METROPOLITAN MOSQUITO CONTROL DISTRICT
2022 OPERATIONAL REVIEW & PLANS FOR 2023

Annual Report to the Technical Advisory Board

MMCD field staff picking up tires for recycling in 2022.

MMCD photo

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

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 2023

Mike Gamache	Anoka County
Julie Jeppson	Anoka County
Mandy Meisner	Anoka County
Gayle Degler	Carver County
Tom Workman	Carver County
Laurie Halverson	Dakota County
Mary Hamann-Roland	Dakota County
Liz Workman	Dakota County
Kevin Anderson	Hennepin County
Angela Conley	Hennepin County
Chris LaTondresse	Hennepin County
Nicole Frethem	Ramsey County
Rena Moran	Ramsey County
Mai Chong Xiong	Ramsey County
Dave Beer	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 2022-2023

Elizabeth Schiffman, Chair	Mn Department of Health
Donald Baumgartner	US EPA
Stephen Kells	University of Minnesota
Phil Monson	Mn Pollution Control Agency
Steve Kloiber	Mn Dept. of Natural Resources
John Moriarty	Three Rivers Park District
Susan Palchick	Hennepin Co. Public Health
Vicki Sherry	US Fish & Wildlife Service
Christopher Smith	Mn Dept. of Transportation
Christine Wicks	Mn Dept. of Agriculture

Metropolitan Mosquito Control District Contributing Staff

Arleen Schact	Interim Executive Director
Diann Crane	Entomologist
Janet Jarnefeld	Technical Services/Tick
Kirk Johnson	Vector Ecologist
Carey LaMere	Technical Services/Black Fly
Scott Larson	Assistant Entomologist
Alex Carlson	Public Affairs
Nancy Read	Data Systems Coordinator
Mark Smith	Technical Services Manager
John Walz	Technical Services/Black Fly

METROPOLITAN MOSQUITO CONTROL DISTRICT

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Saint Paul, MN 55104-3431

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TTY use Minnesota Relay Service

July 27, 2023

Dear Reader:

The following report is the Metropolitan Mosquito Control District's (MMCD) 2022 Operational Review and Plans for 2023. 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 on February 7, 2023, are included in this report.

TAB's recommendations and report were accepted by the Commission at their July 27, 2023, meeting. The Commission approved the MMCD 2022 Operational Review and Plans for 2023 and thanked the TAB for their work.

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

Sincerely,

Arleen Schacht

Arleen Schacht
Interim Executive Director/Business Administrator

DEPARTMENT OF HEALTH

Protecting, Maintaining and Improving the Health of All Minnesotans

April 6, 2023

Commissioner Fran Miron
Chair
Metropolitan Mosquito Control Commission
2099 University Ave West
St. Paul, MN 55104

Dear Commissioner Miron,

The Technical Advisory Board (TAB) met on February 7, 2023, to review and discuss MMCD operations in 2022 and plans for 2023. Since the Board's formation in 1981, the member representatives have met at least once per year to provide an 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:

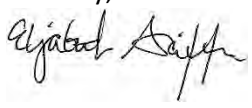
Resolution #1 – The TAB supports the program presented in the 2022 Review and 2023 Plan and acknowledges and appreciates the efforts of the MMCD staff in its presentation.

Resolution #2 – The TAB encourages the MMCD Commissioners to keep a requirement that the Director has an entomological or biological background, so science continues to drive MMCD decisions.

Resolution #3 – The TAB thanks the MMCD for developing a strong Integrated Vector and Pest Management program based on prevention and reducing the need for reactive techniques for pest management such as adulticides. The TAB urges the Commission to continue this emphasis, including ensuring that the budget must be based on preventative measures.

Resolution #4 - The TAB supports the District's intent to explore collection of updated public input to inform its practices.

Sincerely,



Elizabeth Schiffman, MPH, MA
Chair, Technical Advisory Board

Minnesota Depart of Health
Infectious Disease Epidemiology, Prevention, and Control Division
St. Paul, MN 55164
www.health.state.mn.us

Table of Contents

Executive Summary

The Metropolitan Mosquito Control District (MMCD or the District) strives to provide cost effective service in an environmentally sensitive manner. This report presents MMCD's efforts to accomplish that goal in 2022 through mosquito, black fly, and tick surveillance, disease monitoring, mosquito and black fly control, new product testing, data management, and communication with the public. It also presents plans for 2023 as we continue to provide an integrated mosquito management program for the benefit of District residents.

Mosquito Surveillance

For the second year in a row, the summer was uncharacteristically dry which impacted the timing and emergence of mosquito populations. The snowfall total from the preceding winter was 43.9 inches, 10.1 inches below normal. After a cool and wet spring, dry conditions began in June and precipitation remained below average through October with most of the seven-county metro in moderate to severe drought.

Adult spring *Aedes* emerged May 16 and peaked June 6. Our primary pest mosquitoes, summer *Aedes,* had their main emergence on June 6, which was earlier than normal but around the same time as 2021. Populations of the cattail mosquito, *Coquillettidia perturbans*, which depend on adequate water levels in their cattail marsh larval habitats from the previous fall through adult emergence in early July, were lower than normal and lower than expected based on previous history. The extremely low water levels in fall of 2022 reduced larval habitat for this species, and we expect adult populations to remain low in 2023.

Mosquito- and Tick-borne Disease

District staff provide 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), West Nile virus (WNV), and Jamestown Canyon virus (JCV), as well as tick-borne illnesses such as Lyme disease and human anaplasmosis.

The Minnesota Department of Health reported 19 WNV cases in 2022 with two occurring in District residents. The hot, dry conditions favor development of the vectors of WNV, unlike many other mosquito species which are more productive in wetter years, which partially explains why both 2021 and 2022 had more human cases than 2020 and 2019. Eastern equine encephalitis is a growing concern in Minnesota, but, thankfully, there were no reported human or horse cases of EEE in Minnesota. There was one case of JCV in Minnesota in 2022, which was reported in a resident of Ramsey County.

The District continued monitoring the distribution of ticks in the metro area. The average number of *Ixodes scapularis* (deer ticks) per mammal was 2.23, which is the highest MMCD has ever recorded. In 2022, the District again collected *I. scapularis* from at least one site in all seven counties. As has been the case in our counties north of the Mississippi River for many years, there are now many areas south of the river where residents might encounter *I. scapularis*.

No tick-borne disease case data is yet available for 2020 - 2022. There were 1,528 confirmed and probable Lyme disease and 407 human anaplasmosis cases in MN in 2019.

Mosquito and Black Fly 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. Given the low rainfall much of the year, MMCD only applied larvicide to 129,497 acres, which is over 20,000 fewer acres than in 2021 (150,299 acres treated). A cumulative total of 301,813 catch basin treatments were made to control WNV vectors. In 2022, 841 fewer acres of adulticide treatments were made (1,696 acres) than in 2021 (2,537 acres) due to fewer mosquitoes during drought conditions.

We planned to reinstate 100% of the larval control cut in 2017 because the District's financial situation supported it. However, with dry conditions in 2022 this additional control was not needed. The District once again plans to reinstate 100% of larval control in 2023 if weather conditions require it.

To control black flies in the metro area, MMCD made 55 small stream treatments and 46 large river treatments with *Bti* when the larval population of the target species met the treatment threshold. The average number of adult black flies per sweep in 2022 was 0.57, which was higher than 2021 (0.18), but lower than the 1996-2021 average of 1.24. This was the second year that *Simulium tuberosum* larval populations were treated in small streams, responding to public concern from high populations of this species in recent years. Due to 2021 drought conditions, scheduled non-target monitoring on the Mississippi River took place in 2022 with multiplate samplers placed in the river. In 2023, the District plans to continue monitoring *S. tuberosum* larval and adult populations to better understand its distribution, abundance, and life history.

Product and Equipment Testing

Evaluation of products, equipment, and processes is an important part of our program. In 2022, we found that 5 lb/acre dosages of VectoBac® G *Bti* achieved limited control of spring *Aedes* and *Ae. vexans* in sites treated by helicopter. A lower control rate than previous years was noted by staff in early spring applications and an investigation of low control rate was initiated in our North region. In 2023, we plan to collect more efficacy data to evaluate treatments in air sites.

MMCD Technical Services reviewed two automated systems for identifying and sorting mosquitoes in 2022.

In 2023 we plan to review the expansion of our drone program including an evaluation of the DJI Agras T10 drone platform.

Data Management, Public Information, Sustainability, and New Technologies

MMCD continued to explore how drones can be incorporated into our program. MMCD expanded larvicide treatments by drone in regular operations, and in 2022 staff treated 257 sites

using Altosid® P35 and VectoLex® which was more than the 132 sites treated in 2021. The number of acres treated by drone almost doubled from 182.89 in 2021 to 343 in 2022. We also continued our use of drones for aerial photography and site scouting.

We made big improvements to our mapping abilities in 2022 by completing the transition to QGIS, building a new catch basin treatment map, and rebuilding the mobile map for field data and expanded entry of new sites. We also began a major upgrade of the field data system software which will continue in 2023.

Public requests for adult mosquito treatments peaked in early June at the same time as the peak of mosquito numbers in sweep collections. Overall, customer calls were down significantly compared to the last 10 years likely due to low mosquito numbers. MMCD attended a number of public events, which continued to return in 2022 with many seeing attendance numbers that were similar to pre-COVID-19 levels.

Chapter 1 *Mosquito Surveillance*

2022 Highlights

- Snowfall season total was 43.9 inches, 10.1 inches below normal
- The spring of 2022 was cool and wet while the summer was warm and dry
- Abnormally dry conditions began in June and by the end of October we were 10 inches below normal and in severe drought
- There was one large summer floodwater brood & eight small-medium broods
- Identified 10,288 larval and 7,150 adult samples (excluding NJ trap samples)
- Adult spring *Aedes* emerged May 16 and peaked June 6
- The major summer *Aedes* emergence was June 6. This was the only large peak of the summer due to the dry conditions
- *Cq. perturbans* emerged beginning June 6 and peaked July 5 and were high the next two consecutive weeks
- Predicted catch rate for *Cq. perturbans* for 2022 was 24.7/trap. The actual value was 13.88/trap. The prediction for 2023 is 18.1 per trap

2023 Plans

- Evaluate Biogents BG Pro vs current CO_2 trap
- Publish a paper on the mosquito fauna of the Twin Cities metropolitan area

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. MMCD uses a variety of surveillance strategies 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.

Fifty-three known mosquito species occur in Minnesota, although one (*Aedes albopictus*) reintroduced yearly, all with a variety of host preferences. Forty-nine species occur in the District, 24 of which are human biting. Other species prefer to feed on birds, large mammals, reptiles, amphibians, and even worms. Mosquitoes differ in their peak activity periods and in how strongly they are attracted to humans or trap baits (e.g., light, CO_2, or highly organic water), 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; however, adults can live for three months and lay multiple egg batches. Summer *Aedes* (five species) begin hatching in late April and early May in response to rainfall and warmer temperatures. Adults can lay multiple egg batches and live on average two weeks. *Coquillettidia perturbans* (the cattail mosquito) develops in cattail marshes. There is one emergence, which begins in early June, peaking around the Fourth of July. Disease vectors include *Aedes triseriatus*, *Culiseta melanura*, and *Culex 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.

2022 Surveillance

Precipitation

Rainfall is a key factor for understanding floodwater mosquito populations and planning control efforts. Generally, rain amounts over one inch can induce a hatch of *Aedes* mosquitoes. For that reason, MMCD uses a network of rain gauges, read daily by staff or volunteers, to measure rainfall. The rainfall network was established over 60 years ago. These data are shared with the Minnesota State Climatologist's office for analysis. Currently, rain gauge data is entered directly into the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) system to make the measurements available more quickly for each other, the National Weather Service (NWS), and the public. This system has limitations because of the sparse gauge network in some areas of the District.

The NWS River Forecast Center (RFC) creates a 4x4 km grid of precipitation estimates based on a combination of NEXRAD (Next Generation Weather Radar), satellite, and ground rain gauge measures (including MMCD's gauges submitted through CoCoRaHS). This dataset is one of the best sources of timely, high resolution precipitation information available.

Average seasonal rainfall in the District is calculated from May-September using historical MMCD rain data and CoCoRaHS gauges. This time-period is referred to as the 'mosquito season'. Rainfall during the mosquito season (May 1-October 1, 2022) was 13.84 inches – well below the 63-year District average of 19.81 inches. April rainfall can influence adult emergence in May as well. The average precipitation for the weeks of March 27 through October 1, 2022 was 18.17 inches.

Figure 1.1 shows the sum of daily rainfall averages by week across the District from March 27-October 1, 2022. Average weekly rainfall over the one-inch threshold occurred five weeks from May through September. Heavy rains occurred the week of May 9 (2.25 inches). From then to the first week of August, there was only one week (week of July 4) where rainfall measured one inch. A large rain event occurred the week of August 9 when 2.18 inches of rain fell. There were two more rain events in August which yielded about 1.2 inches of rainfall in each week.

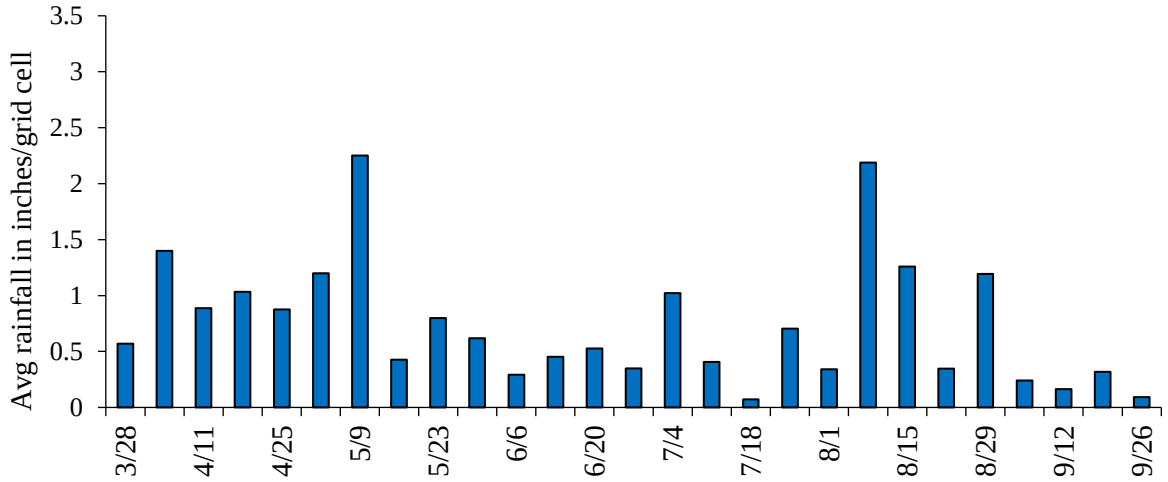


Figure 1.1 Sum of daily rainfall averages per week per grid cell, 2022 (RFC data). Dates represent the Monday of each week.

Typically, spring *Aedes* mosquito larvae develop over a period of months (mid-March to early May), and summer species develop over a period of days (7-10). Water temperature and precipitation amounts influence how quickly larvae develop in sites. The winter/spring of 2021-2022 was cold, averaging 4.8°F colder than the norm. Temperatures in January and February were 5.5-6.1°F below the norm (Fig. 1.2). March was closer to normal, but April was again 6.1°F below the norm. From May through September, temperatures were above the norm but not remarkably so. The summer of 2022 was warm, but not nearly as hot as 2021. The frost left the ground on April 4, and ice-out on Lake Minnetonka occurred April 15; the average ice-out date is April 13.

The snowfall total for the season was 43.9 inches from November-March. The Twin Cities normal average snowfall is 54 inches (from 1981-2010). Precipitation in January and February was near normal while March and April were each about 1.0 inch above the norm (Fig. 1.2). Beginning in May, very few rain events of significant amounts occurred. In fact, May, June, and July were a cumulative 6.91 inches below normal, August was near normal, but September and October were also below the norm (-2.78 and -2.34 inches, respectively). Abnormally dry conditions began in June, by the end of July we were in moderate to severe drought, and by the end of September most areas of the District were in severe drought (https://droughtmonitor.unl.edu). The dry conditions continued and by the end of October we were experiencing extreme drought conditions.

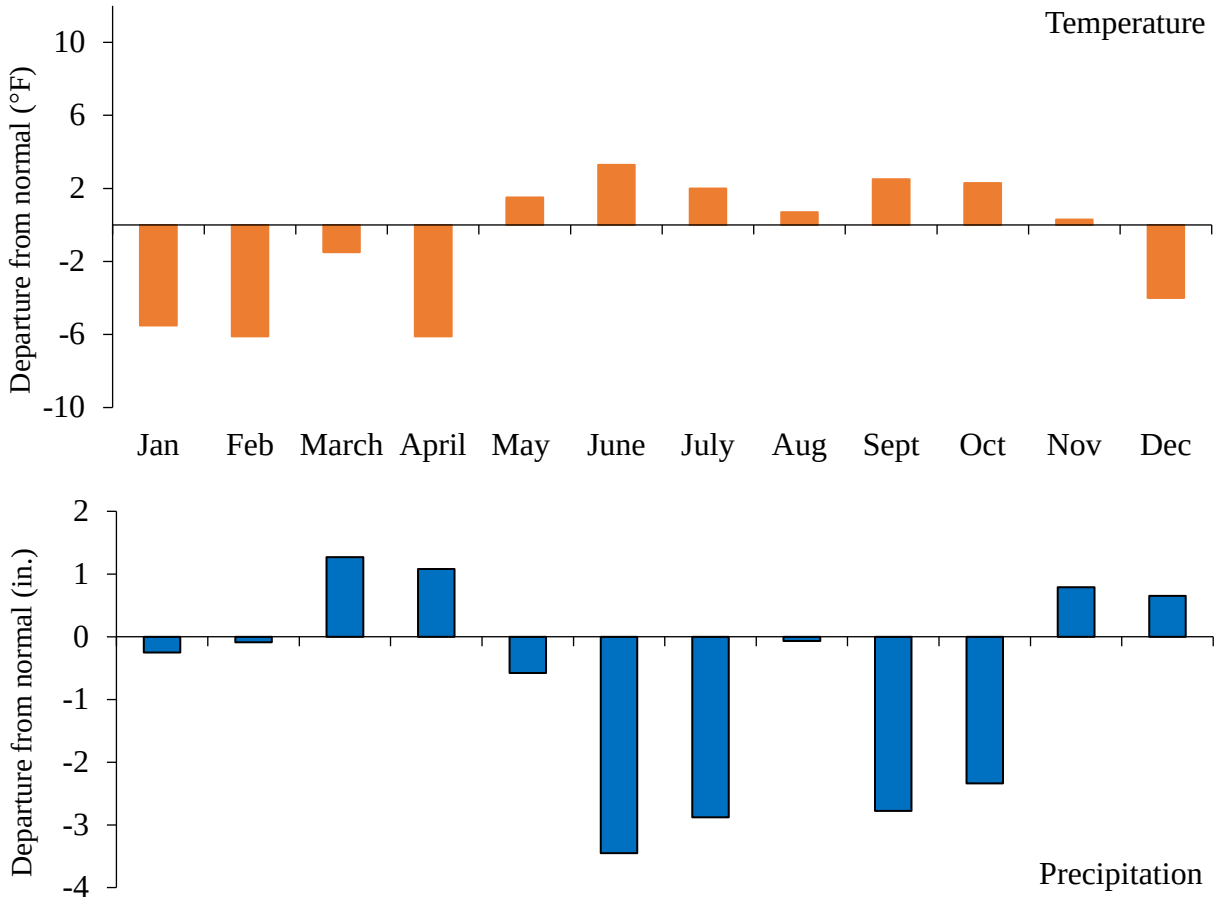


Figure 1.2 Monthly departures from normal for temperature and precipitation January-December 2022 (source: National Weather Service, Twin Cities Station).

Snowmelt and rainfall during March through early May triggered spring *Aedes* and floodwater *Aedes* to hatch. By May 12, the species composition transitioned to floodwater *Aedes*. There were nine rain events sufficient to produce floodwater *Aedes* hatches (i.e., broods): one was a large, District-wide event (May 8-14), two were medium, and six were small broods which occurred in localized areas. August, which had closer to normal precipitation, had one small and two medium-sized broods. The actual area affected by rainfall, the amount of rainfall received, and the resultant amount of mosquito production and acreage treated by helicopter determines brood size. Figure 1.3 depicts the geographic distribution and magnitude of weekly rainfall received in the District from March 27-September 17, 2022. Since some weeks had multiple rain events, the cumulative weekly rainfall does not identify individual rain events. Medium to dark gray shading indicates rainfall greater than or equal to one inch, enough to initiate a brood.

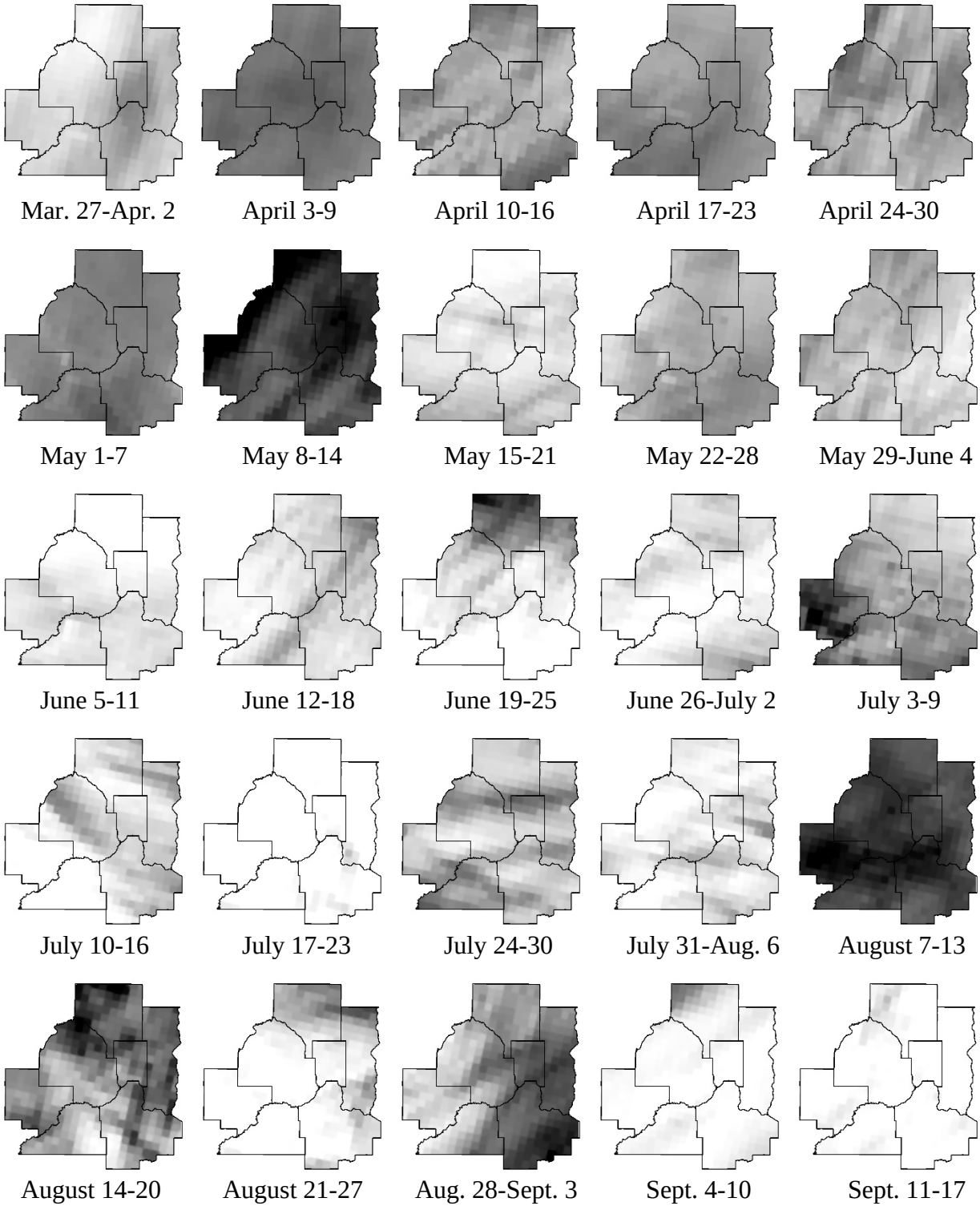


Figure 1.3 Weekly rainfall in inches, 2022. RFC-corrected data using 406 4x4 km grid cells. Inverse distance weighting was the algorithm used for shading of maps.

Larval Collections

Larval mosquito inspections are conducted to determine if targeted species are present at threshold levels or to obtain species history in larval development sites. A variety of habitats are 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. japonicus*, and *Ae. albopictus*. The majority of larval collections are taken from floodwater sites using a standard four-inch dipper. The average number of larvae collected in 10 dips is recorded as the number of larvae per dip. Larvae are submitted to MMCD's Entomology Lab for identification.

