personnel turnover, much due to retirement, and we are dealing with succession planning like many other agencies. We are also dealing with the challenge of sustainable funding, having had several record treatment years without increased funding.

2015 Season Highlights
Sandy Brogren started the Season Overview with a description of the precipitation and temperature patterns for 2015. There was not much snowfall over the winter and 2015 started out warm and dry. We got major precipitation in July, and also a warm and wet fall. She described the four main groups of mosquito species we encounter in the District, and how their biology relates to habitats and rainfall. Spring *Aedes* hatched later than usual, and had very low numbers.

Summer *Aedes* also started late and were above normal only for a short time in July from large rains. *Coquillettidia perturbans* were somewhat below average this year.

Stephen Manweiler discussed the treatment response to the weather patterns. July's weekly rainfalls produced a steady need for larval control, and we once again treated a record amount of acres with *Bti* and we had perfect weather for larval control. Adulticide treatments decreased slightly.

Mark Smith described some changes in MMCD's adulticide program. Resmethrin has not been re-registered and it will no longer be available in 2016 (company did not feel re-registration was cost-effective given small market). We expect to expand our use of Zenivex (etofenprox), which we have been testing and it appears to work well, in addition to Anvil (sumithrin).

There has also been a label change for droplet size for our barrier treatment material, permethrin, to a larger droplet size, and we needed a new method to be able to calibrate our equipment. Mark described the Malvern Laser and spray booth that MMCD is now using for calibrating equipment. This gives us much more thorough information, and helps us ensure compliance with the droplet regulations and make more effective treatments. We would also like to be a resource for other applicators in the region.

DB – do you get a lot of residue in the booth? MS – we are able to collect the material. DB – do you have to clean the lenses? MS – we had quite a challenge with that, but have a system for that now.
RDM – is the droplet size a function of the equipment, material, or both? MS – both. Most pyrethroids are fairly consistent. Laser is more reliable for measuring size.
JM – when you switched techniques did you find that your old equipment was pretty good or off? MS – it was good on the smaller droplets, it only had issues with larger droplets.

Sandy Brogren presented the Black Fly report (John Walz was at a national Black Fly meeting). The amount of *Bti* used in small streams in 2015 was higher than average, due to rainfall increasing discharge around the time of treatments. The large rivers were treated more often than in some of the past years, because of fairly constant, treatable flows, in contrast to some recent years with flood levels that were untreatable. Daytime sweeps showed that the adult black fly levels were the lowest yearly average ever.

JM – treatment sites in large rivers shows few farther south on Mississippi? GM – sites chosen for both access and concentration of larval population.
JM – if there were more treatments on the Minnesota, does that mean it is getting cleaner? GM – mostly it was the pattern of flow rates.

Janet Jarnefeld described tick results that are available. Record numbers of ticks, record ticks per mammal, and record number of positive sites were observed in 2015. We had a lone star tick turned in from a dog groomer, thanks to suggestion from Roger Moon to contact groomers. There is also a new spirochete, *Borrelia mayonii*, which causes a variant of Lyme disease, which is present in low numbers in MN and WI.

RM – would it be feasible to test MMCD's ticks for *B. mayonii*? JJ, DN – we have sent nymphs for testing. DN described work that went into finding this new spirochete.

Kirk Johnson reported on West Nile virus, activity was low in MN. The proportion of neuroinvasive cases appears to be higher, which suggests that non-neuroinvasive cases are being underreported. There were only six cases in Minnesota, and only three in the District, of which only two were probably infected locally. There were no La Crosse encephalitis cases in the District. There were two Jamestown Canyon cases reported in the state, one in MMCD.

PM – do you anticipate using the same kinds of control strategies and pesticide use if Zika became a problem? KJ – yes, and if container species are the main vector, a big part of control is removing containers, it may not always involve pesticides. RM – If something like *Ae. aegypti* got here, would they get into the stormwater or sewer system? KJ – Unsure, organic content is high in catch basins so they may not be favored by *Ae. aegypti*. RM – *albopictus*? KJ – We have not collected *Ae. albopictus* from stormwater sites. We do see *Ae. japonicus* in stormwater structures. RM – how long is human viremic? DN – a short time, maybe 7 days. KJ – for viruses with similar vectors (chikungunya, dengue), we have seen some transmission in Florida, but very low.

Break 2:05-2:15 p.m.

Pollinators Update
Mike McLean presented information on pollinator concerns and actions that MMCD is taking. We try to use products that have the least impact on bees, at times and places when bees are not foraging. We do direct outreach to beekeepers, and communicate with city licensing authorities and check Driftwatch for recorded beehive locations. New this year, if hive locations are registered on Driftwatch, beekeepers can receive compensation for damage. We include Driftwatch sites in our records, but also have many more that we have found through direct outreach or licenses. The label on adulticides is clear that treatments should not be made to flowering plants.