To expedite sample processing for high priority helicopter treatments (air sites), most larvae are identified to genus only, but again in 2022 we identified the spring *Aedes* to species until May 12, when the prevalent larval species were summer floodwater *Aedes*. After that time, we returned to genera level identifications. *Culex* larvae are always identified to species to differentiate vectors. Staff process lower priority samples as time permits and those are identified to species. In 2022, lab staff identified 10,060 larval samples (Fig. 1.4). The 25-year average is 19,874 larval samples per year. The low number of samples in 2020, 2021, 2022 was related to decreased staffing levels due to the COVID-19 pandemic, and also due to drought conditions experienced in 2021 and 2022.

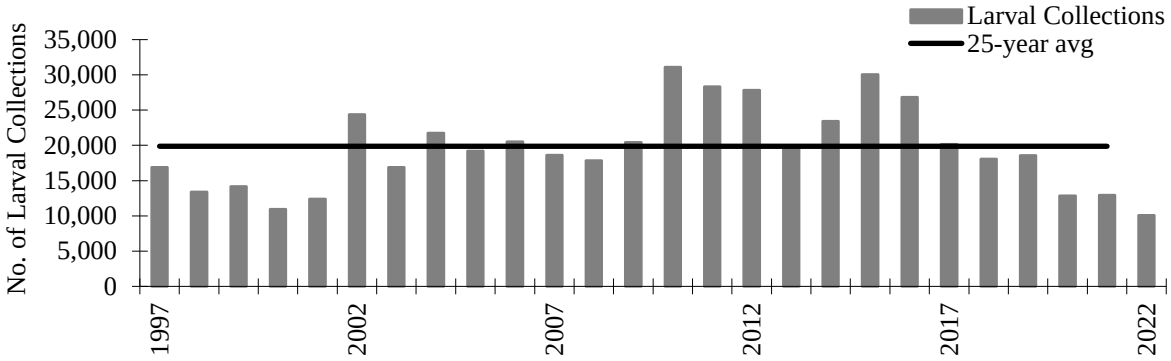


Figure 1.4 Yearly total larval collections, 1997-2022, and 25-year average. Prior to 2015, these totals did not include container samples.

The results of 7,808 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 we also sample catch basins, stormwater structures, and other man-made features (e.g., swimming pools, culverts, and artificial ponds). Those results are displayed separately (shaded column) from the natural wetlands results in Table 1.1.

The top five most frequently encountered species in wetlands were: *Aedes vexans* (31.9% of total), *Culex restuans* (16.4%), *Cx. territans* (15.2%), *Ae. cinereus* (12.7%), and *Cx. pipiens* (10.2%) (Table 1.1). *Culex* were abundant because their typical habitat is permanent water, which is less likely to dry up, even in the moderate to severe drought conditions experienced in 2022. Three *Culex* species (*restuans, pipiens*, and *territans*), and *Ae. japonicus* were the most abundant species in structures (Table 1.1).

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, 2022; the total number of samples processed to species is in parentheses

	Percent of samples where species occurred by facility							
Species	North (1,747)	East (1,812)	South Rosemount (930)	South Jordan (754)	West Plymouth (597)	West Maple Grove (561)	Wetland Total (6,401)	Structures Total (1,407)
Aedes abserratus	4.69	4.64	2.69	1.19	6.20	2.32	3.91	-
aurifer	0.29	0.06	-	-	-	-	0.09	-
canadensis	0.11	0.94	2.69	1.33	0.17	0.18	0.87	-
cinereus	12.02	13.19	8.06	11.14	21.78	12.83	12.65	0.14
dorsalis	-	0.11	-	-	-	-	0.03	-
excrucians	8.53	10.10	5.38	4.51	8.04	10.87	8.20	-
fitchii	1.43	1.88	0.22	0.40	0.34	1.07	1.12	-
flavescens	-	-	-	-	-	-	-	-
hendersoni	-	-	-	-	-	0.18	0.02	-
implicatus	0.34	0.06	-	-	-	0.36	0.14	-
intrudens	-	-	0.11	-	-	-	0.02	-
japonicus	0.23	0.44	0.43	0.40	0.17	0.36	0.34	7.11
nigromaculis	0.06	-	-	-	-	-	0.02	-
provocans	4.69	2.37	0.43	-	0.67	2.14	2.27	-
punctor	2.23	4.25	0.75	0.80	5.53	2.50	2.75	-
riparius	0.69	0.28	0.22	-	2.18	1.43	0.62	-
spencerii	-	-	-	-	-	-	-	-
sticticus	0.52	0.50	0.22	0.13	0.50	0.18	0.39	-
stimulans	10.48	9.44	9.03	6.50	9.55	10.70	9.44	-
triseriatus	0.11	0.06	0.11	-	0.17	0.36	0.11	0.92
trivittatus	1.14	0.83	3.98	1.33	0.84	0.53	1.41	0.07
vexans	32.86	28.70	43.98	31.83	29.65	21.39	31.87	5.97
Ae. unidentifiable	45.16	31.57	36.67	32.49	39.53	51.87	38.65	3.34
Anopheles earlei	-	-	-	-	-	-	-	-
punctipennis	2.06	1.82	0.86	1.06	1.01	0.89	1.50	2.06
quadrimaculatus	2.86	2.26	0.86	2.79	1.01	1.07	2.06	1.21
walkeri	0.17	0.06	-	-	-	-	0.06	-
An. unidentifiable	7.10	6.29	2.90	4.51	2.01	2.50	5.08	5.26
Culex erraticus	-	-	-	-	-	-	-	-
pipiens	5.04	14.13	6.88	12.47	15.75	10.16	10.20	70.08
restuans	12.08	19.59	15.27	20.42	21.78	10.52	16.42	70.65
salinarius	-	0.06	-	-	-	-	0.02	-
tarsalis	0.57	0.99	0.54	2.52	2.68	1.60	1.20	1.99
territans	18.15	17.00	9.46	18.17	10.05	11.23	15.20	10.38
Cx. unidentifiable	3.21	8.44	5.38	6.76	8.04	2.50	5.81	47.62
Culiseta inornata	2.92	4.36	9.14	9.42	10.05	4.46	5.80	2.70
melanura	-	-	-	-	-	-	-	-
minnesotae	0.40	-	0.22	0.13	-	-	0.16	-
morsitans	0.11	-	-	-	-	-	0.03	-
Cs. unidentifiable	0.69	0.28	0.43	1.06	0.50	0.53	0.55	-
Or. signifera	-	-	-	-	-	-	-	-
Ps. ciliata	-	-	-	-	-	-	-	-
ferox	0.06	0.06	-	-	-	-	0.03	-
horrida	-	-	-	-	-	-	-	-
Ps. unidentifiable	0.17	0.17	0.32	-	-	-	0.14	-
Ur. sapphirina	4.52	1.77	1.18	0.93	0.17	1.43	2.16	0.50

Adult Mosquito Collections

The District uses a variety of surveillance strategies to collect adult mosquitoes which exploit different behaviors inherent to mosquitoes. Sweep nets are used to survey the mosquitoes attracted to a human host. We use carbon dioxide-baited (CO_2) traps with small, incandescent lights to monitor host-seeking, phototactic (i.e., attracted to light) 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 use an olfactory bait to attract and capture egg-laying *Culex* and *Aedes* species. BG sentinel traps use an attractant lure that mimics human odor to target the invasive species *Ae. aegypti* and *Ae. albopictus* and are placed in areas at high risk for species introductions.

Monday Night Network The sweep net and CO_2 trap data reported here are weekly collections referred to as the 'Monday Night Network'. Staff make two-minute sweep net collections at a prescribed time at their homes on Monday evenings to monitor mosquito annoyance experienced by citizens. In addition, CO_2 traps are set up in natural areas such as parks or wood lots to monitor overall mosquito abundance. To achieve a District-wide distribution of CO_2 traps, some employees set traps in their yards as well. Figure 1.5 shows the sweep net and CO_2 trap locations and their uses [i.e., general monitoring, virus testing (West Nile virus-WNV), and eastern equine encephalitis (EEE) vector monitoring]. Although a few locations are located beyond District boundaries, only data from locations within are included in the analysis. This network of sweep net and CO_2 trap collections was run weekly from May 16-September 19; however, sweep net samples were discontinued after September 13 due to low staffing levels.

Sweep Nets

CO_2 Traps

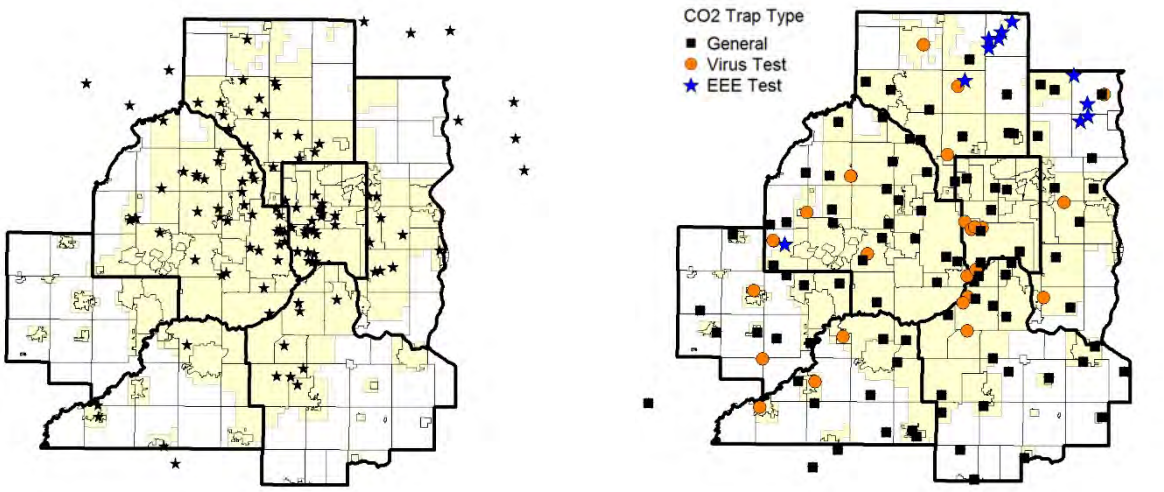


Figure 1.5 Locations of weekly sweep net and CO_2 traps used to monitor general mosquito populations and disease vectors (virus test and EEE test), 2022.

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., *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, are also attracted to mammals; this species is important in the transmission of WNV to humans and is best captured in CO_2 traps.

Sweep Net The District uses weekly 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. There were 115 sweep locations in 2022 (down from 126 in 2021), and the number of collectors varied from 37-82 per evening. The treatment threshold for sweep net sampling is two mosquitoes per two-minute sweep for *Aedes* and one mosquito per two-minute sweep for *Culex*4 (i.e., *Cx. pipiens*, *Cx. restuans*, *Cx. salinarius*, and *Cx. tarsalis*).

Staff made 1,165 collections containing 445 mosquitoes in 2022. As was the case in 2021, very few mosquitoes of any given species were detected in 2022 (Table 1.2). The average number of summer *Aedes* collected in the evening sweep net collections was low, although a bit higher than in 2021. The average for *Cq. perturbans* was even lower than in 2021. Levels of spring *Aedes* were typically low and no *Cx. tarsalis* were detected in sweep samples. Summer *Aedes* and *Cq. perturbans* were well below the 22-year average.

Table 1.2 Average number of mosquitoes collected per evening sweep net collection within the District, 2018-2022 and 22-year average, 2000-2021 (± 1 SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2018	1.50	0.22	0.03	0.009
2019	0.55	0.14	0.09	0.003
2020	0.53	0.48	0.02	0.001
2021	0.13	0.07	0.01	0.002
2022	0.24	0.02	0.05	0.000
22-yr Avg.	1.57 (±0.28)	0.32 (±0.05)	0.10 (±0.03)	0.008 (±0.001)

CO_2 Trap CO_2 traps baited with dry ice are used to monitor host-seeking mosquitoes and the presence and abundance of species that transmit pathogens that cause human disease. The standard placement for these traps is approximately five feet above the ground, the height at which *Aedes* mosquitoes typically fly. Some locations have elevated traps which are placed ~25 feet high in the tree canopy to monitor bird biting species (i.e., *Culex* spp.). The treatment threshold is 130 nuisance mosquitoes per CO_2 trap. Vector species thresholds are discussed in Chapter 4.

In 2022, we placed 137 traps at 127 locations (ten of these locations had low traps paired with elevated traps) to allow maximum coverage of the District (Figure 1.5). Three traps were outside District boundaries, at employee homes, and were not included in these analyses. The “General” trap type locations are used to monitor non-vector mosquitoes. There are 45 traps designated as “Virus Test”; all *Culex*4 collected from these traps are tested for WNV (Figure 1.5).

Additionally, *Cx. tarsalis* from all locations are tested. Eleven trap locations in the network have historically captured *Cs. melanura* and are used to monitor this vector species populations and to obtain specimens for EEE testing (Figure 1.5, "EEE Test" trap type).

A total of 2,238 District low CO_2 trap collections taken contained 180,350 mosquitoes in 2022. The total number of traps operated weekly varied from 107-123. The average number of mosquitoes detected in CO_2 traps is found in Table 1.3. Summer *Aedes*, our most abundant species, increased from 2021, but still was much lower than the 22-year average. *Coquillettidia perturbans* is usually very abundant in the District; however, the average detected this year was half as much as in 2021 and in much lower levels than the past five years. Spring *Aedes* numbers were the highest they've been in the last five years and a bit above the 22-year average. *Culex tarsalis* numbers were very low and decreased almost 70% from 2021 and only one fourth of the 22-year average.

Table 1.3 Average numbers of mosquitoes collected in CO_2 traps within the District, 2018-2022 and 22-year average, 2000-2021 (± 1 SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2018	153.4	52.6	5.3	0.8
2019	160.1	66.1	6.5	0.7
2020	182.4	127.3	3.5	0.2
2021	35.0	28.3	2.7	1.3
2022	53.3	13.9	8.3	0.4
22-yr Avg.	195.3 (±26.1)	55.7 (±7.5)	7.4 (±1.6)	1.7 (±0.3)

Geographic Distribution The weekly District 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, respectively. The computer-assisted interpolations of mosquito abundance portray the predicted abundance of mosquitoes at locations without CO_2 traps. Therefore, some dark areas are the result of single collections without another trap close by and may not reflect actual densities of mosquitoes. Priority area 1 (P1) receives full larval control. A full description of priority areas is in Chapter 4: Mosquito Control.

Spring *Aedes* populations were first detected May 16 in the northern part of the District, although populations become visible on the map the following week (Figure 1.6). Highest levels were detected in northeastern Anoka County on June 6. The first detections of summer *Aedes* occurred May 16 and were noticeable on May 23 in Carver, Scott, and Hennepin counties, mostly along the Minnesota River floodplains. (Fig. 1.7). The highest levels of the summer *Aedes* also occurred June 6 and were widespread in P2 and along the Minnesota River floodplain. Small, localized emergences occurred thereafter and rains at the end of August produced mosquitoes from August 22 to the end of sampling. A second peak of summer *Aedes* occurred September 6. *Coquillettidia perturbans* was first detected in Washington County on June 6 (Figure 1.8). Emergence increased weekly thereafter. Highest levels occurred during July 5-18. Populations steadily declined thereafter. Highest levels occurred outside of P1 on the outer borders of the District.

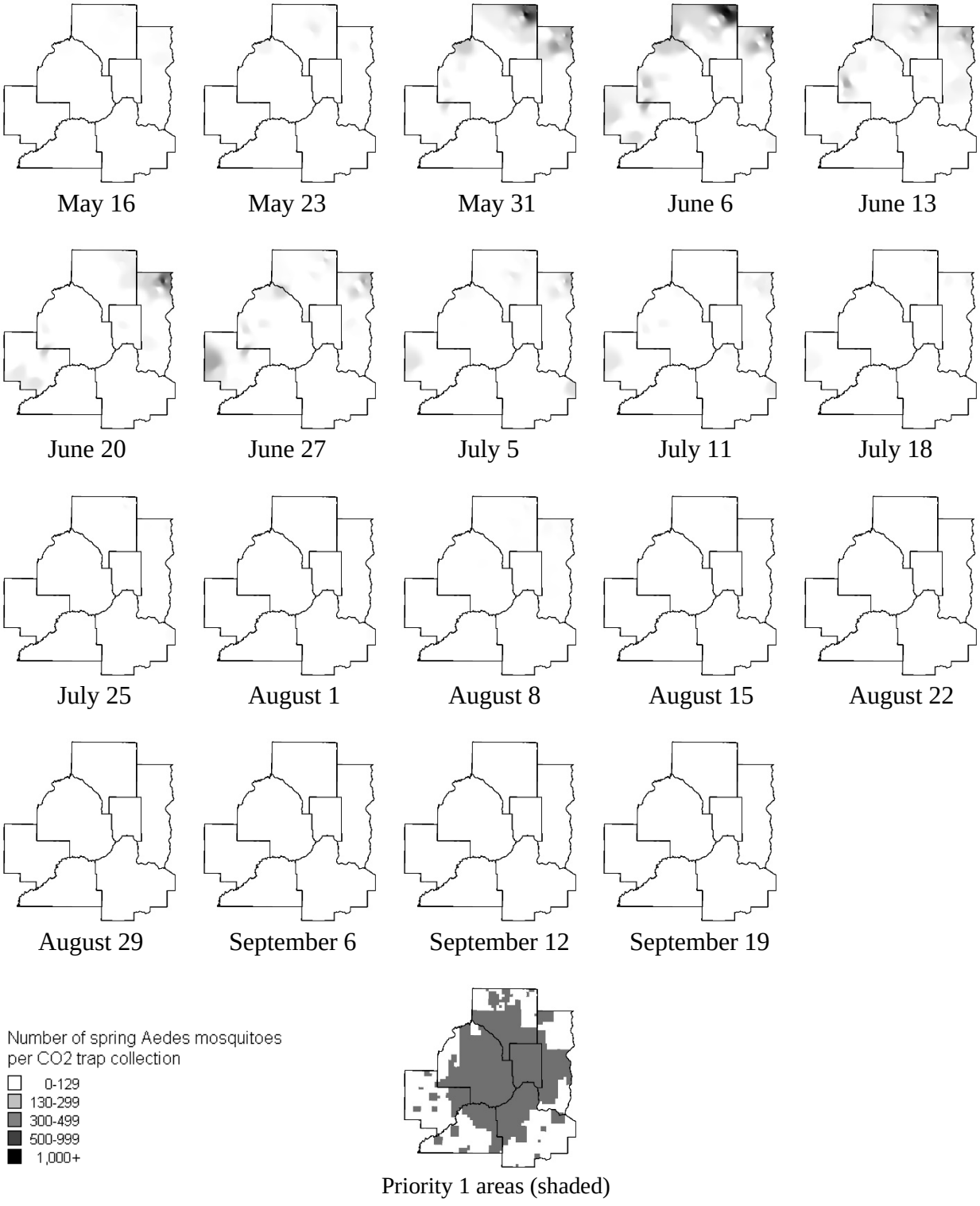


Figure 1.6 Number of spring *Aedes* in District low (5 ft) CO_2 trap collections, 2022. The number of traps operated per night varied from 107-123. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night. Priority zone area map for reference.

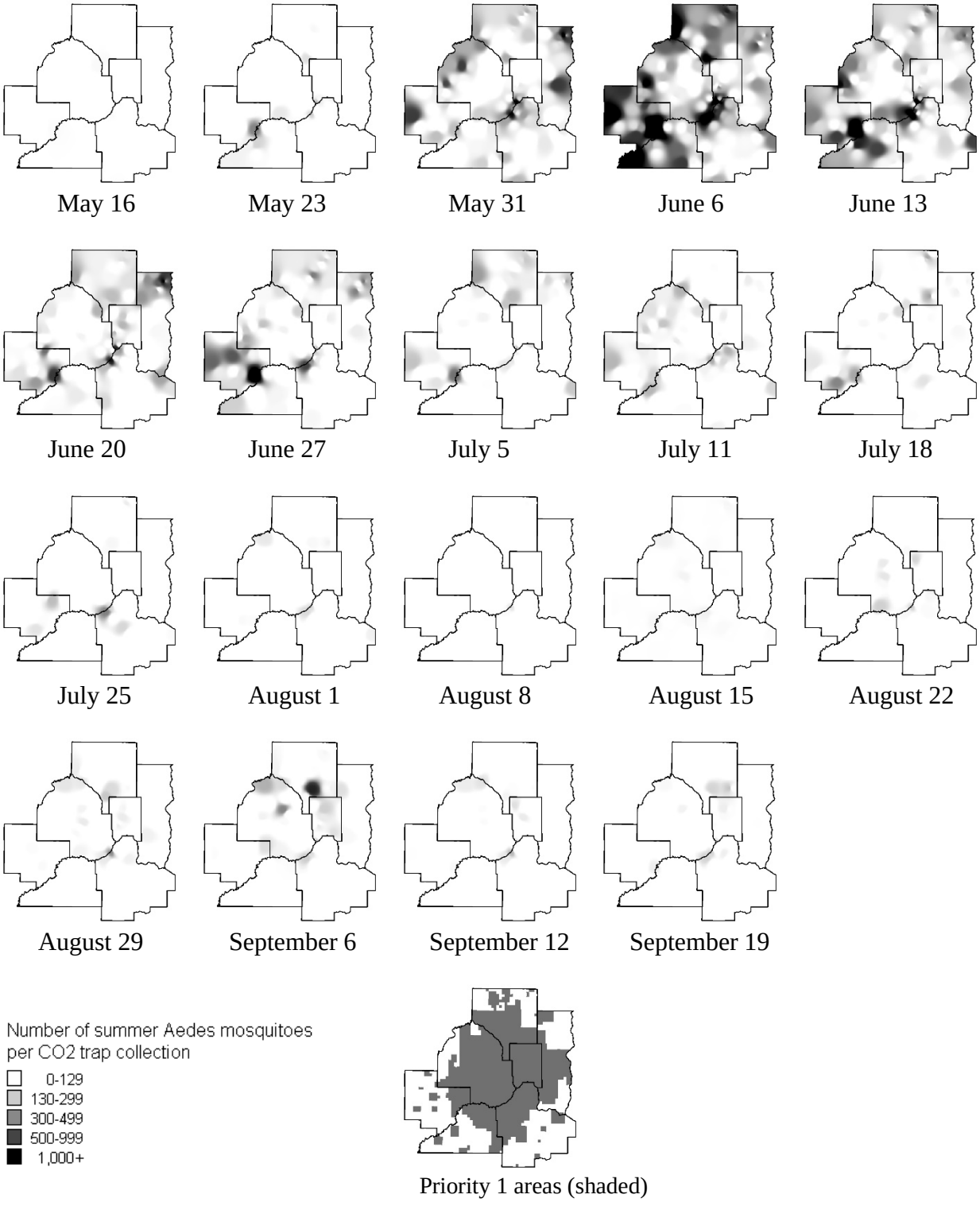


Figure 1.7 Number of summer *Aedes* in District low (5 ft) CO_2 trap collections, 2022. The number of traps operated per night varied from 107-123. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night. Priority 1 area map for reference.

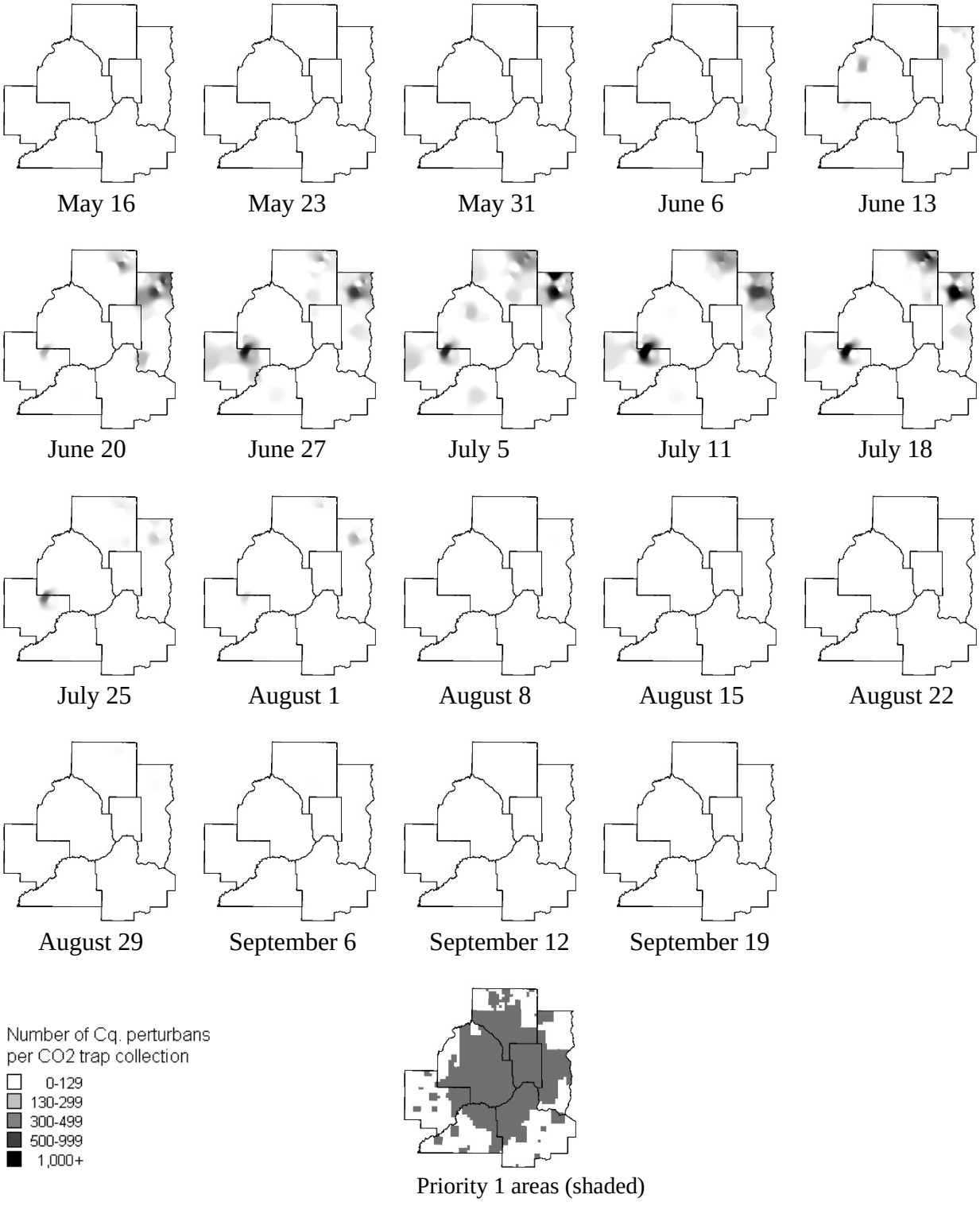


Figure 1.8 Number of *Cq. perturbans* in District low (5 ft) CO_2 trap collections, 2022. The number of traps operated per night varied from 107-123. Inverse distance weighting was the algorithm used for shading of maps. Treatment threshold is >130 mosquitoes/trap night. Priority 1 area map for reference.

Seasonal Distribution As described earlier, spring *Aedes*, summer *Aedes*, and *Cq. perturbans* have different patterns of occurrence during the season based on their phenology. Additionally, temperatures below 55°F inhibit mosquito flight activity. If rain or cold temperatures are forecasted on sampling night, surveillance is postponed until the next night. Figure 1.9 depicts the actual temperature at 9:00 p.m. on the scheduled sampling night. In 2022, sampling with CO_2 traps and sweep nets started May 16. Temperatures at the time of sampling were well above the minimum mosquito flight threshold, except for May 23 and May 31, when the temperature was 58°F and 59°F, respectively .

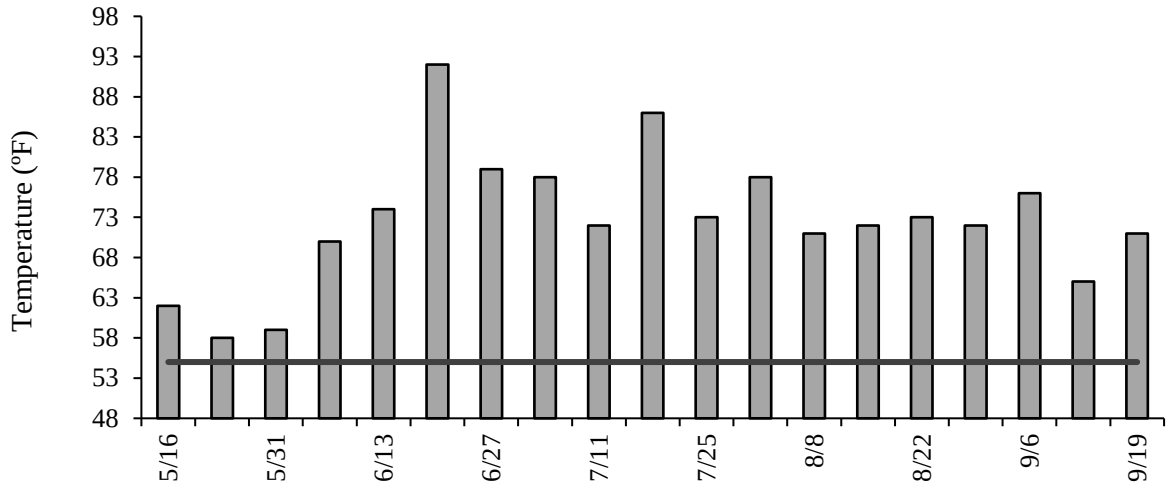


Figure 1.9 Temperature at 9:00 p.m. on actual dates of Monday night surveillance, 2022 (source: National Weather Service, Twin Cities Station). The black horizonal line indicates the mosquito flight threshold, 55°F.

Figures 1.10 and 1.11 show the seasonal distribution of the three major groups of mosquitoes detected in sweep nets and CO_2 traps. Sweep netting detected low levels of spring *Aedes* on May 23 and peaked on June 6 near the 22-year average (Fig. 1.10). Low levels of spring *Aedes* were detected through mid-July, but always below the 22-year average. Highest captures in CO_2 traps also occurred June 6, and populations detected in CO_2 traps were above the 22-year average for the season (Fig. 1.11).

Summer *Aedes* were first detected in sweep net samples on May 23 and in CO_2 traps on May 25 (Fig. 1.10 and Fig. 1.11, respectively). The summer *Aedes* in sweep samples were well below the 22-year average. The highest levels in CO_2 traps were seen on June 6, above the 22-year average (Fig 1.11). Very low levels occurred thereafter, and a very small increase occurred September 7. Mosquito levels in CO_2 traps were well below the 22-year average after the June 6 peak.

The single generation *Cq. perturbans* was initially detected June 13 in sweep nets and CO_2 traps. The peak in sweep nets occurred on June 27 and the last *Cq. perturbans* was collected on July 25 (Fig. 1.10). The population was well below the 22-year average (Fig. 1.10). Highest levels in CO_2 traps occurred July 7 (Fig. 1.11) and were below the 22-year average the entire year.

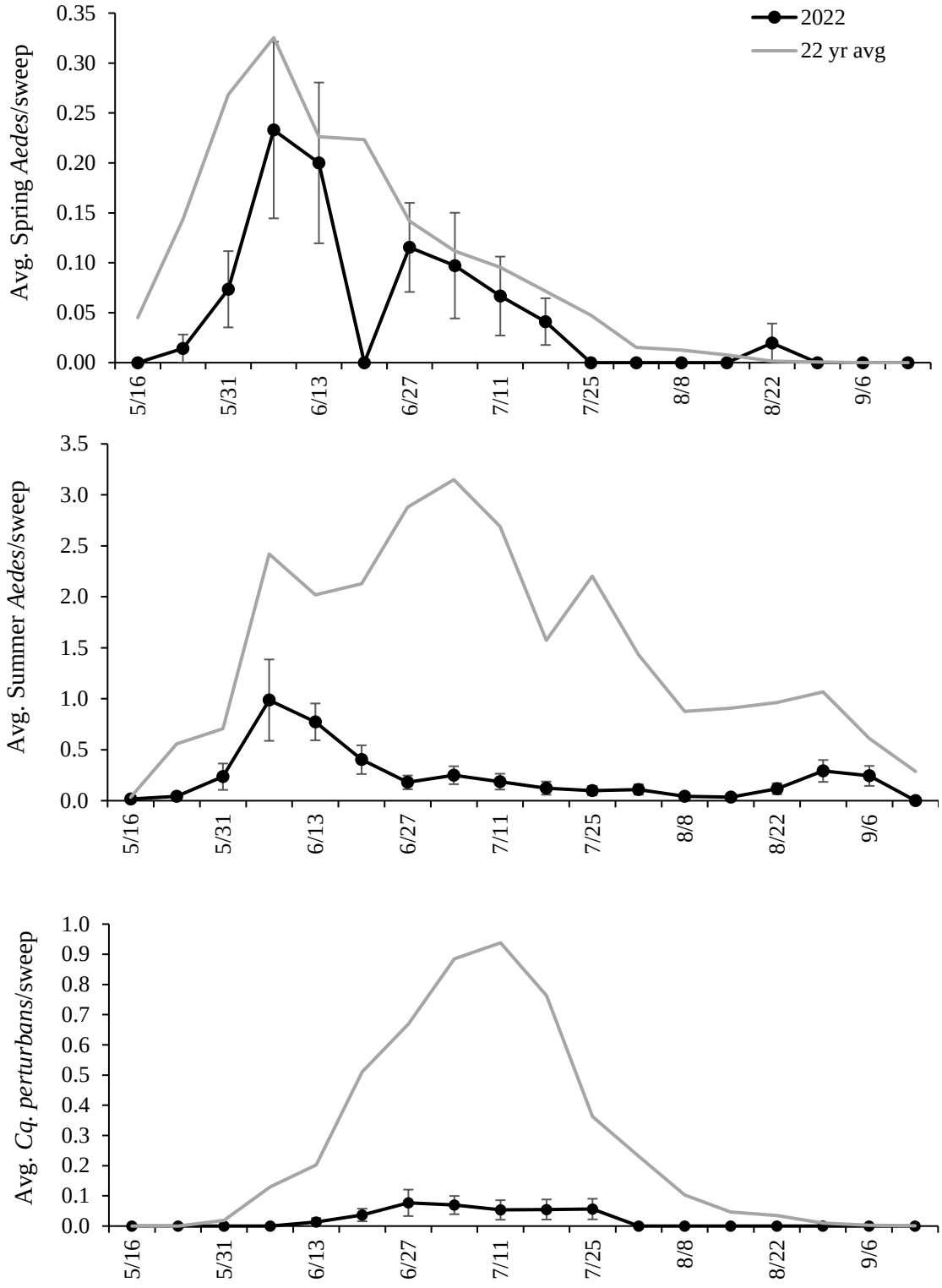


Figure 1.10 Average number of spring *Aedes*, summer *Aedes*, and *Cq. perturbans* per sweep net collection, 2022 vs. 22-year average. Dates are the Mondays of each week. Error bars equal ± 1 standard error of the mean.

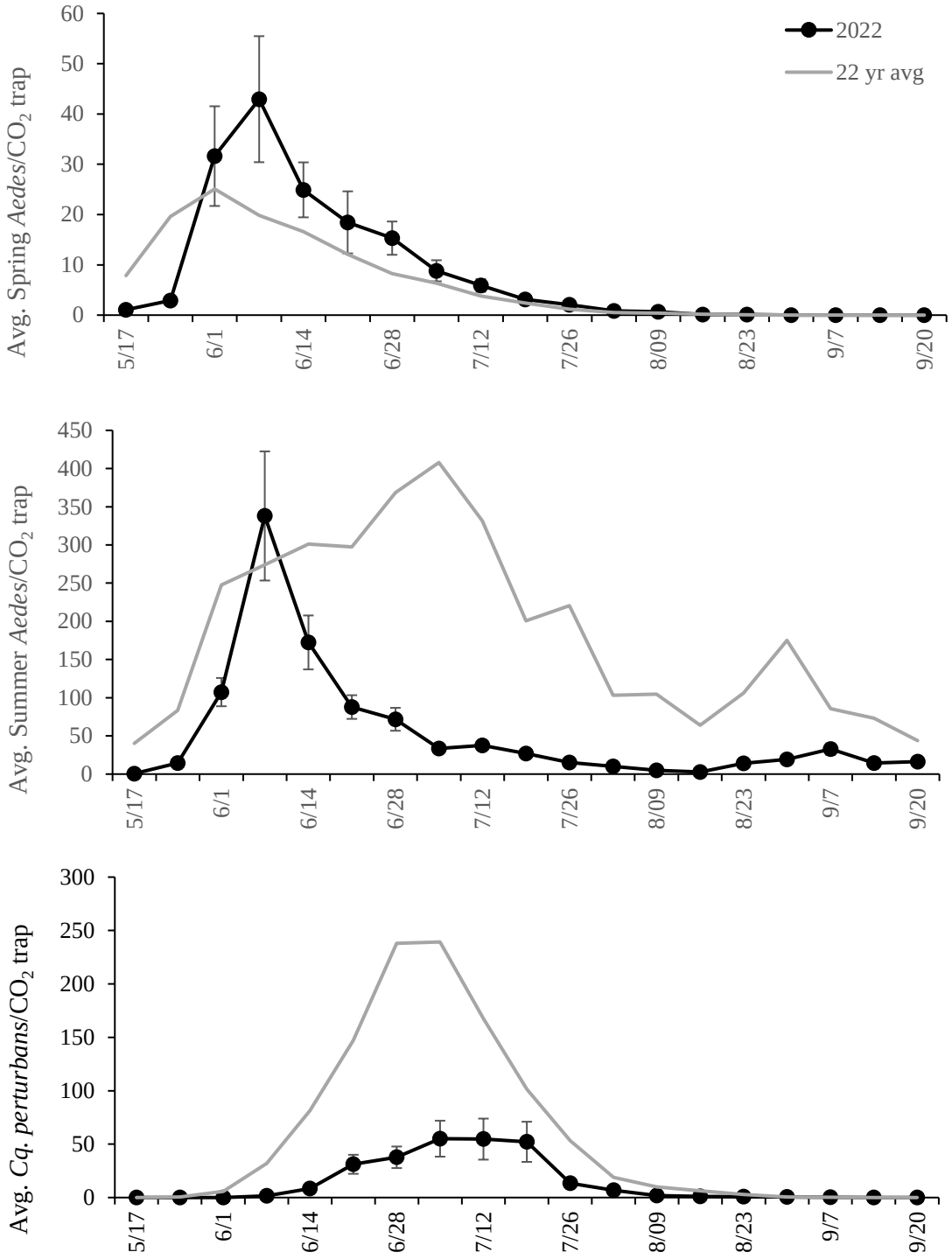


Figure 1.11 Average number of spring *Aedes*, summer *Aedes*, and *Cq. perturbans* per CO_2 trap, 22 vs. 22-year average. Dates are the Tuesday of each week, except when sampling falls on a holiday. Error bars equal $\pm$ 1 standard error of the mean.

The difference in mosquito levels in priority zones (P1 = full larval treatment and P2 = limited or no larval treatment) is shown in Figure 1.12. Spring *Aedes* levels were highest in P2, and summer *Aedes* were higher in P1, but still high in P2. The average *Cq. perturbans* was highest in P2 as well.

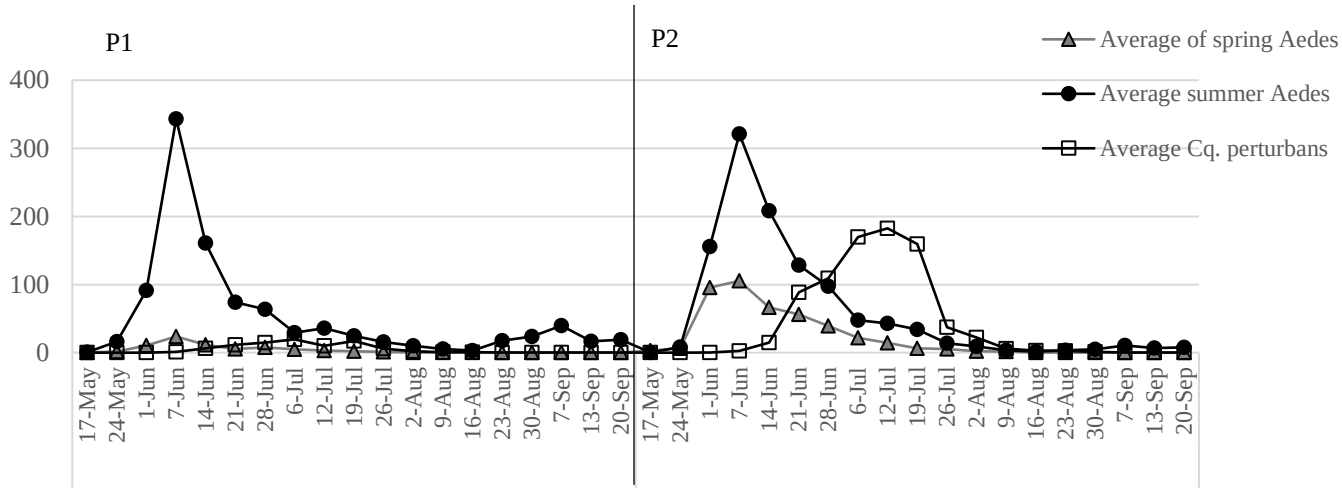


Figure 1.12 Average number of spring *Aedes*, summer *Aedes*, and *Cq. perturbans* per CO_2 trap, 2022 in P1 and P2.

New Jersey (NJ) Light Traps For many years, mosquito control districts used the NJ light trap as their standard surveillance tool. The trap uses a 25-watt incandescent 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.

In 2018, we reduced the trapping locations to only include those sites that were productive and that have been operating for twenty years or more. The four traps are in the following locations: Trap 9 in Lake Elmo, Trap 13 in Jordan, Trap 16 in Lino Lakes, and Trap CA1 in the Carlos Avery State Wildlife Management Area (Figure 1.13). Traps 9 and 16 have operated from 1965-2022. The CA1 trap started in 1991. Trap 13 has been at MMCD's Jordan Office location since 1998.

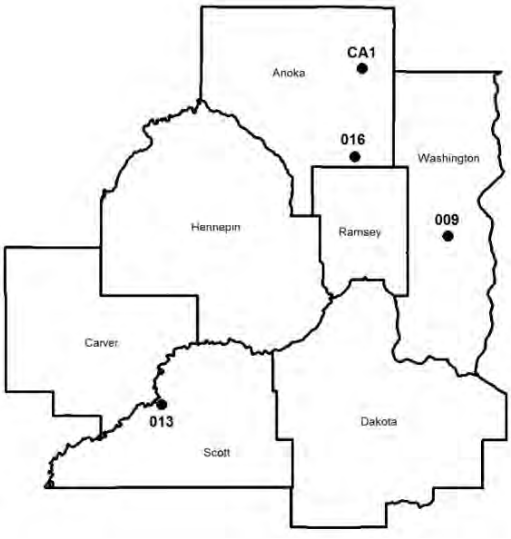


Figure 1.13 NJ light trap locations, 2022.

Trapping occurs nightly for 20 weeks from May through September and staff identify all adult female mosquitoes to species. Adult male mosquitoes are simply counted. A comparison of the major species collected from those four traps is shown in Appendix B.

The top five most abundant species collected were *Cq. perturbans* (30.7% of all female mosquitoes captured), *Ae. abserratus/punctor* (23.8%–includes *Ae. abserratus*, *Ae. punctor*, and unidentifiable *abserratus/punctor*), *Ae. vexans* (22.6%), *Ae. cinereus* (7.2%), and *An. quadrimaculatus* (4.5%) (Table 1.4). The Carlos Avery trap (CA1) collected 85.4% of all females collected followed by Lino Lakes (7.8%, Trap 16), Jordan (4.8%, Trap 13), and Lake Elmo (2.0%, Trap 9).

Trap 9, located in Lake Elmo, Washington County, had *Ae. vexans*, *An. quadrimaculatus*, and *Cq. perturbans* as the most abundant species.

Trap 13 is located in Jordan, Scott County. The trapping location is adjacent to a river floodplain with nearby cropland in a rural landscape. The most abundant species collected were *Ae. vexans* and *An. quadrimaculatus*.

Trap 16 is located in Lino Lakes, Anoka County. The most abundant species collected in this trap was *Ae. vexans* followed by *An. quadrimaculatus.*

CA1, located in the northern part of the District in Columbus, Anoka County, has a variety of mosquito habitats including ephemeral spring woodland pools, cattail marshes, and many other types of habitats from permanent to temporary marshes and spruce-tamarack bogs. Consequently, this location has a diverse mosquito fauna. The top species captured most frequently in CA1 were *Cq. perturbans, Ae. vexans, Ae. abserratus/punctor*, and *Ae. cinereus*.

Table 1.4 Total numbers and frequency of occurrence for each species collected in New Jersey light traps, May 7-September 23, 2022

	Trap Code, Location, and Number of Collections				Summary Statistics		
	9 Lake Elmo	13 Jordan Office	16 Lino Lakes	CA1 Carlos Avery	Total Collected	% Female	Avg per
Species	140	140	133	136	549	Total	Night
Ae. abserratus	0	0	3	770	773	5.57%	1.408
atropalpus	0	0	0	0	0	0.00%	0.000
aurifer	0	0	0	2	2	0.01%	0.004
canadensis	0	0	0	27	27	0.19%	0.049
cinereus	2	1	53	1,015	1,071	7.72%	1.951
diantaeus	0	0	0	0	0	0.00%	0.000
dorsalis	0	0	0	0	0	0.00%	0.000
excrucians	0	4	3	65	72	0.52%	0.131
fitchii	0	0	0	8	8	0.06%	0.015
hendersoni	0	0	0	0	0	0.00%	0.000
implicatus	0	0	0	0	0	0.00%	0.000
japonicus	0	0	0	1	1	0.01%	0.002
nigromaculus	0	0	0	0	0	0.00%	0.000
punctor	0	0	2	322	324	2.34%	0.590
riparius	0	0	0	1	1	0.01%	0.002
spencerii	0	0	0	0	0	0.00%	0.000
sticticus	1	35	0	73	109	0.79%	0.199
stimulans	0	0	0	58	58	0.42%	0.106
provocans	0	0	0	2	2	0.01%	0.004
triseriatus	0	0	0	0	0	0.00%	0.000
trivittatus	1	19	2	4	26	0.19%	0.047
vexans	149	562	715	1,706	3,132	22.57%	5.705
abserratus/punctor	0	2	5	2,201	2,208	15.91%	4.022
Aedes unidentifiable	27	1	4	203	235	1.69%	0.428
Spring *Aedes* unident.	0	0	1	40	41	0.30%	0.075
Summer *Aedes* unident.	0	0	0	1	1	0.01%	0.002
An. barberi	0	0	0	0	0	0.00%	0.000
earlei	0	0	0	0	0	0.00%	0.000
punctipennis	1	11	11	66	89	0.64%	0.162
quadrimaculatus	82	57	335	148	622	4.48%	1.133
walkeri	0	3	0	30	33	0.24%	0.060
An. unidentifiable	48	14	28	64	154	1.11%	0.281
Cx. erraticus	0	1	0	1	2	0.01%	0.004
pipiens	0	1	10	5	16	0.12%	0.029
restuans	2	7	31	94	134	0.97%	0.244
salinarius	0	0	0	0	0	0.00%	0.000
tarsalis	0	3	3	3	9	0.06%	0.016
territans	1	1	7	30	39	0.28%	0.071
Cx. unidentifiable	4	0	4	15	23	0.17%	0.042
Cx. pipiens/restuans	13	1	27	42	83	0.60%	0.151
Cs. inornata	7	3	5	50	65	0.47%	0.118
melanura	0	0	0	1	1	0.01%	0.002
minnesotae	1	0	24	112	137	0.99%	0.250
morsitans	1	0	1	22	24	0.17%	0.044
Cs. unidentifiable	0	0	0	7	7	0.05%	0.013
Cq. perturbans	43	14	91	4,111	4,259	30.70%	7.758
Or. signifera	0	0	0	0	0	0.00%	0.000
Ps. ferox	0	0	0	0	0	0.00%	0.000
horrida	0	0	0	0	0	0.00%	0.000
Ps. unidentifiable	0	0	0	0	0	0.00%	0.000
Ur. sapphirina	2	6	9	36	53	0.38%	0.097
Unidentifiable	3	0	6	24	33	0.24%	0.060
Female Total	388	746	1,380	11,360	13,874	100.00%	25.271
Male Total	71	360	433	8,448	9,312		
Grand Total	459	1,106	1,813	19,808	23,186		

Long-term CO_2 Trap Network

Until 2021, New Jersey light traps were the only adult surveillance method that was speciated. Because there are only four New Jersey trap locations, we wanted to augment the full adult species information from a wider geographic distribution in the District. We randomly selected 15 CO_2 trap locations from our Monday Night Surveillance network where we will do full species identifications. We divided the District into regions (S, W, NE), and randomly selected five traps per region. Selected traps were not at employees/past employee's homes and locations were at least 10 km (6.2 miles) apart. The designated traps are shown in Table 1.5.

Figure 1.14 shows the selected traps from the Monday Night Surveillance network. Samples from these locations were initially identified to broad species group levels necessary for the Monday Night surveillance and then were saved for later full identifications. Full species identifications for the 15 traps are in Appendix C.