BS – what buffer is needed to protect bees? MM – we look at swath width for product and double it.
JM – if you are cold fogging on a street, are you avoiding pollinator gardens? MM – fog is meant to drift and impinge on mosquitoes at night, breaks down quickly on foliage.
DB – do you notify beekeepers if you do adulticiding near their hives? MM – if they have subscribed for notification through e-mail, or for particular requests we will do calls. DB – so you have actually contacted all those 160 hive owners? MM – through outreach. Note that we also get some beekeepers that request control.
RM – have you had any documented cases of bee kills? MM – not specifically related to us. Not aware of any compensation claims. CW – five bee kills reported statewide, two were compensated because pesticides were found on the bees. RM – materials? CW – thiomethoxam [neonicotinoid] RM – my sense is that adulticides MMCD uses are low on risk. MM – they are short lived, and treatments avoid habitats, although pyrethrins can cause bee mortality. Biggest problem we have is lack of central hive registry.
[Don B. had to leave the meeting at this time.]

Subgroup Report – Natular Nontarget Studies

Nancy Read described the background on Natular use and nontarget concerns, including a brief summary of the 2014 research that showed no effects on three of the four invertebrate groups of concern. At the TAB meeting in 2015 a plan was devised to try to get information on the remaining group, amphipods (scuds), and re-examine 2014 samples to look for possible community effects.

Diann Crane described the study that was done this year in cattail sites. This year's study used a brass mesh screen dipper instead of D-net as it was more effective in the cattail habitat. We found very few amphipods, but also found isopods and extracted those.

Roger Moon discussed the results. The number of isopods four days later was actually somewhat higher in treated sites after treatment. There were very few amphipods, but there was no apparent change after treatment.

Stephen Manweiler described the mosquito collection results in the emergence cages. There was some evidence of efficacy, fewer of the cages in treated sites had emergence, but overall percent control was low. There is some question whether the treatment was too close to the emergence date for effective control. Previous studies had better control. We plan one more cage test this year, treating in mid-May, to see if we can get uniform control. If we do get good efficacy, we will run another test before using Natular operationally in cattail sites.

Diann presented the questions that remain regarding continued processing and amphipod studies and the community study.

GM – what you should do next depends on what level of use you plan on for Natular; if you are going to use it more, then yes these studies could be important. Natular G is a 7 day release, why would it show a difference 23 days after treatment? SM – good question.

RM – could you afford to use it if it worked well? SM – yes.

GM – if you can maintain the samples in alcohol, I would say don't put effort into it this summer. See how the efficacy trials are going, then decide after that whether to process the samples.

RM – modify wording – consider the study sufficient for now, until you know more. Interested in helping with the subsampling question.

PM – what does manufacturer say? SM – described information received from the manufacturer [see 2013-2014 TAB report]. We also tested this in catch basins, had some issues with that as well. Natular G30 works well with summer floodwater mosquitoes in consistently productive sites.

RM – we contacted the company, they provided limited data.

PM – amphipods, were they found to be sensitive? MMCD could do standard toxicity tests on species like chironomids. I would expect amphipods in more open areas. GM – we've found amphipods in some cattail sites, typically more open. Chose amphipods because there was some evidence that crustaceans more likely to be affected.

RM – 2014 tests were in spring

SM – we are not testing Natular G in spring sites this year; we will just be testing methoprene.

PM- is there an analytical approach? Can you test for it in the water? Can be challenging with natural products. SM – manufacturer has done some of that.

JM – have any other control districts done non-target testing? SM – not that we know of.

General Discussion and Resolutions
TAB members then proposed, discussed, and approved the following motions to be communicated to the MMCD Commission:

Motion – That the TAB commends MMCD for its general practice of looking at both efficacy and environmental effects for new products. The TAB also recommends that MMCD staff preserve remaining 2014-2015 nontarget study samples, and discontinue processing until decisions are made regarding further Natular use operationally.
Motion by RM, second by JM. Approved.

Motion – That the TAB commends MMCD for working with beekeepers in the metro area, and for MMCD's efforts to identify and follow best management practices for pollinator protection.
Motion by JM, second by RS
Discussion: CW stated that there are defined Best Management Practices available from Dept of Ag web site (http://www.mda.state.mn.us/protecting/bmps/pollinators.aspx).
Approved.

Motion – That the TAB commends the District for maintaining surveillance and control of exotic mosquitoes, including potential vectors of Zika virus.
Motion by DN, second by VS. Approved.

RS stated the District has assembled a remarkable amount of very valuable information on mosquitoes, ticks and black flies, and when something like Zika comes along we are better prepared to deal with those situations. Well done, keep it up.

NR asked if there were any concerns about TAB membership and if there were any suggestions relative to additional members. Gary asked that if TAB members have additional ideas please let Nancy or Stephen know. PM asked if there is any official citizen engagement, and TAB discussed history and technical nature of the review process. CW suggested someone from the beekeeping community, and has a list. JM suggested Kyle Zimmer from St. Thomas.

Meeting adjourned 3:40 p.m.
Next chair will be the representative from MN Dept. of Health (Dave Neitzel).

Our Vision

To be the leading mosquito abatement district in the world

technology • public service • stewardship • effectiveness • partnership • innovation

Our Mission

To promote health and well being by protecting the public from disease and annoyance caused by mosquitoes, black flies, and ticks in an environmentally sensitive manner.

Our Values

We value integrity, trust, cooperation, respect and competence in our interactions with colleagues and customers.

mmcd
METROPOLITAN MOSQUITO CONTROL DISTRICT

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First Draft February 8, 2016
Second Draft April 19, 2016
Final May 21, 2016

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