Table 1.5 Traps used for long-term study by region

West Region	South Region	Northeast Region
C013 – Watertown	D063 – Thompson Co. Pk	A120 – (v) Ajawah EEE
H625 – Ft. Snelling Golf Course*	D181 – Miesville	A183 – Innsbruck Park
H284 – Dayton	DSR4 – Eureka (Rice Lk)	E001 – Stillwater
H291 – Eden Prairie	S139 – Credit River	E004 – Forest Lake
H566 – Eagle Ridge	S154 – (v) Jackson Town Hall	SF02 – (v) Grandstand

*The Ft. Snelling Golf Course trap (H625) replaced the Post Road low trap (H157) in 2022 and is located less than 1 mile away

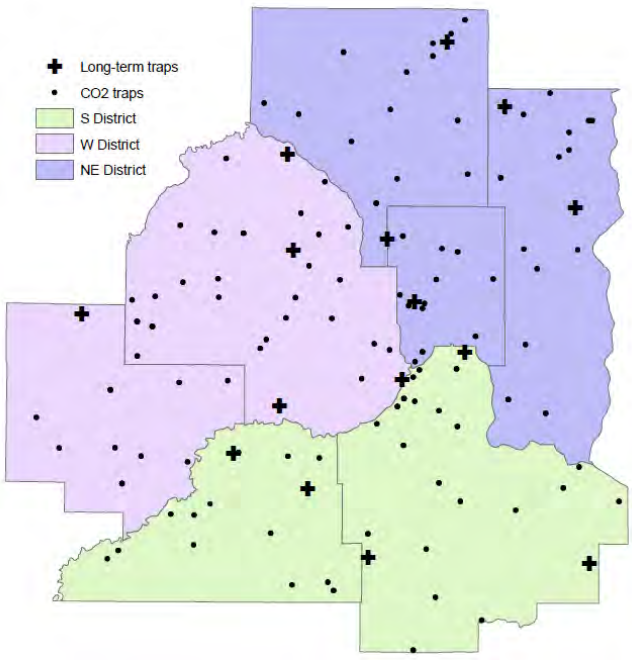


Figure 1.14 Locations of 15 traps selected for long-term CO_2 trap full species level identifications. Green shading is South, lavender shading is West, and purple shading is Northeast.

Coquillettidia perturbans Population Prediction

Coquillettidia perturbans is typically a common species with one generation per year. Adults lay their eggs in cattail marshes in July and August; the eggs hatch, larvae overwinter in the marsh attached to cattail roots, and adults emerge the following June-July, typically peaking around July Fourth. Adult populations are influenced by rainfall amounts from the previous year. Higher *Cq. perturbans* captures in CO_2 traps occurred (2003, 2011, 2017, and 2020) following years with above normal rainfall amounts (Figure 1.15). A model developed by Dr. Roger Moon (University of MN) is used to predict *Cq. perturbans* in the coming year based on the number of adults collected and the average weekly total rainfall in the previous year.

The predicted catch rate in 2022 was 24.7 *Cq. perturbans* per CO_2 trap, but the actual rate was 13.88 (Figure 1.15). The predicted number of *Cq. perturbans* collected per CO_2 trap in 2023 is 18.1. This model explains ~82% of the variation in predicted *Cq. perturbans* abundance (adjusted R-squared = 0.798). The prediction helps identify population trends for the coming year, and larval dips confirm abundance and treatment locations.

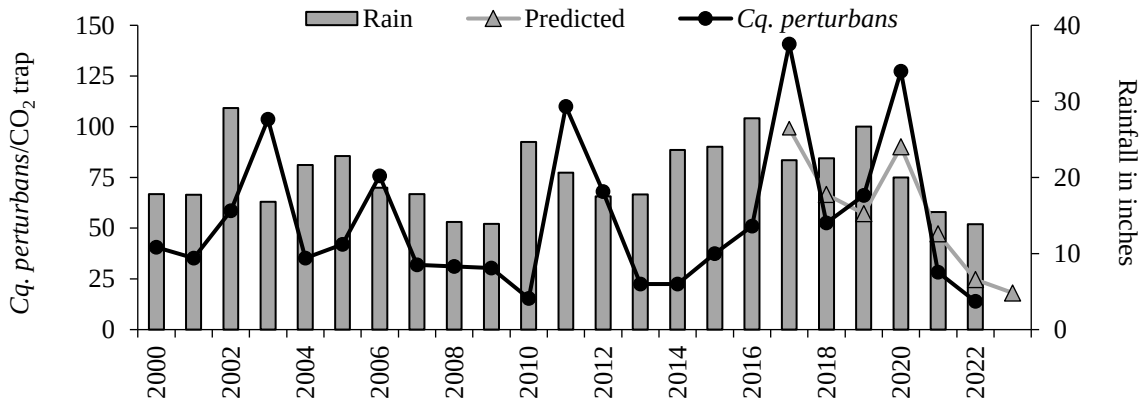


Figure 1.15 Average seasonal rainfall per gauge, average number of *Coquillettidia perturbans* in CO_2 traps, 2000-2022, and predicted amounts for 2017 and beyond.

Rare Detections

With our Monday Night Network, we monitor other species which are considered uncommon or rare in Minnesota. *Culex erraticus*, *An. quadrimaculatus*, and *Psorophora* species have experienced significant changes in populations in recent years.

Culex erraticus The first adult *Cx. erraticus* specimens weren't collected until 1988 when four were detected in NJ light trap samples. Since then, we have been detecting *Cx. erraticus* adults sporadically. Numbers have remained relatively low, but in 2012, 650 adults were collected (Fig 1.16). From 2013 to 2020 the total collected have ranged between 2-33. In 2021, we collected 368 adult *Cx. erraticus* (Fig. 1.16), second to the number collected in 2012 (both hot, dry summers). In 2022, the numbers dropped a bit to 251.

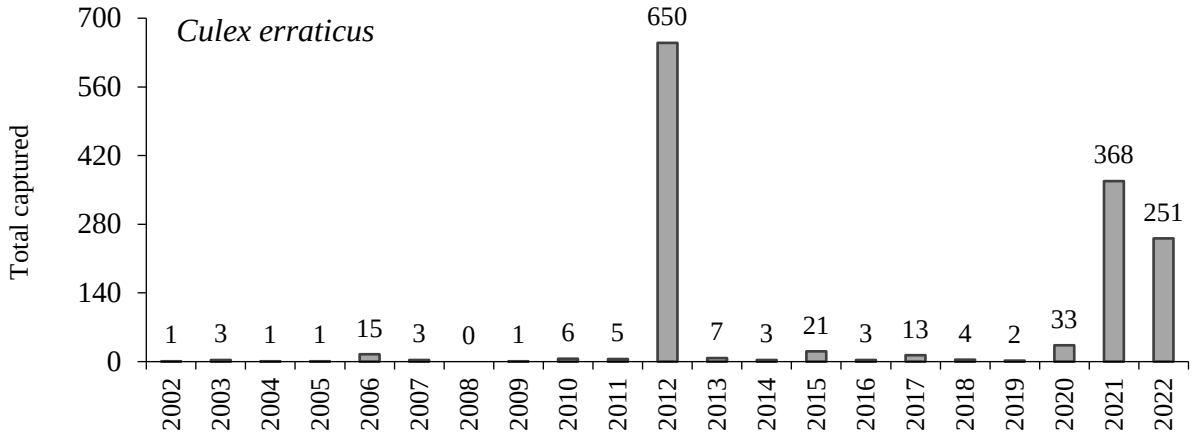


Figure 1.16 Total yearly *Culex erraticus* collected from Monday Night CO_2 traps (low, high, and any outside District), 2002-2022.

Anopheles quadrimaculatus *Anopheles quadrimaculatus* is no longer considered rare in the District. A marked increase in numbers was first detected in 2006 and populations have been detected at higher levels since then (Fig. 1.17). The average collected per year from 2002-2009 is 104.87 and the average collected per year from 2010-2022 is 2,639.15.

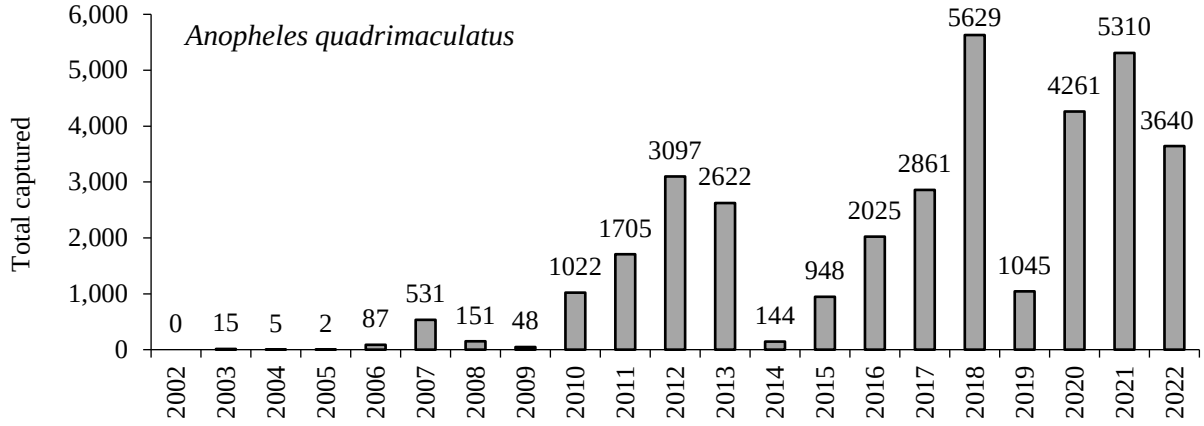


Figure 1.17 Total yearly *An. quadrimaculatus* collected from Monday Night CO_2 traps (low, high, and any outside District), 2002-2022.

Psorophora Adult *Psorophora ferox* and *Ps. horrida* numbers have also been increasing (Fig. 1.18) since 2010. From 2005-2009, 205 *Psorophora* spp. specimens were collected and from 2010-2020, 6,912 were collected. The drought conditions in 2021 and 2022 reduced the number of these floodwater mosquitoes. Only 245 were detected throughout the District in 2021 and even lower levels occurred in 2022 when only 75 specimens were collected.

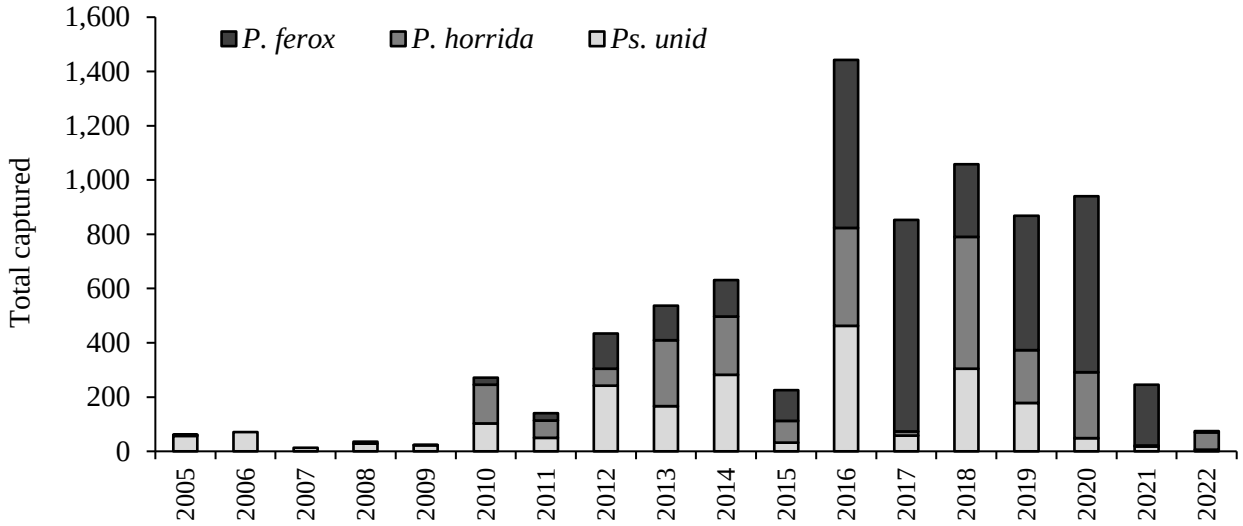


Figure 1.18 Total yearly *Ps. ferox, Ps. horrida,* and *Ps. ferox/horrida* (*Ps. unid*) collected from Monday Night CO_2 traps (low, elevated, and any outside District), 2005-2022.

2023 Plans – Surveillance

Ongoing: Surveillance will continue as in past years. We will evaluate sweep net, CO_2, and gravid trap locations to ensure adequate distribution and that target species are collected. We will also evaluate the long-term CO_2 trap network.

CO_2 trap comparison: We have been using our current CO_2 trap style (American Biophysics ABC trap) since 2001. This trap was an improvement over the Hauser's Machine Works CO_2 trap which used black paint cans to hold dry ice and D-cell batteries to run the trap. A Latin square study design will be used to evaluate a new type of CO_2 trap (Biogents BG-Pro) compared to our current American Biophysics ABC trap. The new trap has many features: it uses a 5- or 6-volt power bank instead of a 6-volt battery (although it can use a 6-volt battery); it uses LED rather than incandescent light; the airflow is bidirectional where the ventilator creates a downward flow though the suction funnel in the center of the trap then the airflow changes direction inside the trap body and is released through the top surface surrounding the suction funnel; the collection bag is placed above the fan which reduces specimen damage; and the dry ice is housed in an insulated lunch cooler rather than a thermos jug. Our current ABC trap is sturdy, albeit heavier while the new trap is light and seems to be easier to set up. The study will compare the two types of traps to determine if there is a difference in the species composition and abundance, as well as the amount of nontarget insect bycatch captured.

Faunal paper: We are working on publishing a paper of the mosquito fauna of the Twin Cities metropolitan area. We have many years of collection data and have seen some faunal changes over time. We intend to submit a manuscript describing the mosquito species of our area.

Chapter 2 Mosquito-borne Disease

2022 Highlights

- There were 19 WNV cases reported in Minnesota residents, two in District residents
- There were three LAC cases reported in Minnesota
- There was one JCV case reported in Minnesota
- Eastern equine encephalitis was not detected in Minnesota
- WNV was detected in 42 District mosquito samples
- MMCD Collected and recycled 11,753 tires

2023 Plans

- Provide surveillance and control for La Crosse encephalitis prevention
- Work with others to better understand Jamestown Canyon virus transmission
- Conduct catch basin larvicide treatments to manage WNV vectors
- Communicate disease prevention strategies to other local governments
- Conduct surveillance for WNV and other mosquito-borne viruses
- Monitor for *Ae. albopictus* and other invasive species
- Conduct *Cs. melanura* surveillance and control for EEE prevention

Background

District staff provide 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), Jamestown Canyon virus (JCV), and West Nile virus (WNV).

La Crosse encephalitis prevention services were initiated in 1987 to identify areas within the District where significant risk of acquiring LAC 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 this 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 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. *Culex tarsalis* is a bridge vector for both viruses, meaning it bridges the gap between infected birds and humans and other mammals. Western equine encephalitis can 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 *Coquillettidia perturbans*, can acquire the virus from a bird and pass it to a human in a subsequent feeding.

Jamestown Canyon virus is native to North America. It is transmitted by mosquitoes and amplified by deer. Infections occasionally cause human illnesses. Documentation of JCV illness has been on the rise in Minnesota and Wisconsin. We are working to better understand the JCV cycle so that we are prepared to provide the best risk prevention service that we can.

The District uses a variety of surveillance methods to measure mosquito vector populations and to detect mosquito-borne pathogens. Results are used to direct mosquito control services and to enhance public education efforts so that the risks of contracting mosquito-borne illnesses are significantly reduced.

2022 Mosquito-borne Disease Services

Source Reduction

Water-holding containers such as tires, buckets, tarps, and 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 2022, District staff recycled 11,753 tires that were collected from the field (Table 2.1). Since 1988, the District has recycled 723,069 tires. In addition, MMCD eliminated 1,087 containers and filled 92 tree holes (Table 2.1). This reduction of larval habitats occurred through inspection of public and private properties and while conducting a variety of mosquito, tick, and black fly surveillance and control activities.

Table 2.1 Number of tires, containers, and tree hole habitats eliminated during each of the past 10 seasons and long-term average

Year	Tires	Containers	Tree holes	Total
2013	17,812	2,410	386	20,608
2014	21,109	3,297	478	24,884
2015	24,127	2,595	268	26,990
2016	18,417	1,690	261	20,368
2017	14,304	1,809	298	16,411
2018	9,730	1,993	478	12,201
2019	9,763	1,611	395	11,769
2020	11,824	3,134	375	15,333
2021	10,939	1,086	162	12,187
2022	11,753	1,087	92	12,392
Ave 2000-2022	16,691	2,686	618	19,995

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 LAC encephalitis are diagnosed in children under the age of 16. In 2022, there were 21 LAC 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.

In 2022, MMCD staff collected 1,459 aspirator samples to monitor *Ae. triseriatus* populations. Inspections of wooded areas and surrounding residential properties to eliminate larval habitat were provided as a follow-up service when *Ae. triseriatus* adults were collected. The District's adulticide treatment threshold (≥ 2 adult *Ae. triseriatus* per aspirator collection) was met in 126 aspirator samples. Adulticides were applied to wooded areas in 19 of those cases. Adult *Ae. triseriatus* were captured in 245 of 1,258 wooded areas sampled. The mean *Ae. triseriatus* capture was in the lowest quartile of observations over the past 20 years (Table 2.2).

Table 2.2 *Aedes triseriatus* aspirator surveillance data – past 20 seasons

Year	Total areas surveyed	No. with *Ae. triseriatus*	Percent with *Ae. triseriatus*	Total samples collected	Mean *Ae. triseriatus* per sample
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
2016	1,268	393	31.0	1,590	0.75
2017	1,173	361	30.8	1,334	0.98
2018	1,211	374	30.9	1,394	0.75
2019	1,055	342	32.4	1,170	0.97
2020	1,604	437	27.2	2,001	0.57
2021	1,516	309	20.4	1,959	0.42
2022	1,258	245	19.5	1,459	0.57

Aspirator sampling began during the week of May 23 and continued through the week of September 12. Weekly mean collections of *Ae. triseriatus* remained well below the long-term average most of the season due to drought conditions (Fig. 2.1). We observed peaks above the long-term average of 1.57 *Ae. triseriatus* per sample during the week of June 27 and 1.31 during the week of August 22.

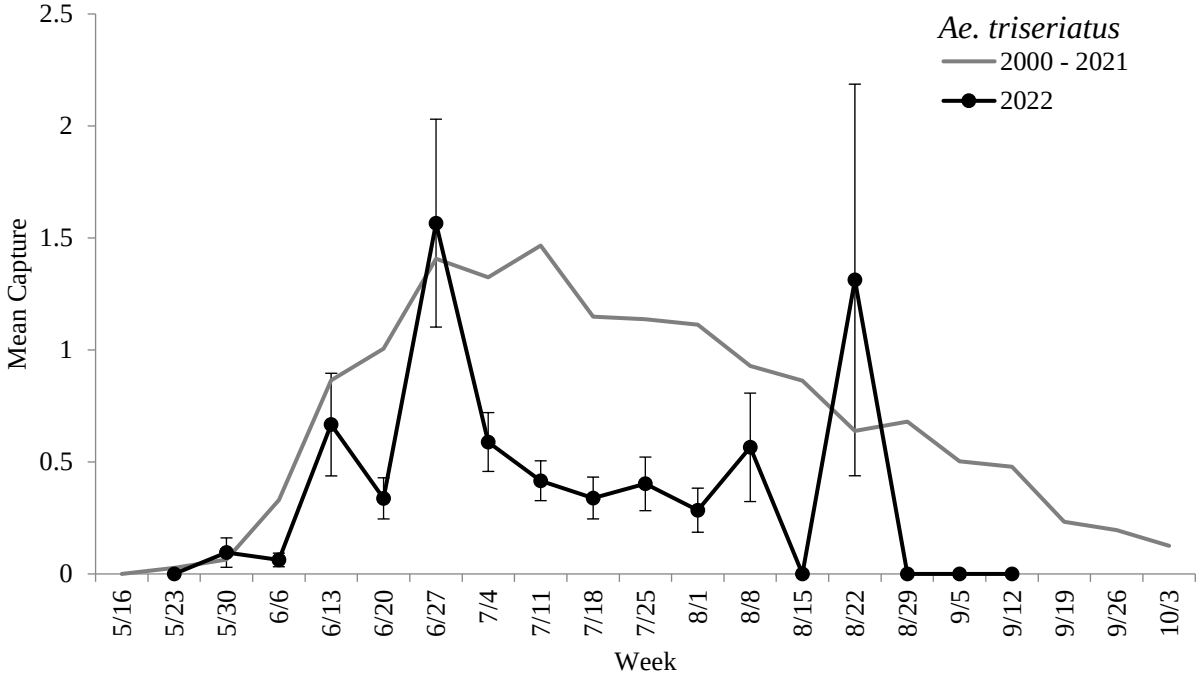


Figure 2.1 Mean number of *Ae. triseriatus* adults in 2022 aspirator samples plotted by week compared to mean captures for the corresponding weeks of 2000-2021. Dates listed are Monday of each week. Error bars equal ± 1 standard error of the mean.

La Crosse Encephalitis in Minnesota There were three LAC cases reported in Minnesota in 2022 (Hennepin Co., Olmsted Co., Wright Co.). Since 1970, the District has had an average of 1.94 LAC cases per year (range 0-10, median 1). Since 1990, the mean is 1.24 cases per year (range 0-8, median 0).

Invasive Species Each season, MMCD conducts surveillance for invasive mosquito species. MMCD laboratory technicians are trained to recognize invasive 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 invasive mosquito 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 easily transported as eggs or larvae. *Aedes albopictus*, first collected in the US 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 widespread across eastern North America and commonly collected throughout the District.

Aedes albopictus *Aedes albopictus* were collected in 25 samples in 2022. All of the samples were collected from a tire recycling facility or adjacent properties in Scott County. Specimens were reared from 10 ovitrap samples collected from July 29 to September 15. Eight BG Sentinel samples contained *Ae. albopictus* with collections occurring from June 29 to September 21. Five gravid trap samples contained the species; specimens were collected from August 17 to September 21. Two aspirator samples collected on September 9 and September 15 contained *Ae. albopictus*. A total of 28 specimens were collected in the 15 samples that contained adult *Ae. albopictus*.

Routine surveillance of tires and containers in and near the area where *Ae. albopictus* were collected by other methods did not result in the collection of *Ae. albopictus* larvae in 2022.

This was the 20th year in total and 11th consecutive year when *Ae. albopictus* were collected by MMCD staff; the first was in 1991. *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 now 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.

In 2022, *Ae. japonicus* larvae were found in 274 samples. Most were from containers (97), and stormwater structures/artificial ponds (75). Larvae were also found in samples from 55 tires, 25 catch basins, 21 wetlands, and one tree hole.

The frequency of *Ae. japonicus* occurrence in larval samples from containers and tires generally increased each year as they spread throughout the District. Since becoming more common, the frequency of occurrence has fluctuated. In 2022, we observed a small increase in *Ae. japonicus* collections from the previous year (Fig. 2.2). *Aedes japonicus* have been collected less frequently from tree holes than in tires and containers. Of eight larval samples from tree holes, only one contained the species in 2022.

Aedes japonicus adults were identified in 374 samples. They were found in 174 aspirator samples, 112 gravid trap samples, 76 CO_2 trap samples, seven two-minute sweep samples, four BG Sentinel trap samples, and one New Jersey trap sample.

In 2022, the rate of capture of *Ae. japonicus* in aspirator samples remained near average for the year with the exception of the season peak during the week of August 22 at 1.6 *Ae. japonicus* per sample (Fig. 2.3). No *Ae. japonicus* were captured in the last three weeks of surveillance when only seven samples were collected. In Figure 2.3, the 2011 to 2021 average represents the period from when *Ae. japonicus* first occupied parts of all seven District counties. The 2014–2021 average represents the period when the species has been found consistently throughout all areas of the District.

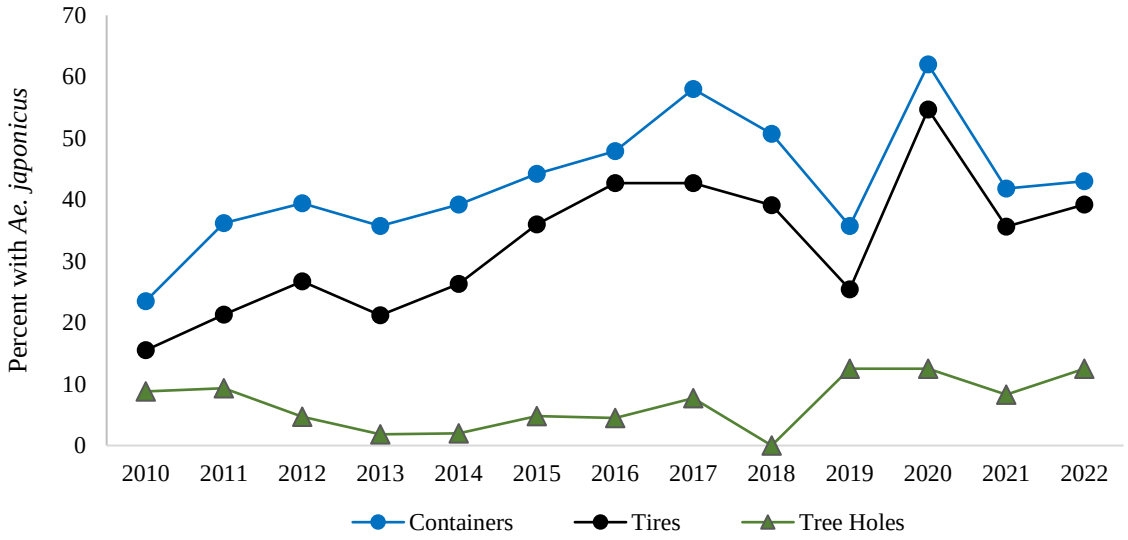


Figure 2.2 Percentage of larval samples from containers, tires, and tree holes containing *Ae. japonicus* by year.

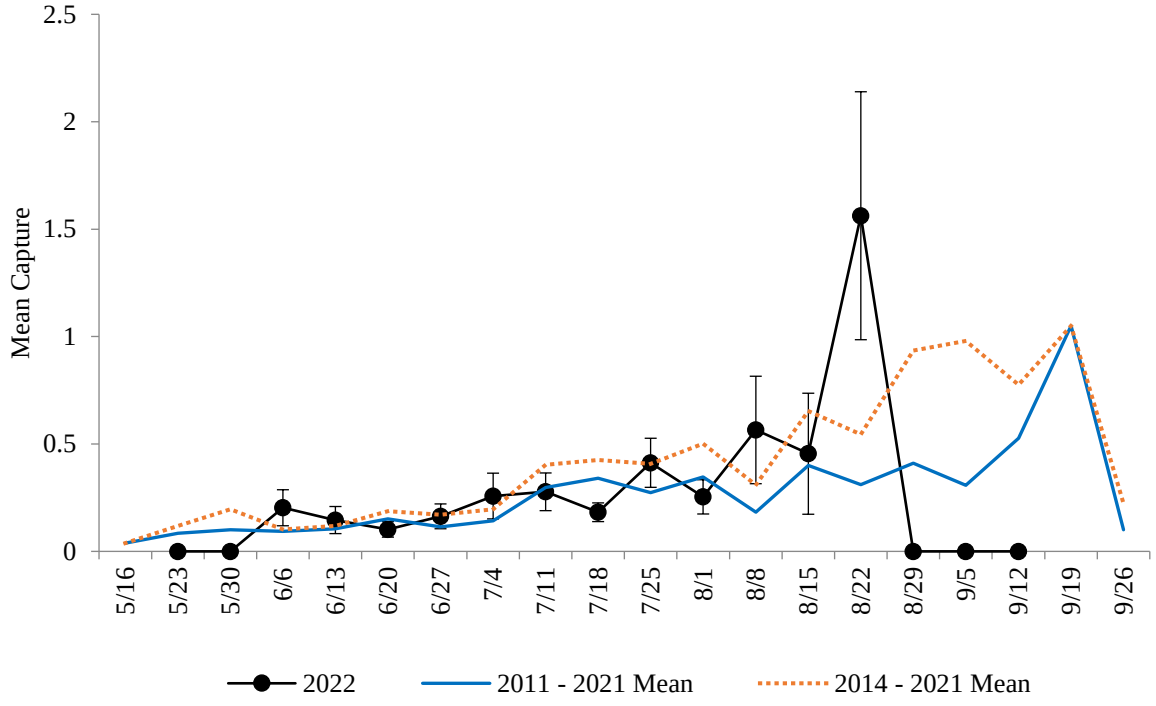


Figure 2.3 Mean number of *Ae. japonicus* adults in 2022 aspirator samples plotted by week compared to mean captures for the corresponding weeks of 2011-2021 and 2014-2021. Dates listed are Monday of each week. Error bars equal ± 1 standard error of the mean.

West Nile Virus (WNV)

West Nile virus circulates among many mosquito and bird species. It was first detected in the U.S. in New York City in 1999 and has since spread throughout 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 West Nile virus was detected in 46 states in 2022. The U.S. Centers for Disease Control and Prevention received reports of 1,035 West Nile illnesses from 41 states and the District of Columbia. There were 79 fatalities attributed to WNV infections. Colorado reported the greatest number of cases with 204. Nationwide screening of blood donors detected WNV in 175 individuals from 27 states.

WNV in Minnesota The Minnesota Department of Health confirmed 19 WNV illnesses in residents of Minnesota in 2022. Additionally, there were eight veterinary reports of WNV illness in captive animals in Minnesota.

WNV in the District There were two WNV illnesses reported in residents of the District in 2022, one each in Hennepin and Ramsey counties. Since WNV arrived in Minnesota, the District has experienced an average of 9.8 WNV illnesses each year (range 0-27, median 8). When cases with suspected exposure locations outside of the District are excluded, the mean is 8.0 cases per year (range 0-27, median 6).

Surveillance for WNV: Mosquitoes Surveillance for WNV in mosquitoes began during the week of May 31 and continued through the week of September 27. Several mosquito species from 43 CO_2 traps (10 elevated into the tree canopy) and 37 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 617 mosquito pools using the rapid analyte measurement platform (RAMP®), 42 of which were 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, 2022. MIR is calculated by dividing the number of positive pools by the number of mosquitoes tested

Species	Number of mosquitoes	Number of pools	WNV+ pools	MIR per 1,000
Cx. erraticus	109	13	0	0.00
Cx. pipiens	483	23	1	2.07
Cx. restuans	779	33	1	1.28
Cx. tarsalis	517	77	2	3.87
Cx. pipiens/Cx. restuans	4,579	252	22	4.80
Culex species	5,344	219	16	2.99
Total	11,811	617	42	3.56

The warm dry conditions of a second consecutive drought year were nearly ideal for amplification of WNV in 2022. The virus was first detected in mosquitoes during the week of June 20 when a mixed *Cx. pipiens/Cx. restuans* pool was positive. Only two pools of *Cx. tarsalis* were positive for WNV, both collected during the week of August 29. Of the season's 42 WNV positive mosquito samples, 14 were collected in Ramsey Co., 12 in Hennepin Co., eight in Dakota Co., six in Anoka Co., and one each in Scott and Washington counties.

Following the first WNV positive samples during the week of June 20, positive samples were collected every week from July 4 through September 12 (Fig. 2.4). The minimum WNV infection rate in mosquitoes peaked during the week of August 29 at 10.59 per 1,000 mosquitoes tested.

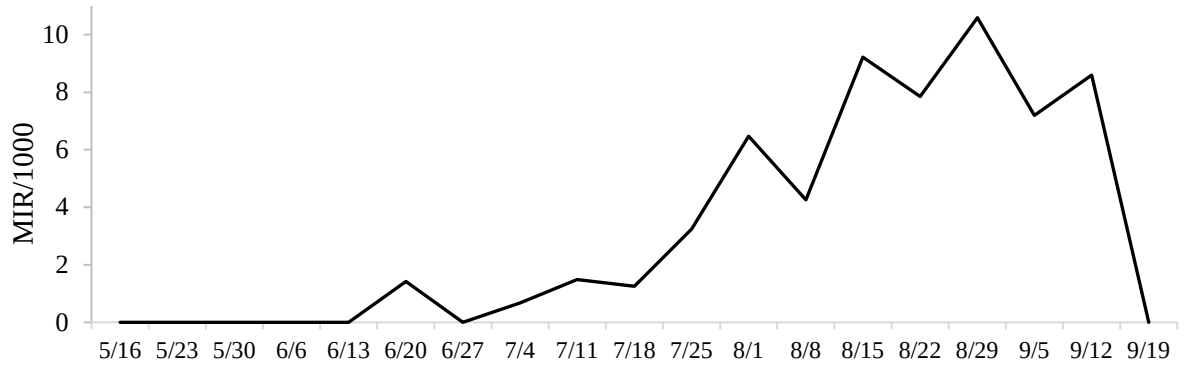


Figure 2.4 Weekly minimum WNV infection rates (MIR) per 1,000 *Culex* specimens tested in 2022. Dates listed are the Monday of the sampling week.

Avian Mortality Since some birds, especially corvids, are susceptible to WNV, the District operates a passive surveillance system to monitor bird mortality. Reports of dead birds aid in identifying areas where WNV might be active. The District received ten reports of dead birds by telephone, internet, or from employees in the field in 2022. Nine of the birds reported were corvids, seven were American crows, and two were blue jays.

Adult *Culex* Surveillance

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.

Culex tarsalis is the most likely vector of WNV for human exposures in our area. Collections of *Cx. tarsalis* in CO_2 traps were low throughout the 2022 season. Weekly mean collections peaked at 1.5 *Cx. tarsalis* per sample on July 25 (Fig. 2.5). As is typical, few *Cx. tarsalis* were captured by gravid trap in 2022.

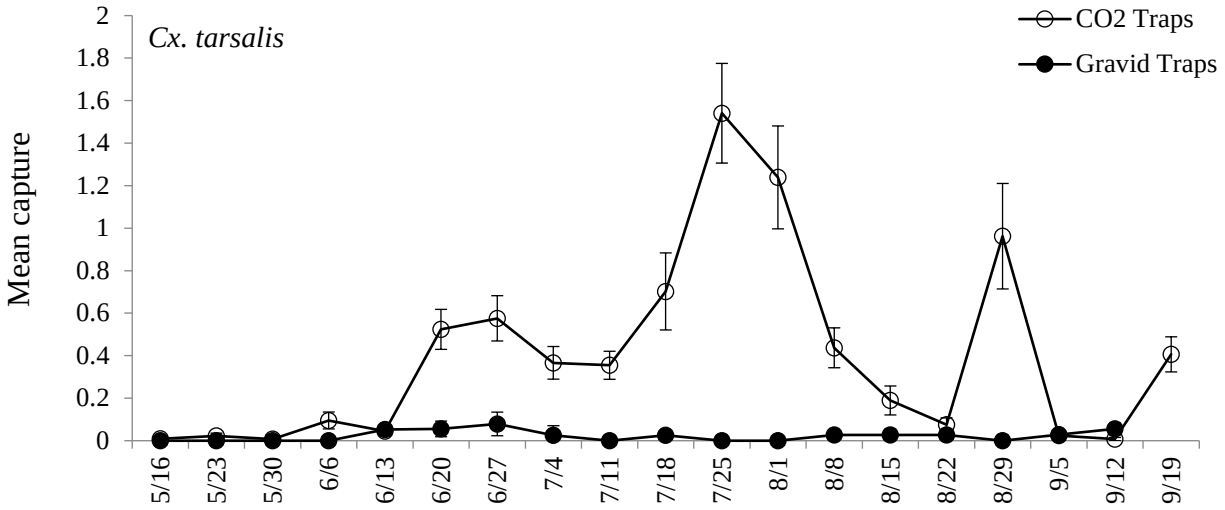


Figure 2.5 Average number of *Cx. tarsalis* in CO_2 traps and gravid traps, 2022. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

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. The CO_2 trap captures of *Cx. restuans* peaked on June 27 at 0.8 per trap. Gravid trap collections of *Cx. restuans* were highest from mid-June to early July. The peak rate of capture occurred during the week of June 27 at 7.4 per trap (Fig. 2.6).

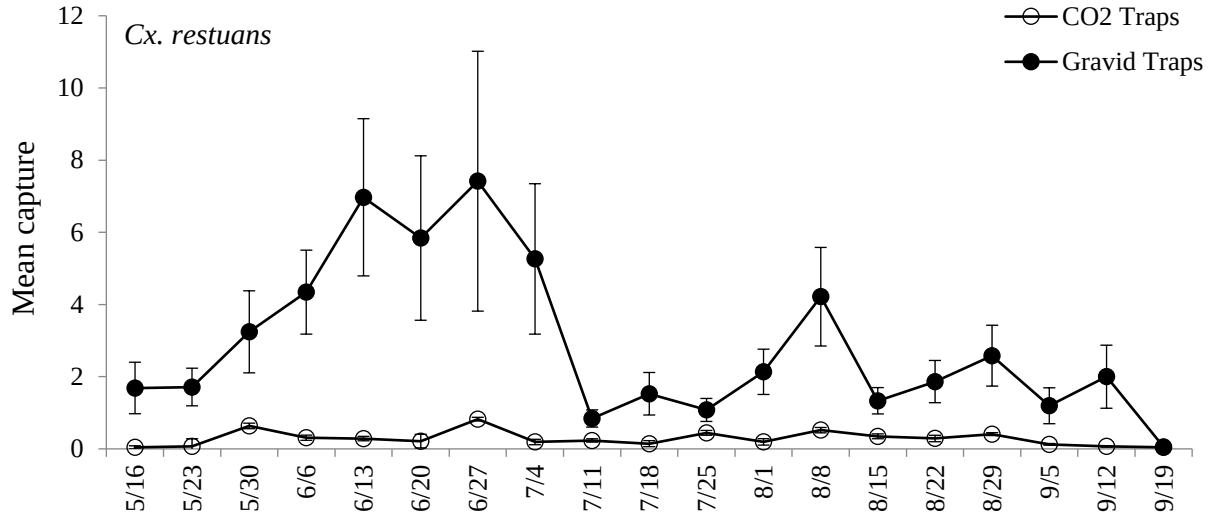


Figure 2.6 Average number of *Cx. restuans* in CO_2 traps and gravid traps, 2022. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

Culex pipiens is an important WNV vector 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 early in the season and peak late in the summer when temperatures are typically warmer. In 2022, collections of *Cx. pipiens* in both CO_2 traps and gravid traps peaked during the week of August 8 (Fig.2.7). The rate of capture peaked at 6.1 per gravid trap and at 1.1 per CO_2 trap.

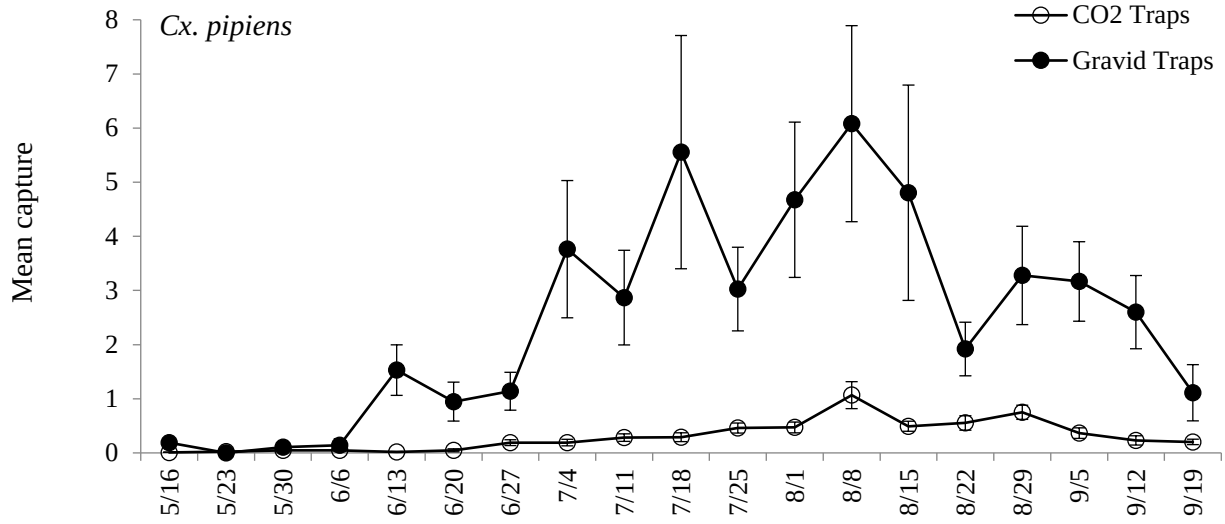


Figure 2.7 Average number of *Cx. pipiens* in CO_2 traps and gravid traps, 2022. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

Often, *Cx. pipiens* and *Cx. restuans* adults are difficult to distinguish from each other. In these instances, they are grouped together and identified as *Cx. pipiens/restuans* (Fig. 2.8). When *Culex* mosquitoes can only be identified to genus level due to poor condition of the specimens, they are grouped as *Culex* species (Fig. 2.9). 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. Collections of both groups mimicked each other week to week in 2022 and likely consisted of mostly *Cx. restuans* until early July and mostly *Cx. pipiens* thereafter.

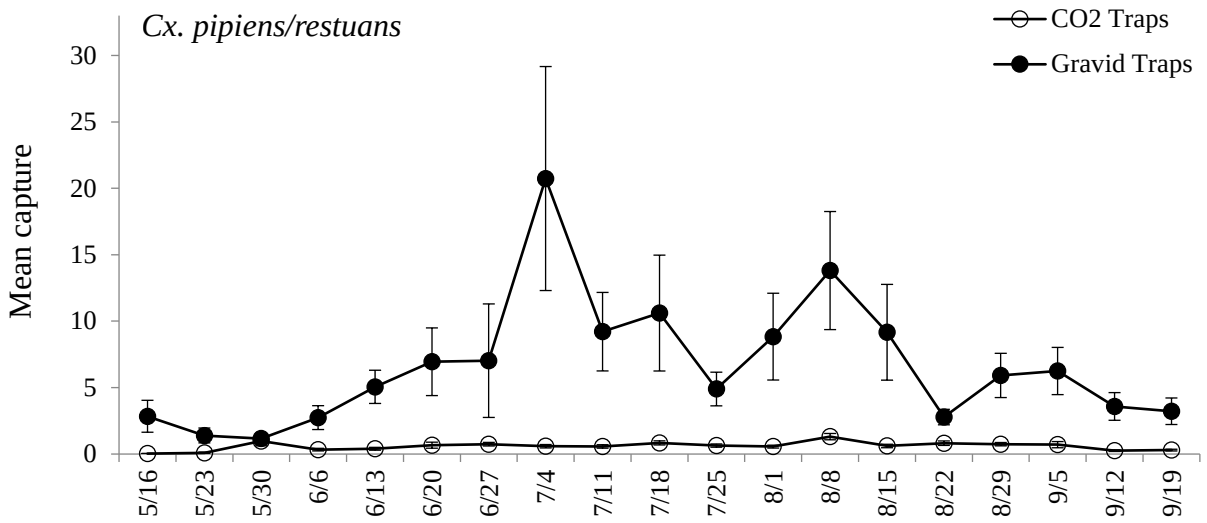


Figure 2.8 Average number of *Cx. pipiens/restuans* in CO_2 traps and gravid traps, 2022. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

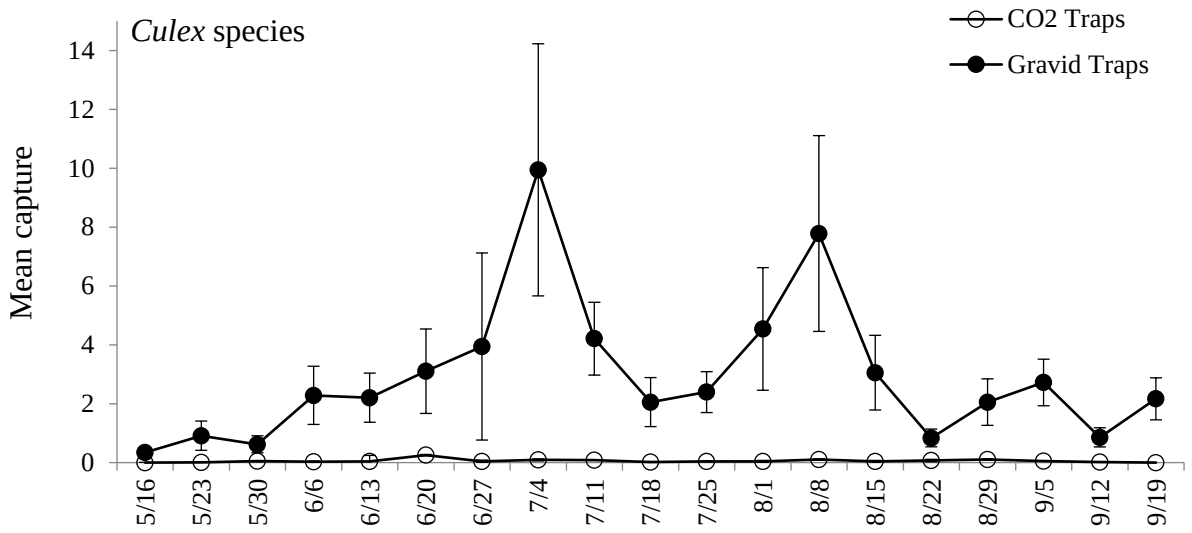


Figure 2.9 Average number of *Culex* species in CO_2 traps and gravid traps, 2022. Dates are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

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 Constructed Habitats Since 2006, MMCD field staff have been working to locate stormwater structures, evaluate habitats, 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, curb and gutter, swimming pools, ornamental ponds, and intermittent streams.

Technicians collected 938 larval samples from stormwater structures and other constructed habitats. *Culex* vectors were found in 89.2% of the samples in 2022 (Table 2.4). *Culex pipiens* were found more frequently than any other year since the District began surveillance in stormwater management structures. The frequency of *Cx. restuans* collections was within the range typically observed for these habitats.

Table 2.4 Frequency of *Culex* vector species in samples collected from stormwater management structures and other constructed habitats from 2018-2022

	Yearly percent occurrence				
Species	2018 (N=765)	2019 (N=664)	2020 (N=404)	2021 (N=1,236)	2022 (N=938)
Cx. pipiens	46.5	5.4	24.0	40.8	65.7
Cx. restuans	63.7	75.0	59.9	65.8	69.1
Cx. salinarius	0.0	0.0	0.0	0.0	0.0
Cx. tarsalis	1.4	3.2	0.7	3.5	2.7
Any *Culex* vector spp.	81.2	79.7	71.0	83.2	89.2

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 United States 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 2022, we continued the cooperative mosquito control plan for underground habitats. Nineteen 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. Nine hundred ninety briquets were placed in 896 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 assisting with underground stormwater habitat treatments, number of structures treated, and the number of briquets used in 2022

City	No. of structures treated	No. of briquets used	City	No. of structures treated	No. of briquets used
Arden Hills	15	15	Mendota Heights	18	19
Bloomington	92	100	Moundsview	5	5
Brooklyn Park	4	15	New Brighton	5	8
Columbia Heights	12	16	Prior Lake	66	66
Eagan	61	61	Roseville	27	29
Edina	61	122	Savage	56	56
Golden Valley	132	132	Shoreview	22	25
Hastings	2	2	Spring Lake Park	3	4
Little Canada	3	3	Woodbury	62	62
Maplewood	250	250			

Larval Surveillance in Catch Basins Catch basin larval surveillance began the week of May 30 and ended the week of September 26. Larvae were found during 483 of 567 catch basin inspections (85.2%) in 2022 (Fig. 2.10).

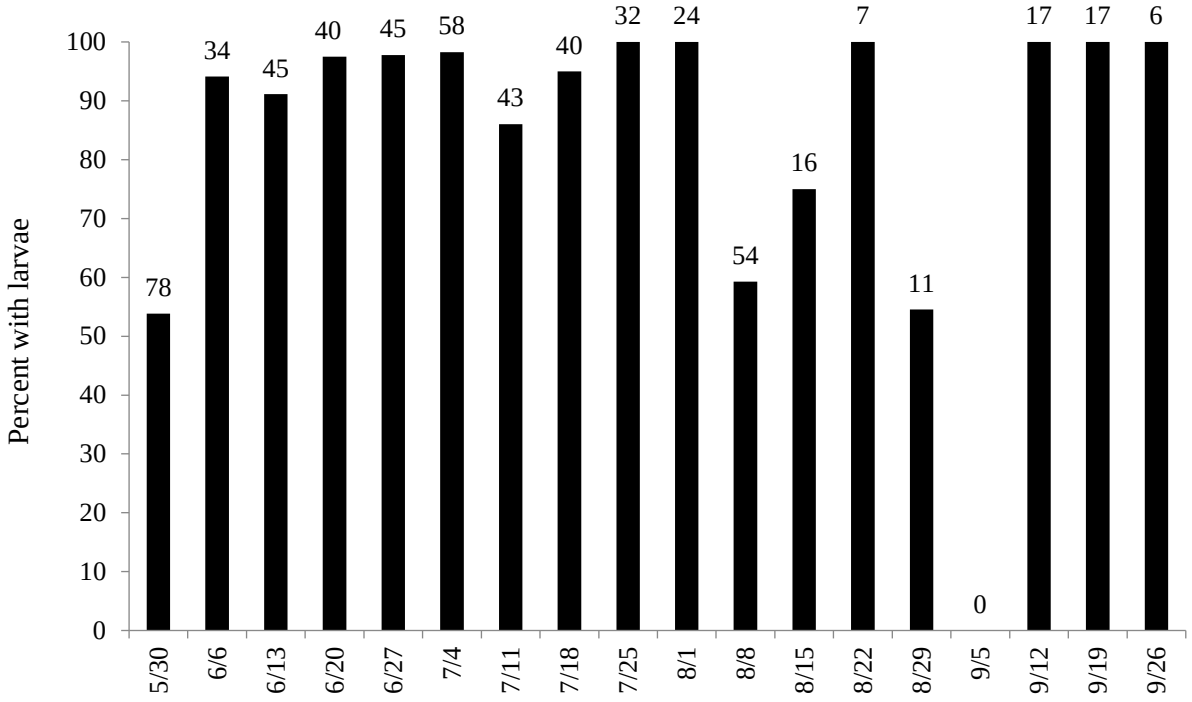


Figure 2.10 Percent of catch basins inspected with mosquitoes present in 2022. Bars are labeled with the number of inspections occurring during the week.

Mosquito larvae were identified from 475 catch basin samples. *Culex restuans* were found in 72.8% of catch basin larval samples. *Culex pipiens* were found in 78.1% of samples. At least one *Culex* vector species was found in 99.8% of samples. *Culex restuans* were collected more

frequently than *Cx. pipiens* until the week of July 4 when *Cx. pipiens* became more prevalent for all but one week of the remainder of the season (Fig. 2.11).

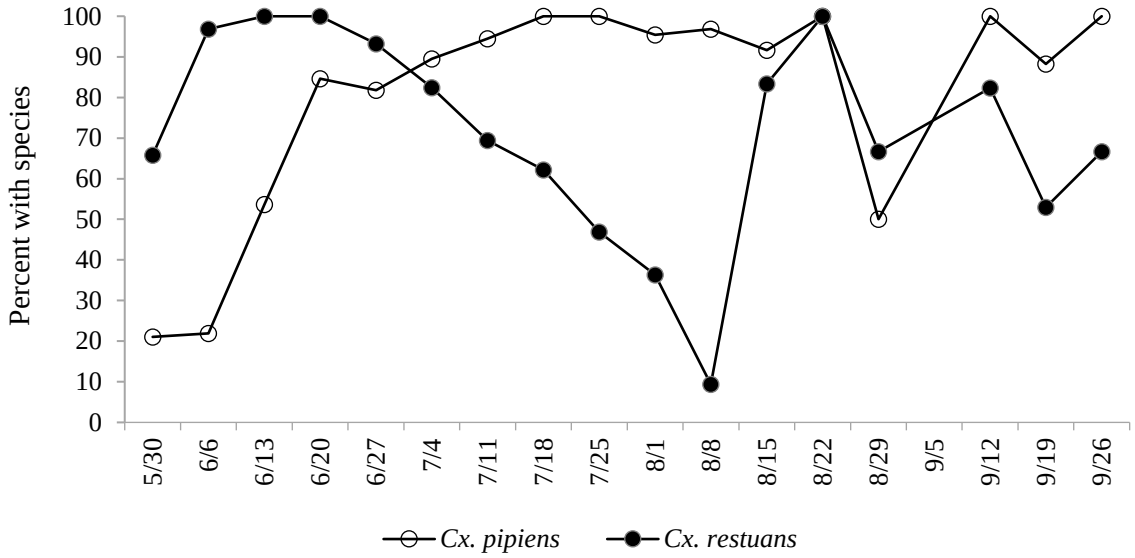


Figure 2.11 Percent occurrence of *Cx. pipiens* and *Cx. restuans* in catch basin larval samples by week. No sampling occurred during the week of September 5.

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 has routinely detected antibodies to the EEE virus in wolves, moose, and elk in northern Minnesota.

In 2022, one human EEE illness was reported to CDC from Wisconsin. There were veterinary reports of EEE activity from 22 counties in six states. Five states reported EEE positive findings from mosquito samples. There were no detections of the EEE virus in Minnesota in 2022.

***Culiseta melanura* Surveillance** *Culiseta melanura*, the enzootic vector of EEE, is relatively rare in the District and is usually 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. Larvae are most frequently found in caverns in sphagnum moss. Overwintering is in the larval stage with adults emerging in late spring. There are multiple generations per year, and progeny of the late summer cohort become 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.

Surveillance for adults by CO_2 trap and aspirator indicated the 2022 *Cs. melanura* population was low. Four pools containing 35 *Cs. melanura* were tested in the MMCD lab for EEE using the VecTOR Test Systems EEE virus antigen assay kit. All samples were negative for EEE.

District staff monitored adult *Cs. melanura* at 11 locations (Fig. 1.5, p. 8) using 12 CO_2 traps. Six 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 feet into the tree canopy, where many bird species roost at night. The first *Cs. melanura* adults were collected in CO_2 traps during the week of May 30 (Fig. 2.12). The population remained low throughout the season with a maximum capture of 1.75 per trap during June 13.

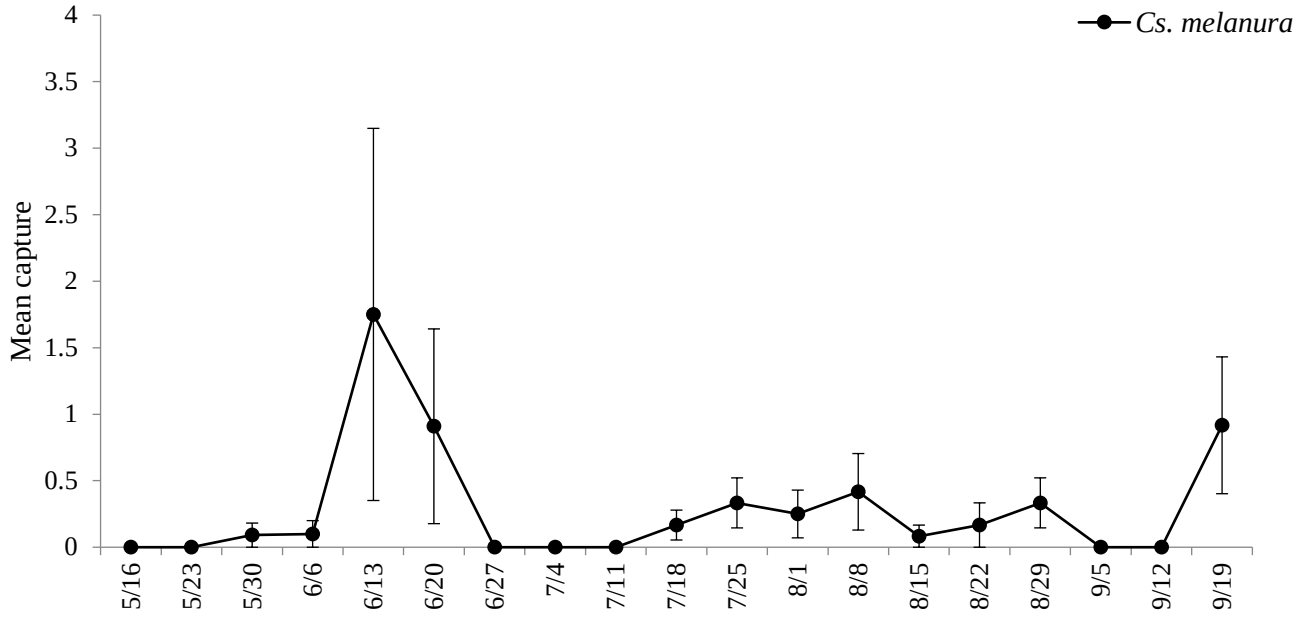


Figure 2.12 Mean number of *Cs. melanura* adults in CO_2 traps from selected sites, 2022. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

Staff collected a season total of only 15 *Cs. melanura* in 67 aspirator samples from wooded areas near bog habitats. The first aspirator captures of *Cs. melanura* occurred during the week of July 4 (Fig. 2.13). *Culiseta melanura* adults were collected during just two of the seven weeks with aspirator samples. The peak rate of capture was 3.0 *Cs. melanura* per sample during the week of July 25.

Culiseta melanura develop primarily in bog habitats in the District, and larvae can be difficult to locate. In 2022, three sites were surveyed for *Cs. melanura* larvae. There were no *Cs. melanura* larvae collected.

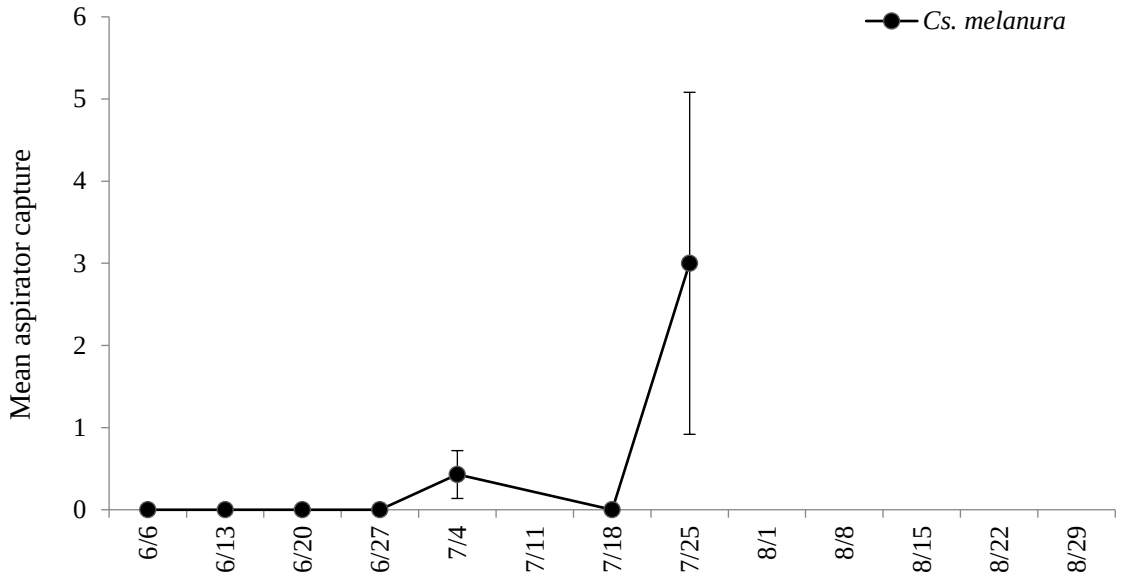


Figure 2.13 Mean number of *Cs. melanura* in 2021 aspirator samples plotted by week. Dates listed are Monday of each week. Error bars equal ± 1 standard error of the mean.

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 by University of Minnesota researchers in southern Minnesota. The virus has not been detected in Minnesota since then. *Culex tarsalis* collections were low in the District in 2022 (Fig. 2.5).

Jamestown Canyon Virus (JCV)

Jamestown Canyon virus is native to North America and circulates among mosquitoes and deer species. The virus has been detected in many mosquito species, although the role of each in transmission of JCV is not well defined. Several spring, snowmelt *Aedes* species are likely responsible for maintenance of the JCV cycle and for incidental human infections. In rare cases, humans suffer moderate to severe illness in response to JCV infections.

Eight JCV cases were reported nationally from four states in 2022. There was one JCV illness reported in Minnesota from Ramsey County.

The District has partnered with the Midwest Center of Excellence for Vector-borne Disease (MCE-VBD) to investigate JCV transmission in the region. Mosquitoes collected by MMCD have been tested at MCE-VBD for JCV. Results from samples collected in 2021 were returned after publication of the 2021 report to the Technical Advisory Board. Three of 60 samples from 2021 were positive for JCV. Two adult mosquito samples and one sample of larvae/pupae were

positive. The positive adult samples were a pool *of Ae. provocans* collected on June 8 in Linwood Township and a pool of banded-legged spring *Aedes* collected on June 15 in May Township. The larval/pupal sample was collected from a wetland on April 13 in Scandia in a location where adult *Ae. provocans* previously tested positive. This is a significant finding as it is the first documentation of transovarial transmission of JCV in the District. Transovarial transmission of JCV by *Ae. provocans* has been documented in areas of Wisconsin where human JCV illnesses have occurred. We pooled 255 samples from 2022 surveillance for testing by MCE-VBD. Results are pending.

2023 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, tire, and container habitat reduction. Eliminating small aquatic habitats will also serve to control populations of *Ae. japonicus*, *Cx. pipiens,* and *Cx. restuans*.

The District will continue to survey aquatic habitats for *Culex* larvae for use in the 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 to reduce WNV amplification.

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

Chapter 3 Tick-borne Disease

2022 Highlights-preliminary

- Number of sites positive for *Ixodes scapularis* was 56 out of 100
- Average *I. scapularis* per mammal was 2.11 (new record)
- *Amblyomma americanum* no reports or specimens received
- Latest available (2019) Lyme case total: 1528 confirmed and probable cases (source MDH)
- Anaplasmosis cases in 2019 totaled 407 (7.2 cases per 100,000, source MDH)

2023 Plans

- *I. scapularis* surveillance at 100 sampling locations
- Conduct baseline tick surveys in public parks
- Education, identifications, and homeowner consultations
- Update the Tick Risk Meter, provide updates on Facebook, and post signs at dog parks
- Track collections of *Amblyomma americanum* or other new or unusual tick species, including *Haemaphysalis longicornis*
- Participate in the inter-agency collaboration across MN for *H. longicornis* tracking

Background

Infected *Ixodes scapularis* (also known as the deer tick or blacklegged tick) primarily transmit two important pathogens in our area: Lyme disease, caused by the bacterium *Borrelia burgdorferi*, and human anaplasmosis (HA), caused by the bacterium *Anaplasma phagocytophilum*. Other rare pathogens also cause infection, including Powassan virus and human babesiosis.

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

The original purpose of MMCD's tick surveillance program was to determine the range and abundance of *I. scapularis*. This was achieved by sampling 545 total sites from 1990-1992. Today, we continue to identify and monitor the distribution of deer ticks via a 100-site sampling network, which is a subset of those original sites. In addition, our study allows us to rank deer tick activity throughout the season, to possibly detect new tick species, and to educate us and others so we can better inform people about reducing the risk of contracting a tick-borne illness. All collected data are summarized in a report and presented to the MDH and other agencies for their risk analyses. Additionally, MMCD has collaborated with the University of Minnesota (UMN) and others on spirochete and anaplasmosis studies.

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 protection. District employees provide tick identifications and consultations upon request and are used as a tick referral resource by agencies such as the MDH and the Minnesota Department of Natural Resources.

2022 Tick-borne Disease Services

Lyme Disease and Human Anaplasmosis

Tick surveillance, which began in 1990, continued as in past years. Surveillance first detected increases in the metro *I. scapularis* population in 1998. Obvious expansion began in 2000 and *I. scapularis* collections have remained at those higher levels since. In parallel, but with a two-year lag (to 2002), the MDH has been documenting higher human tick-borne disease cases. Pre-2000, the highest statewide Lyme disease case total was 302 but since 2000 the totals typically average >1,000 per year (range 463-1,431 cases). The all-time high, statewide Lyme disease case record (1,431) was set in 2013. 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 300s. The all-time high HA record of 788 was set in 2011. The MDH reported 915 confirmed Lyme disease cases (and 612 probable cases) and 407 HA cases (confirmed and probable) in 2019, both lower than in 2018. Case totals since 2019 have not been available.

Ixodes scapularis Distribution Study

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. *Ixodes scapularis* was then detected with greater frequency and they are prevalent now in many wooded areas south of the Mississippi River. The 2022 Lyme Tick Distribution Study report will be available on our website in June (https://mmcd.org/publications/). Some preliminary 2022 highlights follow.

The 2022 average number of *I. scapularis* collected per mammal (2.11) surpasses the previous record high of 1.68 that had been set in 2016. In comparison, most (16 years) yearly averages since 2000 have ranged between 1.21-1.68 while yearly averages for the other six years range between 0.39-0.80. From 1990-1999 the yearly averages had ranged from 0.09-0.41 (Table 3.1). In 2022, as in all years since 2007 aside from 2011, we collected at least one *I. scapularis* from all seven counties in our service area. We tabulated positive sites in 2022, similar to yearly positive site totals from 2000-2009 (typically in the 50s) but lower than those for 2017-2021 (all in the 60s). The first time the yearly positive site total was 70 or more was in 2010 and a positive site total of 80 or more was reached in 2015. The record high of 82 positive sites was set in 2016. Interestingly, *I. scapularis* tick loads in 2022 were by far the highest during the week of August 7 (i.e., August 10, 11, and 12), when the average *I. scapularis* per mammal was 22.19 compared to the range of 0.11-3.31 for all other weeks. Maps are included in our yearly Lyme tick distribution study report.

Table 3.1 Yearly totals of the number of mammals trapped and ticks collected by tick species and life stage, and the average number of *Ixodes scapularis* per mammal, 1990-2022; 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. scapularis* / mammal
1990 [a]	3651	9957	8289	994	573	74	27	0.18
1991	5566	8452	6807	1094	441	73	37	0.09
1992	2544	4130	3259	703	114	34	20	0.06
1993	1543	1785	1136	221	388	21	19	0.27
1994	1672	1514	797	163	476	67	11	0.33
1995	1406	1196	650	232	258	48	8	0.22
1996	791	724	466	146	82	20	10	0.13
1997	728	693	506	66	96	22	3	0.16
1998	1246	1389	779	100	439	67	4	0.41
1999	1627	1594	820	128	570	64	12	0.39
2000	1173	2207	1030	228	688	257	4	0.81
2001	897	1957	1054	159	697	44	3	0.83
2002	1236	2185	797	280	922	177	9	0.89
2003	1226	1293	676	139	337	140	1	0.38
2004	1152	1773	653	136	901	75	8	0.85
2005	965	1974	708	120	1054	85	7	1.18
2006	1241	1353	411	140	733	58	11	0.59
2007	849	1700	807	136	566	178	13	0.88
2008	702	1005	485	61	340	112	7	0.64
2009	941	1897	916	170	747	61	3	0.86
2010	1320	1553	330	101	1009	107	6	0.85
2011	756	938	373	97	261	205	2	0.62
2012	1537	2223	547	211	1321	139	5	0.95
2013	596	370	88	42	147	92	1	0.40
2014	1396	2427	580	149	1620	74	4	1.21
2015	1195	2217	390	91	1442	291	3	1.45
2016	1374	3038	576	153	2055	252	2	1.68
2017	1079	1609	243	45	1101	204	6	1.21
2018	765	1439	219	68	1007	139	6	1.50
2019	1121	1164	280	54	645	181	4	0.80
2020	1109	1264	75	61	1072	49	7	1.01
2021	799	767	131	61	439	135	1	0.72
2022	746	2067	386	109	1474	98	0	2.11

[a] 1990 data excludes one *Tamias striatus* with 102 *I. scapularis* larvae and 31 nymphs.

[b] other species mostly *Ixodes muris.* In 1999, a second adult *I. muris* was collected.

Tick-borne Disease Prevention Services

Identification Services and Outreach The overall scope of tick-borne disease education activities and services remained reduced in 2022 but included tick identifications of emailed photos or mailed ticks, updating our Tick Risk Meter on our website, and providing tick-borne disease information via telephone and on MMCD's Facebook page.

Posting Signs, Dog Parks Since the 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. We have also worked on expanding placements into additional metro locations.

Distributing Materials to Targeted Areas Limited distribution of brochures, tick cards, and/or posters occurred.

Additional Updates & Collaborations

Collaborative project with the Centers for Disease Control The tick vector surveillance team dragged for *I. scapularis* in the fall of 2021 for the Centers for Disease Control's (CDC) Rickettsial Zoonoses Branch. The CDC is developing a new molecular laboratory technique which will be able to identify *I. scapularis*. This study could also find that *I. scapularis*, like the newly described *Dermacentor similis* in the West, are not actually *I. scapularis* but a new species entirely. Additional collections were made in the spring of 2022 and were sent to the CDC.

Collaborative project with Jeff Bender, Veterinarian Epidemiologist University of Minnesota. SARS in mice? Abbey Novotny, North Region, had collected samples for a pilot study test in October 2021 and all samples were negative. In 2022, samples were taken from a subset (123) of our *Peromyscus leucopus* collected for surveillance and are being tested for SARS-CoV-2. Results are not yet available.

Asian Longhorned Tick (*Haemaphysalis longicornis)* Surveillance Continued The Asian longhorned tick (*H. longicornus*), first detected in North America on a sheep in New Jersey in the fall of 2017, was later determined to have been present in the United States since at least 2010. The type apparently introduced into the US is parthenogenetic (asexual). The implication is that an introduction of a single tick into an area could potentially cause the Asian longhorned tick to become established in that area. There have been no known introductions of this tick into Minnesota to date.

MMCD continues to participate in an interagency collaboration. Participating agencies include:

- Indian Health Services (northern MN)
- Minnesota Board of Animal Health
- USDA Animal and Plant Health Inspection Service
- Minnesota Department of Health
- Metropolitan Mosquito Control District
- University of Minnesota

- Wildlife Rehabilitation Center of Minnesota

All agencies will continue to keep each other informed of any *H. longicornis* found, and any tentatively identified Asian longhorned ticks will be sent to Dr. Ulrike Munderloh, University of Minnesota, Twin Cities, for confirmation of identifications. Further, the MDH will keep us all informed of the monthly United States Department of Agriculture telemeetings.

MMCD – Asian Longhorned Tick Specific Plans MMCD is in a good position to detect introductions of *H. longicornus* in our service area.

- Staff will continue to turn in any unusual looking adult ticks for identification
- Our tick identification service has been in place for many years providing us with a good platform which is being used to encourage the public to turn in ticks for identification
- Since *H. longicornis* immatures are thought not to feed on mice or other small mammals, our tick surveillance study will not detect them; however, performing and discussing our tick surveillance work within the agency keeps us more attuned to ticks and their associated health risks, which theoretically should make us more likely to check for and to notice unusual tick specimens
- MMCD staff will distribute the Asian longhorned tick identification cards (with lone star ticks on the opposite side) to help the public learn what to look for and to assist us in detecting any possible introductions
- MMCD will continue to utilize Facebook to keep the public informed of *H. longicornis* updates and to enlist their help in watching for this tick

***Amblyomma americanum* (lone star tick)** *Amblyomma americanum* is an aggressive human biter and can transmit bacteria that cause ehrlichiosis and also other pathogens. Both the tick and ehrlichiosis are more common to the southern U.S., but the range of *A. americanum* is moving northward. *Amblyomma americanum* was first collected by MMCD in 1991 via a road-kill examination of a white-tailed deer (*Odocoileus virginianus*) and through 2008 were also submitted to MMCD from the public on a rare, sporadic basis. However, in 2009, for the first time in a number of years, the public submitted *A. americanum* to both MDH and MMCD (from Minneapolis and Circle Pines). From 2009-2020, 42 *A. americanum* were collected by or reported to the MMCD and the MDH. As part of the tick submission process, each agency makes queries regarding travel history, excluding ticks that may have been picked up elsewhere. Neither the MMCD nor the MDH received any *A. americanum* in 2021 or 2022.

2023 Plans for Tick-borne Disease Services

Surveillance and Disease Prevention Services

The metro-based *I. scapularis* distribution study that began in 1990 is planned to continue unchanged. We will also be reviewing options for expanding tick surveillance. The goals are to conduct a multi-year baseline study to provide information for potential control/treatment in high

use public areas, to provide timely public information/education in those areas, and to test collected ticks for tick-borne pathogens, among others.

We will continue our tick-borne disease education activities and services of tick identifications, homeowner consultations, updating the Tick Risk Meter on our website, and using social media. We will stock local government agencies, libraries, and other locations with tick cards, brochures, and/or posters, distribute materials at local fairs and the Minnesota State Fair, set up information booths at events as opportunities arise and offer a comprehensive presentation that covers tick biology, pathogens transmitted that cause disease, and prevention measures. We will also continue to post signs 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 typically ceases for the year.

Amblyomma americanum and Other New or Unusual Ticks

***Amblyomma americanum* (lone star tick)** MMCD and MDH continue to discuss possible strategies that would enable both agencies to detect possible establishment of the lone star tick 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.

***Haemaphysalis longicornus* (Asian longhorned tick), Possible Minnesota Introductions** We will continue to partner with the other Minnesota agencies involved in this effort. All agencies will keep each other informed of any Asian longhorned ticks found, and all ticks will be sent to Dr. Ulrike Munderloh, University of Minnesota – Twin Cities, for confirmation of identifications.

Chapter 4 Mosquito Control

2022 Highlights

- Drought conditions impacted larval and adult numbers and treatment acres
- In 2022, 20,802 fewer acres were treated with larvicide (129,496 acres) than in 2021 (150,298 acres)
- In 2022, 841 fewer acres of adulticide treatments were made (1,696 acres) than in 2021 (2,537 acres)
- A cumulative total of 301,813 catch basin treatments were made to control WNV vectors
- We planned to reinstate the larval control cut in 2017 because the District's financial situation supported it, but dry conditions reduced service demand

2023 Plans

- Reinstate 100% of the larval control cut in 2017 as part of the expenditure reduction steps
- Continue spring *Aedes* larval surveillance in areas with high adult abundance to target potential Jamestown Canyon virus vectors
- Continue to collaborate with groups such as Monarch Joint Venture to use monarch ecology and migration data to mitigate potential impacts of adult mosquito control
- Work closely with the Minnesota Pollution Control Agency to fulfill the requirements of a NPDES permit

Background

The mosquito control program targets the principal summer pest mosquito *Aedes vexans*, several species of spring *Aedes*, the cattail mosquito (*Coquillettidia perturbans*), several known disease vectors (*Ae. triseriatus, Culex tarsalis, Cx. pipiens, Cx. restuans, Cx. salinarius*), and *Ae. 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 (82,205 potential sites) are scrutinized for all target mosquito species.

Larval habitats are diverse. They vary from 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 (1-4 instar), and larvae are the target species (human biting or disease vector). Some smaller sites (i.e., sites treated when frozen with Altosid® briquets) can be treated using a drone (see Chapter 7 for details).

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® FG) 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 parks and recreation areas, for public events, or in response to mosquito annoyance reports. Special emphasis is placed on areas where disease vectors have been detected, especially if there is also evidence of virus circulation.

Three synthetic pyrethroids were used in 2022: permethrin, sumithrin, and etofenprox. Sumithrin (Anvil®) and etofenprox (Zenivex®) can be used in agricultural areas. Local (barrier) treatments are applied to foliage where adult mosquitoes rest (mosquito harborage). Ultralow volume (ULV) treatments employ a fog of very small droplets that contact mosquitoes where they are active. Barrier treatments are effective for up to seven days. ULV treatments kill mosquitoes and dissipate within hours. A description of the control materials is found in Appendix D. Appendix E 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. Appendices F and G contain a historical summary of the number of acres treated with each control material. Insecticide labels are located in Appendix H.

The District uses priority zones to focus service in areas where the highest numbers of people benefit (Figure 4.1). 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 less 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. P1 receives 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 4.1 Priority zones 1 (shaded-P1) and 2 (white-P2), with District county and city/township boundaries, 2022.

2022 Mosquito Control

2022 Program Influences

In 2022, our mosquito control program was affected by a few issues. Our goal when facing these issues and others, is to continue to provide as many services as possible to the residents of the District in an efficient and effective manner. The main issues in 2022 and their solutions were:

- **Drought conditions**: Starting in 2021, much of the metro area was impacted by drought conditions. These conditions continued into 2022 and impacted the wetlands which reduced the work employees were doing. Staff focused their work on potential disease reduction. The drought also had a positive effect on our budget, due to the lowered service demands. These budget savings will help us restore more of the services that were eliminated in 2017.
- **Hiring seasonal staff**: In 2022, we had difficulty hiring seasonal staff. Our applications were down, as well as the length of time staff could work during the season. Facilities worked together to share staff when needed to accomplish the work. For the 2023 season, we will continue to work on our recruitment process. We are also working on a more seamless process of sharing staff between different offices.
- **COVID-19:** In 2022, we still had some COVID-19 restrictions in place that limited our staff and the work that they do. These included only having one person per truck, hiring only enough staff for the number of vehicles we had, and staff being away from work because of having COVID-19 or being exposed to COVID-19. As the season went on, some of these restrictions were changed, allowing for staff to work together more. We are looking forward to getting back to even more "normal" in 2023.

2022 was one of the driest years since 1989. Adult mosquito abundance was very low overall. Larval and adult control were both lower than the previous five years (Table 4.1). Hiring seasonal staff in general and the limitations due to COVID-19 that began in 2020, including hiring fewer seasonal employees, continued through 2022 (Table 4.1). The dry conditions mitigated service delivery impacts from lower staffing levels.

Table 4.1 Number of acres treated, and number of seasonal technicians hired, 2017-2022

	2017	2018	2019	2020	2021	2022
Acres larval control	193,890	187,727	212,172	194,911	150,299	129,497
Acres adult control	42,012	38,479	22,325	6,450	2,537	1,696
Seasonal technicians	234	229	229	184	187	179

The dry conditions and resultant lower service demands in 2022 reduced our expenditures below our 2022 budget. In 2023, using budget savings from the last three years, along with our 2023 levy increase, we will restore the 2017 service cuts. We also will have sufficient reserves to afford at least one high service demand year similar to 2014-2016 without depleting our reserves below the minimum level required to support District cash flow needs.

Larval Mosquito Control

Thresholds and Control Strategy Larval surveillance occurs prior to treatments, and control materials are applied when established treatment thresholds are met, as appropriate. Ground site treatments and cattail site treatments are based on presence/absence criteria. For treatments by air, larval numbers must meet treatment thresholds. Table 4.2 displays the treatment thresholds established for each species group and priority zone. The threshold is the average number of larvae collected in 10 dips using a standard four-inch diameter dipper. P1 and P2 areas can have different thresholds to help focus limited time and materials on productive sites near human population centers.

Table 4.2 Air site larval thresholds by priority zone and species group in 2022

Priority zone	Spring *Aedes*	Summer *Aedes*	*Culex*4[a]	Summer *Aedes* + *Culex*4 combined
P1	1.0	2.0	2.0	2
P2	1.0	5.0	2.0	2

[a] *Culex*4 = *Cx. restuans*, *Cx. pipiens*, *Cx. salinarius*, *Cx. tarsalis*

Control for a season begins in the fall of the previous year when we survey cattail sites for larvae of the cattail mosquito, *Cq. perturbans*. Some sites are treated with VectoLex® (*Bacillus sphaericus*) then to eliminate larvae before they overwinter. Some sites where *Cq. perturbans* larvae are limited to holes in cattail mats are treated with Altosid® briquets (methoprene) in February or early March when the wetlands are still frozen. Other sites with cattail mosquito larvae present are treated with controlled release methoprene products (such as Altosid® pellets and Altosid® P35) by air or ground starting in late May to prevent adult emergence (usually peaking around July 4). Surveillance and control for the next season begins again in the fall.

Spring *Aedes* tend to be long-lived, aggressive biters and can lay multiple egg batches. Consequently, they have a lower treatment threshold than summer *Aedes* (Table 4.2), which typically lay only one batch of eggs. In 2018, the spring *Aedes* threshold was raised from 0.5 to 1 per dip in P1 due to historically low adult numbers and the high resource use. This allowed for more resources to be available for P2 areas where numbers of adult spring *Aedes*, which are potential Jamestown Canyon virus (JCV) vectors, were much higher. After mid-May, when most larvae found are summer floodwater species, the summer *Aedes* threshold of 2/dip in P1 and 5/dip in P2 is used (Table 4.2). The *Culex*4 (*Cx. restuans*, *Cx. pipiens*, *Cx. salinarius*, *Cx. tarsalis*) threshold is 2 in both priority zones (Table 4.2). If *Aedes* and *Culex* vectors are both present in a site and neither meet the threshold individually, the site can be treated if the combined count meets the 2/dip threshold.

Some sites that have a sufficient history of floodwater *Aedes* larval presence are treated with controlled-release materials formulated to apply before flooding (“pre-hatch”). This allows staff more time to check and treat other sites after a rainfall. The first ground and aerial prehatch treatments (Natular® G30, Altosid® pellets, Altosid® P35, MetaLarv® S-PT) were applied in mid-May with a second round in mid-June and a third in mid-July.

Season Overview In 2022, expanded larval spring *Aedes* surveillance in P1 and P2 occurred in areas with higher past adult abundance. However, due to the drought conditions, many of the wetlands were found to be dry. Staff detected the first spring *Aedes* larvae on March 18, the same day as in 2021. Aerial *Bti* treatments to control the spring *Aedes* brood began on May 5, thirteen days later than 2021 (April 22). The mosquito species composition switched to primarily *Ae. vexans* (summer floodwater) in early-May; the summer *Aedes* larval threshold was used beginning on May 12. In addition to the spring *Aedes* brood, there were one large and eight small-medium broods of summer floodwater species (a typical season has four large broods).

Aerial pre-hatch treatments (Natular® G30, Altosid® P35, MetaLarv® S-PT) to control floodwater *Aedes* were applied in mid-May, mid-June, and the end of July. The last application was done at the end of July because of the dry conditions in the wetlands. Most aerial treatments to control cattail mosquitoes using MetaLarv® S-PT were applied May 24 – May 27 (Figure 4.2); VectoLex® FG was applied September 20 to control the overwintering larval cattail mosquito population.

The amount of control materials used, and acres treated in 2022 was less than in 2021 (Table 4.3). The number of acres treated in 2022 was 13.8% less than the previous year; however, the number of catch basin treatments increased by 6% in 2022. Altosid® pellets were used in 2021 but were completely replaced by Altosid® P35 in 2022 for catch basin treatments, as the per pound cost was lower (Table 4.3).

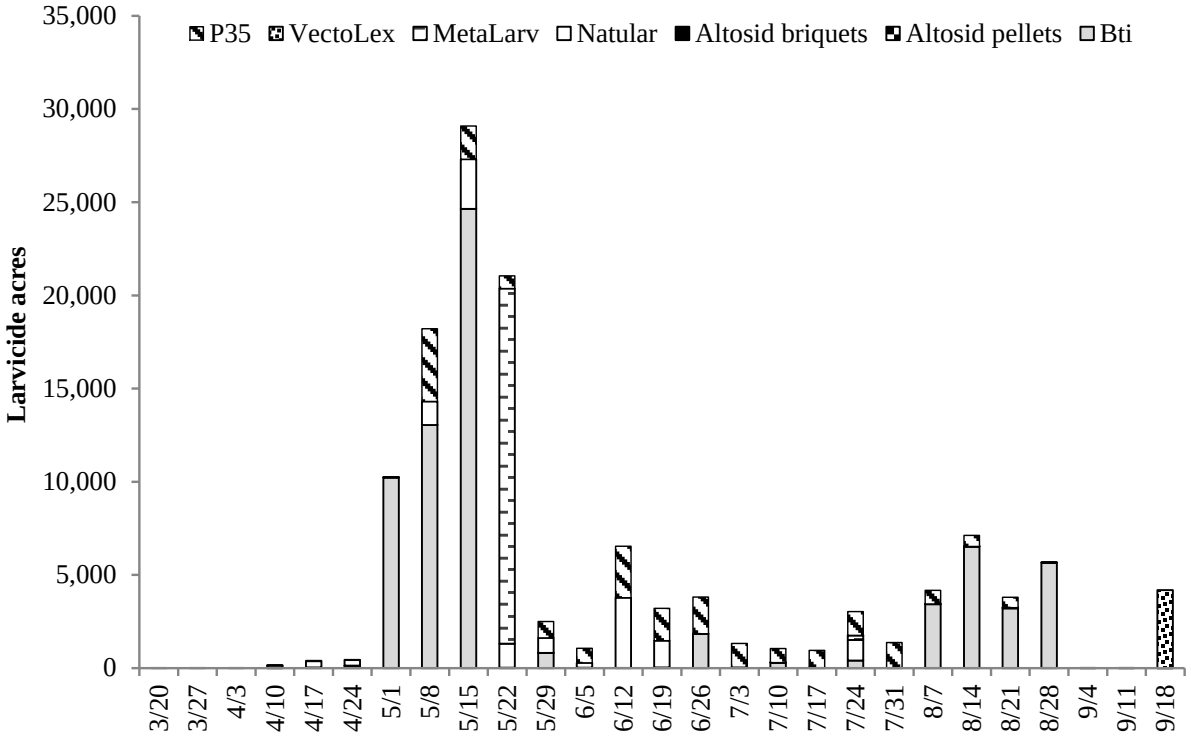


Figure 4.2 Acres treated with larvicide each week (March-September 2022). Date represents start date of week.

Table 4.3 Comparison of larval control material usage in wetlands, stormwater structures (other than catch basins) and containers, and in stormwater catch basins for 2021 and 2022 (research tests not included)

	2021		2022	
Habitat and material used	Amount used	Acres treated	Amount used	Acres treated
Wetlands and structures				
Altosid® briquets (cases)	175.67	141.00	138.72	119.00
Altosid® pellets (lb)	0.38	0.16	0.80	0.26
Altosid® P35 (lb)	73,104.78	26,511.00	58,543.53	22,069.00
MetaLarv® S-PT (lb)	55,643.88	19,431.00	56,313.78	19,296.00
Natular® G30 (lb)	100,679.52	19,968.00	64,994.23	13,468.00
VectoLex® FG (lb)	74,246.17	5,255.00	61,951.32	4,235.00
VectoBac® G (lb)	396,881.97	78,992.00	348,838.15	70,309.00
Total wetland and structures		150,298.2		129,496.3
	Amount used	No. CB treatments	Amount used	No. CB treatments
Catch basins				
Altosid® briquets (cases)	1.92	414	1.48	325
Altosid® pellets (lb)	105.62	13,550	0	0
Altosid® P35 (lb)	2,188.50	270,810	2,473.58	301,352
VectoLex® FG (lb)	0	0	2.27	136
Total catch basin treatments		284,774		301,813

Cattail Mosquito Control Reduction Evaluation From 2018 through 2020, some control materials were shifted to P1 cattail treatments. Cattail mosquito larvicide treatments in P2 largely were not applied in 2017 as part of a strategy to reduce expenditures. Relatively limited treatments were resumed in a few local areas within P2 in 2020 and 2021. Larval surveillance in late 2017 detected more sites containing cattail mosquito larvae in P1 than could be treated in spring 2018 with available resources. A similar number of acres containing cattail mosquito larvae were detected in late 2018. In 2018, larvicides were shifted from floodwater pre-hatch to treat more cattail sites, but available resources still were insufficient. All available resources were used in P1 in 2019. In 2020 and 2021, acreage requiring treatment was a bit lower in P1 which enabled us to treat a relatively small amount of P2, mainly a few areas near P1.

Three years (2014-2016) of high precipitation flooded many acres of cattail sites. Adult mosquito surveillance documented a large increase in adult cattail mosquitoes throughout the District in 2017 (see Chapter 1 for details); levels decreased in 2018 suggesting that drier conditions in 2018 through 2022 reduced water levels (and *Cq. perturbans* larval habitat) in many cattail sites. We compared adult cattail mosquito abundance in groups of CO_2 traps in P1 (cattail larvicide treatments maintained in 2016-2022) and P2 (limited cattail larvicide treatments completed in 2016, largely curtailed in 2017-2021 and restored in 2022) in Washington and Hennepin counties (Figure 4.3). Abundance in traps located in Linwood Township in Anoka County (no cattail mosquito control from 2016-2022) served as a reference (Figure 4.3).

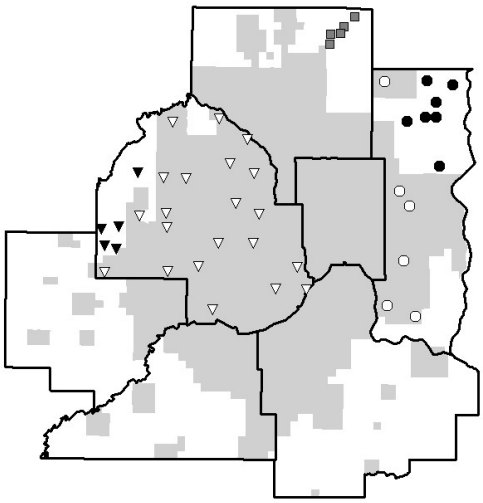


Figure 4.3 Location of CO_2 traps in Hennepin County (P1 white triangles, P2 black triangles), Washington County (P1 white circles, P2 black circles), and Anoka County (Linwood Township) (gray squares). P1 is shaded light gray.

Adult *Cq. perturbans* abundance as measured by CO_2 trap captures in 2016-2022 documented a large increase in 2017 throughout the District; abundance was more variable but lower in 2018-2021 and lowest in 2022 (Table 4.4). In each year from 2016-2022, abundance was lower in P1 than in P2 in Hennepin and Washington counties (Table 4.4) suggesting that widespread larval control is lowering adult *Cq. perturbans* abundance in P1. The change in adult *Cq. perturbans* abundance each year was less variable in P1 suggesting that widespread larval control effectively suppressed *Cq. perturbans* abundance from 2016 through 2022.

The environmental impact of high precipitation in 2014, 2015, and 2016 and lower overall precipitation from 2017 through 2022 seems to have more strongly affected *Cq. perturbans* abundance in P2. From 2016 through 2021, a much larger proportion of cattail mosquito production acreage in P1 was treated with larvicide compared to P2. When environmental conditions support high larval *Cq. perturbans* abundance, a greater proportion of acreage probably will require wide-scale larval control to more significantly decrease adult *Cq. perturbans* abundance.

Coquillettidia perturbans surveillance for 2023 (completed August–October 2022) detected lower abundance of this species as compared to 2022. The drought conditions, lower total acres found breeding, and our budget will allow us to treat all the P2 sites we had surveyed.

Table 4.4 Adult *Coquillettidia perturbans* mean abundance in Monday Night Network CO_2 trap annual collections (2016-2022) in five groups of CO_2 traps [mean (± 1 SE)]; P1 and P2 are priority treatment zones, n=number of CO_2 traps, F=full, N=no control, and L=limited control is the control status

	Hennepin Co.		Washington Co.		Anoka Co. Linwood Twp.
	P1	P2	P1	P2	P2
Year	(n=21)	(n=5)	(n=6)	(n=7)	(n=5)
2016	19.3 (±4.6) F	42.0 (±15.4) L	30.6 (±11.4) F	161.1 (±26.8) L	325.1 (±67.5) N
2017	57.8 (±12.7) F	158.7 (±57.1) N	123.5 (±81.9) F	424.8 (±76.7) N	750.2 (±164.1) N
2018	15.7 (±4.7) F	93.6 (±34.9) L	32.4 (±21.2) F	174.9 (±48.0) L	257.9 (±77.3) N
2019	18.5 (±5.3) F	257.3 (±200.9) N	47.2 (±27.8) F	197.5 (±53.6) N	210.0 (±48.0) N
2020	50.3 (±11.6) F	185.2 (±69.3) N	48.8 (±13.9) F	355.5 (±66.1) N	297.0 (±64.9) N
2021	14.8 (±7.9) F	27.3 (±11.2) L	25.5 (±8.7) F	133.4 (±39.6) N	72.3 (±28.5) N
2022	2.49 (±0.85) F	6.45 (±2.6) L	11.0 (±2.9) F	84.7 (±31.8) N	51.6 (±13.1) N

Spring *Aedes* Control Strategy Larval surveillance for spring *Aedes* was first expanded in 2018 to potentially shift some spring larvicide treatments into P2 to expand the area within the District that received larval control targeting suspected vectors of Jamestown Canyon virus. In 2022, we maintained the P1 spring *Aedes* larval threshold raised in 2018 from 0.5 to 1.0 larvae per dip to treat sites that contained higher concentrations of larvae (in both P1 and P2). In 2022, we attempted to treat approximately as many acres in P2 as in 2021, but the dry conditions limited total acreage treated in 2022 (Table 4.5).

Table 4.5 Aerial *Bti* treatment-acres to control spring *Aedes* in P1 and P2 during 2018, 2019, 2020, 2021, and 2022

	Number of acres treated by year				
Priority area	2018	2019	2020	2021	2022
P1	18,044.52	31,146.39	18,304.36	28,008.30	18,955.23
P2	2.785.85	874.58	0.00	2,676.21	1,465.99
Total	20,830.37	32,020.97	18,304.36	30,684.51	20,421.22

Spring *Aedes* Control Strategy Evaluation The five groups of CO_2 traps used to compare *Cq. perturbans* abundance also were used to compare spring *Aedes* abundance relative to treatments in 2016-2022. Hennepin P1 and Washington P1 are areas where aerial *Bti* treatments targeting spring *Aedes* were completed from 2016-2022. Limited aerial *Bti* treatments were conducted in Hennepin P2 and Washington P2 in 2016; these treatments were not made in 2017, limited treatments were completed in 2018, 2019, 2021, and 2022. No treatments in P2 were completed in 2020. No significant aerial *Bti* treatments targeting spring *Aedes* were completed from 2016-2022 in Linwood Twp. (Anoka County).

Low and variable numbers of adult spring *Aedes* were captured by CO_2 traps which made evaluating treatment effects challenging (Table 4.6). Spring *Aedes* abundance from 2016 through 2022 in Hennepin P1 and Washington P1 was essentially equal for all seven years; mean abundance each year differed by less than yearly variability (1 SE). Spring *Aedes* abundance was higher in 2019 in Hennepin P1 and Washington P1 but still within variability limits. Yearly

spring *Aedes* abundance in Hennepin P2 and Washington P2 was much more variable. Abundance in P2 appeared higher in 2022 and 2019 than in 2016, 2017, 2020, and 2021, especially in Washington County, although variance also was much higher in 2019. Spring *Aedes* abundance in Linwood Township was higher each year than in Hennepin P1 and Washington P1 and similar to Washington P2 in all years (Table 4.6). The less variable spring *Aedes* abundance in Hennepin P1 and Washington P1 in all seven years suggests that widespread larval control is effectively suppressing spring *Aedes*.

Table 4.6 Adult spring *Aedes* mean abundance in Monday Night Surveillance CO_2 trap annual collections (2016-2022) in five groups of CO_2 traps [mean (± 1 SE)]. P1 and P2 are priority treatment zones, n=number of CO_2 traps, F=full, N=no control, and L=limited control is the control status

	Hennepin County		Washington County		Anoka Co. Linwood Twp.
	P1	P2	P1	P2	P2
Year	(n=21)	(n=5)	(n=6)	(n=7)	(n=5)
2016	0.8 (±0.5) F	3.7 (±1.8) L	0.9 (±0.3) F	2.6 (±0.9) N	6.1 (±0.6) N
2017	1.0 (±0.8) F	1.5 (±0.8) N	0.4 (±0.2) F	8.5 (±5.5) N	17.6 (±4.9) N
2018	1.2 (±0.7) F	7.6 (±3.0) L	1.6 (±0.6) F	22.3 (±9.6) L	37.2 (±10.6) N
2019	2.9 (±1.3) F	13.6 (±7.5) L	2.8 (±0.9) F	38.0 (±15.1) L	22.7 (±4.5) N
2020	0.9 (±0.4) F	2.1 (±0.8) N	1.2 (±0.6) F	18.1 (±4.7) N	14.3 (±2.3) N
2021	0.9 (±0.3) F	2.8 (±2.1) L	2.6 (±1.0) F	9.7 (±2.3) L	17.9 (±4.6) N
2022	2.8 (±1.1) F	8.8 (±5.0) L	5.9 (±2.0) F	37.1 (±10.6) L	55.0 (±19.3) N

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 4.7). Staff conducted a study in the early 1990s that measured peoples' 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. The sampling method used is targeted to specific mosquito species.

Table 4.7 Thresholds by sampling method for important nuisance (*Aedes spp./Cq. perturbans*) and vector species (*Ae. triseriatus, Ae. japonicus, Culex4, Cs. melanura*)

		Total number of mosquitoes			
	Date	2-min	CO_2		2-day gravid
Species	implemented	sweep	trap	Aspirator	trap
Aedes triseriatus	1988			2	
Aedes spp. & *Cq. perturbans*	1994	2 [a]	130		
*Culex*4[b]	2004	1	5	1[c]	5
Ae. japonicus[d]	2022	2	2	2	2
Cs. melanura	2012		5	5	

[a] 2-minute slap count may be used.
[b] *Culex*4 = *Cx. restuans, Cx. pipiens, Cx. salinarius, Cx. tarsalis.*
[c] Aspirator threshold only for *Cx. tarsalis.*
[d] *Ae. japonicus* threshold was changed in 2022; from 2009-2021 it was 1 per collection.

Season Overview In 2022, adult mosquito levels were very low all season. Above-threshold abundance peaked in very early June; vectors were more abundant throughout the season (Figure 4.4). In 2022, MMCD applied 840 fewer acres worth of adulticides than in 2021 because adult mosquito abundance was low (Table 4.8, Appendix F). Adult mosquito control was low all season with its greatest peaks in early June, in response to elevated adult mosquito levels, primarily in Anoka County, and in late August primarily in response to vector mosquitoes (Figure 4.4).

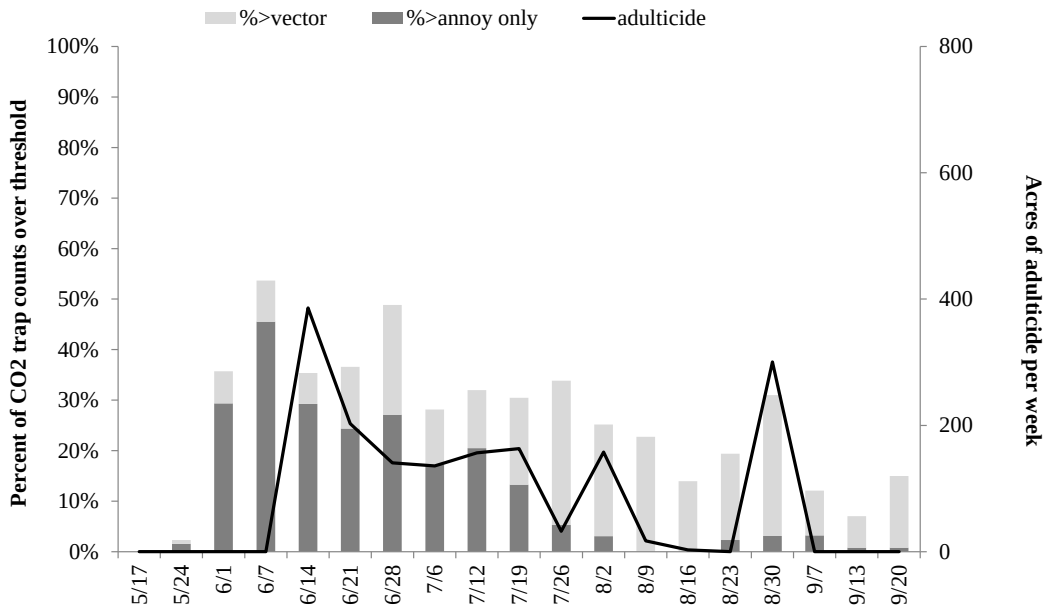


Figure 4.4 Percent of Monday CO_2 trap locations with counts over threshold compared with acres of adulticides applied in 2022 (solid line). Dark bars indicate the percentage of traps meeting annoyance mosquito thresholds and lighter bars represent the percentage of traps meeting the vector thresholds (*Culex*4, *Ae. triseriatus*, *Ae. japonicus*, *Cs. melanura*) on each sampling date. Date is day of CO_2 trap pick up.

Table 4.8 Comparison of adult control material usage in 2021 and 2022

	2021		2022	
Material	Gallons used	Acres treated	Gallons used	Acres treated
Permethrin	22.15	113	65.21	334
Sumithrin*	6.03	257	17.31	722
Etofenprox*	25.38	2,166	7.44	640
Total	53.56	2,536	89.96	1,696

* Products labeled for use in agricultural areas

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.

2023 Plans for Mosquito Control Services

Integrated Mosquito Management Program

In 2023, 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, maximizing mosquito control services given available resources, restoring all services cut in 2017, and complying with all NPDES-related permit requirements. Our control materials budget in 2023 will remain the same as in 2022.

Larval Control

End of Temporary Measures to Decrease Expenditures In 2022, we had planned on restoring all service reductions first implemented in 2017. This included allocating more resources in P2 for cattail mosquito control. Due to drought conditions, we were unable to truly put this plan into place. In 2023, we are planning on restoring all services reductions, including more larval treatments in P2.

Floodwater Mosquitoes The primary control material will again be *Bti* corn cob granules. Larvicide needs in 2023, mainly *Bti* (VectoBac® G), Altosid® P35, Natular® G30, and MetaLarv® S-PT, are expected to be similar to the five-year average larvicide acreage usage (188,888 acres). In 2023, we plan to continue the spring *Aedes* larval threshold used in 2022 (1 per dip in both P1 and P2) and consider expanding P2 treatments as resources allow to reduce potential JCV vectors in areas where human populations are present. Depending on the environmental conditions, we plan to treat spring *Aedes* sites with *Bti* at either 5 lb/acre or 8 lb/acre and determine which *Bti* dosage to use when we switch to the summer *Aedes* threshold. As in previous years, to minimize shortfalls, control material use may be more strictly apportioned 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 with Natular® G30, methoprene products (Altosid® P35, Altosid® briquets, MetaLarv® S-PT), or *Bti* (VectoBac® G). 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 2022 (Table 4.2).

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). The new adult treatment threshold for *Ae. japonicus* is two for all sampling methods.

Ground and aerial larvicide treatments of wetlands have been increased to control *Culex* species. Catch basin treatments control *Cx. restuans* and *Cx. pipiens* in urban areas. Most catch basins will be treated with Altosid® P35. 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 Altosid® P35 treatments by June 24 with subsequent Altosid® P35 treatments every 30 days thereafter.

Cattail Mosquitoes In 2023, control of *Cq. perturbans* will use a strategy similar to that employed in 2022. MMCD will focus control activities on the most productive cattail marshes near human population centers. Altosid® briquet applications will start in February or 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® P35 and MetaLarv® S-PT to minimize per-acre treatment costs. Beginning in late May, staff will apply Altosid® P35 (3 lb/acre) and MetaLarv® S-PT (3 lb/acre) aerially and by ground. Staff will complete late summer VectoLex® FG applications (15 lb/acre), based upon site inspections completed between mid-August and mid-September.

Adult Mosquito Control

Staff will continue to review MMCD's adulticide program to ensure effective resource use and to minimize possible non-target effects. 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 the public.

Additional plans are to:

- use Anvil® (sumithrin) and Zenivex® (etofenprox) as needed to respond to elevated levels of adult mosquitoes as needed
- use Anvil® and Zenivex® as needed to control WNV vectors including in agricultural areas because current labels now allow applications in these areas
- evaluate possible adulticide use in response to *Ae. japonicus* and *Cs. melanura*
- ensure all employees who may apply adulticides have passed applicator certification testing for both restricted and non-restricted use products
- review monarch ecological information available from groups including Monarch Joint Venture to account for seasonal events such the monarch migration in late summer when planning adult mosquito control

- review MMCD’s adulticide policy to understand: 1) how these control methods fit in our IPM plans; 2) how we can use control methods to help protect pollinators and endangered species; 3) how these control methods are viewed by public opinion, and 4) employee's considerations of their use in our organization

Chapter 5 *Black Fly Control*

2022 Highlights

- Made 55 small stream treatments with *Bti* when the *Simulium venustum* or *S. tuberosum* larval populations met the treatment threshold; a total of 24.1 gallons of *Bti* were used
- 2022 was the second year that *S. tuberosum* larval populations were treated
- Made 46 *Bti* treatments on the large rivers when the larval population of the target species met the treatment threshold; a total of 3,585.9 gallons of *Bti* was used
- Monitored adult populations using overhead net sweeps and CO_2 traps; the average black fly/overhead sweep count was 0.57
- Placed multiplate samplers on Mississippi River for non-target invertebrate monitoring study

2023 Plans

- Monitor larval black fly populations in small streams and large rivers and apply *Bti* when treatment thresholds are met
- Monitor adult populations by the overhead net sweep and CO_2 trap methods
- Continue monitoring *Simulium tuberosum* larval and adult populations to understand its distribution and abundance better
- Process non-target study monitoring samples from Mississippi River

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 by staff at 201 small stream and 31 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 following MMCD's permit from the Minnesota Department of Natural Resources (MNDNR).

The small stream treatment program for *Simulium venustum* began in 1984. *Simulium tuberosum* was included in the small stream treatment program for the first time in 2021 due to the increased population of this human-biting species in recent years. Based on the success of a pilot *S. tuberosum* treatment program in five small streams in 2021, the MNDNR permitted up to two *S. tuberosum Bti* treatments at any of the small stream sites listed on MMCD black fly permit that meet the treatment threshold in 2022. A second treatment is allowed for *S. tuberosum*, because there is more than one annual cohort. 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 and treatment locations are shown in Figure 5.1.

2022 Program

Small Stream Program: *Simulium venustum* and *Simulium tuberosum* Control

Simulium venustum and *S. tuberosum* are human-biting black flies that develop in small streams in the MMCD and are targeted for control. *Simulium venustum* has one cohort during the spring and *S. tuberosum* is multivoltine with two or more cohorts. Adults of *S. venustum* and *S. tuberosum* first appear in early to mid-May.

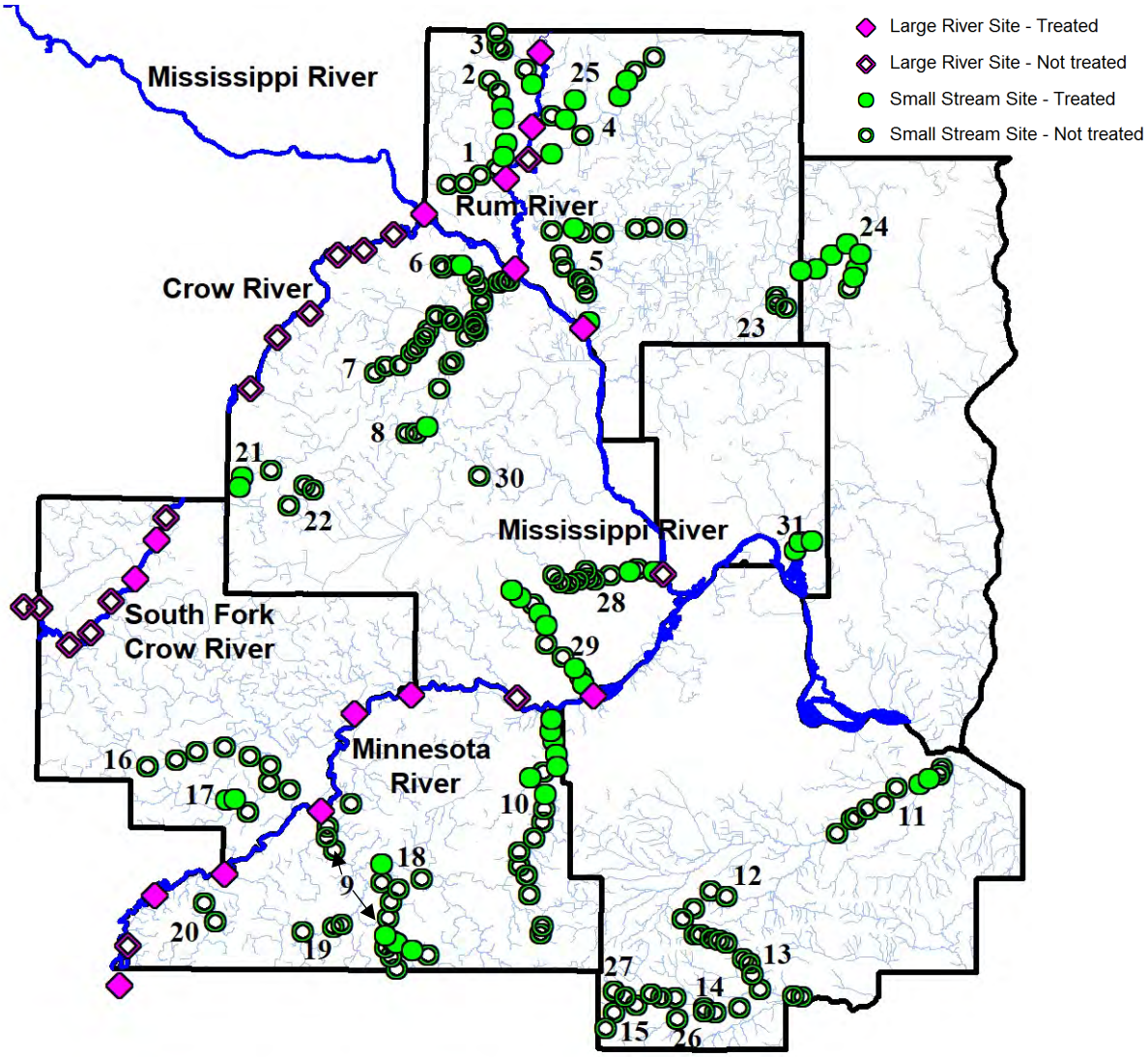


Figure 5.1 Large river and small stream black fly larval monitoring and treatment locations, 2022.

Note: the large river site located outside the District on the Mississippi River is for monitoring only. Since 1991, more than 450 of the 600+ original small stream treatment sites were eliminated from the annual small stream sampling program due to the increased treatment threshold and 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* or *S. tuberosum* populations. The numbers on the map refer to the small stream names listed below:

1=Trott	7=Rush	13=Chub N. Br.	19=Raven W. Br.	25=Ditch 19
2=Ford	8=Elm	14=Chub	20=Robert	26=Chub Trib. 1
3=Seelye	9=Sand	15=Dutch	21=Pioneer	27=Dutch Trib. 1
4=Cedar	10=Credit	16=Bevens	22=Painter	28=Minnehaha
5=Coon	11=Vermillion	17=Silver	23=Clearwater	29=Nine Mile
6=Diamond	12=Vermillion S. Br.	18=Porter	24=Hardwood	30=Plymouth
				31=Battle

Sampling to assess larval populations of *S. venustum* and *S. tuberosum* for treatment thresholds at the MNDNR-permitted small stream sites was conducted between late April and mid-June using MMCD's standard sampling technique. A total of 350 monitoring samples were collected. The treatment threshold was 100 larvae per sample for both species.

In early May, twenty-nine sites on twelve small streams met the treatment threshold for *S. venustum* and these sites were treated once with a total of 15.24 gallons of VectoBac® 12AS *Bti*. The treatment threshold for *S. venustum* was also met once in early May on the Rum River and it was treated with 20.0 gallons of *Bti*. Data for *S. venustum* monitoring and *Bti* treatments on the Rum River are tallied with the large river totals in accordance with the MNDNR permit.

In early May, eleven sites on four streams met the treatment threshold for *S. tuberosum* and 5.51 gallons of *Bti* were used to treat these sites. A second cohort of *S. tuberosum* was treated at 15 sites in mid-June on five streams using 3.33 gallons of *Bti*.

A total of 24.1 gallons of *Bti* was applied to the small streams in 2022. In comparison, the average amount of *Bti* used to treat small stream sites annually during 1996-2021 was 28.3 gallons (Table 5.1).

Table 5.1 Summary of *Bti* treatments for black fly control by the MMCD in 2022 versus long-term average

	2022			Long-term average[1]		
Waterbody	No. sites treated	Total no. treatments	Gal. of *Bti* used	No. sites treated	Total no. treatments	Gal. of *Bti* used
Small stream	49	55	24.1	44.8	44.8	28.3
Large river						
Mississippi	2	10	1,098.1	2.1	10.4	1,133.2
Crow	0	0	0.0	2.1	5.1	93.6
S. Fork Crow	2	2	20.0	5.7	12.1	104.4
Minnesota	7	12	2,333.3	6.0	16.2	1,718.8
Rum	4	22	134.5	3.3	19.5	143.7
Large river totals	15	46	3,585.9	17.2	59.1	3,157.5

[1] The Mississippi, Crow, Minnesota, Rum, and small stream averages are from 1996-2021. The South Fork Crow average is from 2005-2021.

Large River Program

The MMCD targets larval populations of the large river black fly species that are pests of humans for control with *Bti*. *Simulium luggeri* larvae occur mainly in the Rum and Mississippi rivers, although smaller numbers are also found in the Minnesota, Crow, and South Fork Crow rivers. Depending on river flow, *S. luggeri* larvae are present from mid-May through September. *Simulium meridionale* and *S. johannseni* larvae occur primarily in the Crow, South Fork Crow, and Minnesota rivers. These species are most abundant in May and June, although *S. johannseni* emerge earlier than *S. meridionale*. *Simulium johannseni* are univoltine. *Simulium meridionale*

are multivoltine with the largest numbers occurring in the first cohort in May and June, but populations can also be high throughout the summer if river flows are sufficient for good larval production.

Larval black fly populations were monitored weekly between May and mid-September using artificial substrate samplers (Mylar tapes) at the 31 sites permitted by the MNDNR on the Rum, Mississippi, Crow, South Fork Crow, and Minnesota rivers in 2022. 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 are the same treatment thresholds that have been used since 1990.

A total of 476 larval monitoring samples were collected from the large river sites in 2022. The treatment threshold was met in 46 samples from 15 of the permitted sites; the associated sites were treated with a total of 3,585.9 gallons of VectoBac® 12AS *Bti* (Table 5.1). The average amount of *Bti* used annually for the large river treatments between 1996 and 2021 was 3,157.5 gallons. The average number of treatments done annually from 1996 to 2021 was 59.1 at 17.2 sites (Table 5.1).

The average monthly flows between April and September on the Rum, Mississippi, Minnesota, Crow, and South Fork Crow rivers were 17%, 41%, 15%, 12%, and 3% above the long-term average, respectively. Overall, most rivers had near or above average flows in April and May with levels falling below average by August.

Twenty gallons of *Bti* were used for treatments on the South Fork Crow River in 2022. This was the smallest amount of *Bti* used on the South Fork Crow since treatments began on the river in 2005 (Table 5.1). No treatments were done on the Crow River in 2022. This last occurred in 2010. The black fly populations on both these rivers were likely negatively affected by the drought conditions which occurred in the Twin Cities metro area and areas west of the metro during the summer in 2022. When stream flow is reduced because of drought, black fly production declines, which results in fewer treatments because treatment thresholds are not met. Secondly, since the amount of *Bti* needed to achieve the prescribed dose of 25 ppm for a large river treatment is directly proportional to stream flow, less *Bti* is required for a treatment if the treatment threshold is reached during drought conditions. The amount of *Bti* used to treat the Mississippi and Rum rivers was about average in 2022 since the watersheds for these rivers in northern MN were not impacted by drought conditions like they were during 2021.

The efficacy of the VectoBac® 12AS *Bti* treatments was measured by determining larval mortality 250 m downstream from the application point 24 hours after most treatments in 2022. Post-treatment mortality was 98% on the Minnesota River, 98% on the Rum River, and 100% on the Mississippi River. Check-backs were not done following the two treatments on the South Fork Crow River.

Adult Population Sampling

Daytime Sweep Net Collections The adult black fly population was monitored at 54 standard stations (Figure 5.2) using the District's black fly over-head net sweep technique that was established in 1984. Prior to 2004, samples were taken twice weekly. Since then, samples have been taken once weekly from early May to mid-September, generally between 8:00 AM and 10:00 AM. The average number of all species of adult black flies captured in 2022 was 0.57/sweep (± 3.19 SD). In comparison, the average of all species captured in net sweeps from 1996 (the start of operational *Bti* treatments) to 2021 was 1.24/sweep (± 0.80 SD). Between 1984 and 1986, when no *Bti* treatments were done on the large rivers, the average number of all species of adults captured in the net sweeps was 14.80/sweep (± 3.04 SD) (Table 5.2).

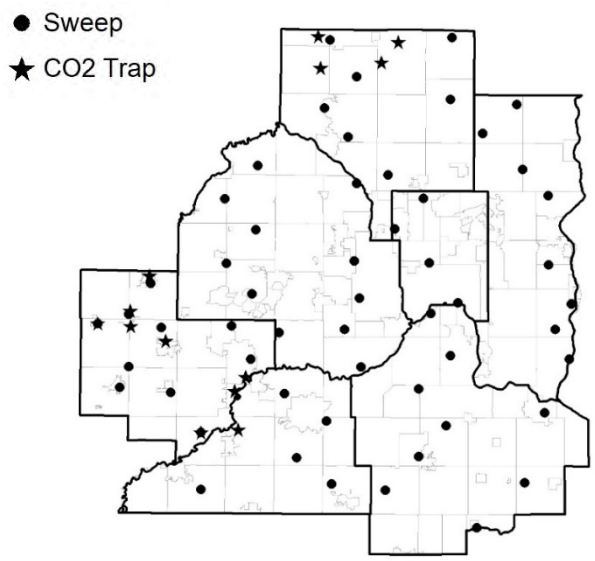


Figure 5.2 Standard overhead sweep net sampling locations (n=54) and CO_2 trap (n=13) sampling locations, 2022.

The county with the highest number of total black flies captured in the sweep net monitoring samples was Anoka County, where a mean of 1.34 (± 7.48 SD) per sample for all species was recorded. The county with the second-highest sweep net count for total black flies was Hennepin County, where the mean was 0.89 (± 3.09 SD) per sample. Washington County was the third-highest county for the net sweep count of total black flies with a mean of 0.47 (± 1.33 SD) per sample.

The most abundant black fly species collected in the overhead sweep net samples in 2022 was *S. luggeri*, comprising 59.7% of the total black fly adults captured with an average of 0.34 (± 3.02 SD) per sample. The second most abundant black fly species captured were *S. meridionale,* comprising 31.3% of the total with an average of 0.18 (± 0.91 SD) specimens per sample. The third most abundant black fly species captured was *S. venustum*, comprising 5.1% of the total with an average of 0.03 (± 0.28 SD) per sample. Very few *S. tuberosum* were collected in 2022, comprising just 0.18% of the total captured in overhead sweep net samples.

Simulium luggeri was most numerous in Anoka County and Hennepin County sweep samples. The mean number of *S. luggeri* per sample was 1.25 (± 7.38 SD) in Anoka County and 0.80 (± 3.00 SD) in Hennepin County. *Simulium meridionale* was most abundant in the Washington County samples, with a mean of 0.44 (± 1.33 SD) per sample. Dakota County had the second-highest number *S. meridionale* with a mean of 0.29 (± 1.41 SD). *Simulium venustum* was most abundant in the Scott County samples, with a mean of 0.12 (± 0.52 SD) per sample.

Table 5.2 Mean number and standard deviation (SD) of black fly adults captured in over-head net sweeps taken at standard sampling locations 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 ± SD			
		All species[5]	*Simulium luggeri*	*Simulium johannseni*	*Simulium meridionale*
No treatments	1984-1986	14.80 ± 3.04	13.11 ± 3.45	0.24 ± 0.39	1.25 ± 0.55
Experimental treatments	1987-1995	3.63 ± 2.00	3.16 ± 2.05	0.10 ± 0.12	0.29 ± 0.40
Operational treatments	1996-2021	1.24 ± 0.80	0.91 ± 0.76	0.01 ± 0.02	0.20 ± 0.27
	2022	0.57 ± 3.19	0.34 ± 3.02	0.001 ± 0.03	0.18 ± 0.91

[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 2005 when permits were received from the MNDNR for treatments on the South Fork Crow River.

[5]All species includes *Simulium luggeri*, *S. meridionale*, *S. johannseni*, and all other black fly species collected.

Black Fly-Specific CO_2 Trap Collections Adult black fly populations were monitored from mid-May through June in 2022 with CO_2 traps set twice weekly at four stations each in Scott and Anoka counties and five stations in Carver County (Figure 5.2). The adult black fly populations at these stations have been monitored with CO_2 traps since 2004. Black flies captured in the CO_2 traps were preserved in alcohol.

A total of 33,969 black flies were captured in the CO_2 traps in 2022. The most abundant species collected in 2022 was *S. meridionale,* with a total of 30,963 specimens that comprised 91.2% of the total black flies collected in the CO_2 samples. *Simulium venustum* was the second most abundant species collected, with a total of 1,818 specimens that comprised 5.4% of the total collection. The third most numerous species collected was *S. johannseni* with a total of 761 specimens that comprised 2.2% of the total. A total of only three *S. tuberosum* and 51 *S. luggeri* were captured in 2022, comprising <0.01% and 0.15% of the total collection, respectively. Table 5.3 lists the mean number of *S. meridionale, S. johannseni,* and *S. venustum* captured in the CO_2 traps in Anoka, Scott, and Carver counties since the trapping program began in 2004.

Table 5.3 Mean number of adult *Simulium venustum*, *S. johannseni*, and *S. meridionale* captured in CO_2 traps set twice per week between May and mid-June in Anoka, Scott, and Carver counties, 2004-2022[a]. Standard deviation (SD) is for 2022 only

	S. venustum			*S. johannseni*			*S. meridionale*		
Year	Anoka	Scott	Carver	Anoka	Scott	Carver	Anoka	Scott	Carver
2004	0.89	2.25	0.25	5.11	0.17	32.93	14.09	0.65	327.29
2005	2.31	3.40	0.84	0.03	3.50	99.04	1.23	23.25	188.02
2006	22.80	3.38	1.82	0.75	38.07	98.75	0.75	10.50	107.53
2007	37.62	35.59	75.67	0.20	32.50	112.77	0.51	172.48	388.64
2008	13.84	228.93	169.63	0.13	20.18	95.63	0.68	75.03	359.02
2009	18.32	238.16	425.00	0.34	22.80	35.92	0.70	98.77	820.25
2010	21.75	44.60	77.00	0.03	6.18	219.38	0.05	256.90	271.08
2011	8.90	60.64	48.30	2.61	280.64	4,584.72[b]	0.93	311.55	268.28
2012	2.89	5.45	0.40	0.95	81.73	154.13	0.41	242.55	100.53
2013	14.61	3.09	1.44	1.18	4.88	14.03	0.00	111.45	322.43
2014	13.64	16.82	8.68	3.36	12.36	702.82	1.32	12.64	193.57
2015	9.83	1.14	0.43	0.37	35.17	12.43	0.17	23.31	161.30
2016	1.70	0.72	0.02	1.50	2.89	35.41	0.86	64.33	501.85
2017	7.48	2.56	1.42	6.17	6.86	71.08	1.00	38.94	298.54
2018	9.79	3.87	4.94	0.00	4.09	280.79	1.36	160.06	436.58
2019	6.89	6.72	0.48	0.53	2.43	3.70	2.36	11,347.24	3,318.10
2020	8.15	40.25	0.41	0.26	5.36	72.85	2.26	386.04	734.85
2021	5.24	13.61	0.61	0.11	0.89	22.53	0.65	83.78	53.08
2022	14.66	21.74	1.95	0.02	0.49	13.40	1.13	185.49	403.49
SD	±28.00	±48.68	±4.87	±0.15	±1.76	±35.28	±2.69	±422.18	±1,257.90
No. Traps	4	4	5	4	4	5	4	4	5

[a]Traps were set once per week in 2020 due to the COVID-19 pandemic.

[b]On May 24, 2011, over 140,000 black flies were collected in the New Germany, Carver County trap.

Simulium tuberosum Small numbers of larvae and adult *S. tuberosum* have been found in larval and adult monitoring samples since the black fly program began in 1984, but until recently they have not been abundant enough to be considered a pest of humans. However, in recent years, the number of *S. tuberosum* in both larval and adult monitoring samples have increased, particularly in Hennepin County, and parts of Scott, Dakota, and Ramsey counties. Between 2011 and 2014, the percentage of *S. tuberosum* collected in District sweep net monitoring samples was less than 1% annually. From 2015-2021, the percentage of *S. tuberosum* in the sweep net samples has ranged between 1.6 and 7.8% (Figure 5.3). Coincident with this increase, the District started receiving large numbers of complaints from the public concerning biting black flies (locally called gnats) (Figure 5.4). Field investigations of complaints about pestiferous black flies indicated that the species responsible was likely *S. tuberosum.*

In response to the outbreak of *S. tuberosum*, the District requested an addendum to its 2021 small stream permit from the MNDNR for a pilot study to treat *S. tuberosum* at twenty-five sites on five small streams when the treatment threshold of 100 larvae per standard sample was reached. As part of this study, the MMCD also conducted enhanced larval sampling for *S. tuberosum* in the small streams throughout the District to better understand its distribution. Follow-up investigations of the 2021 customer complaint areas in Savage and southern Bloomington

showed large populations of both larval and adult *S. tuberosum*, particularly in the Credit River and Nine Mile Creek.

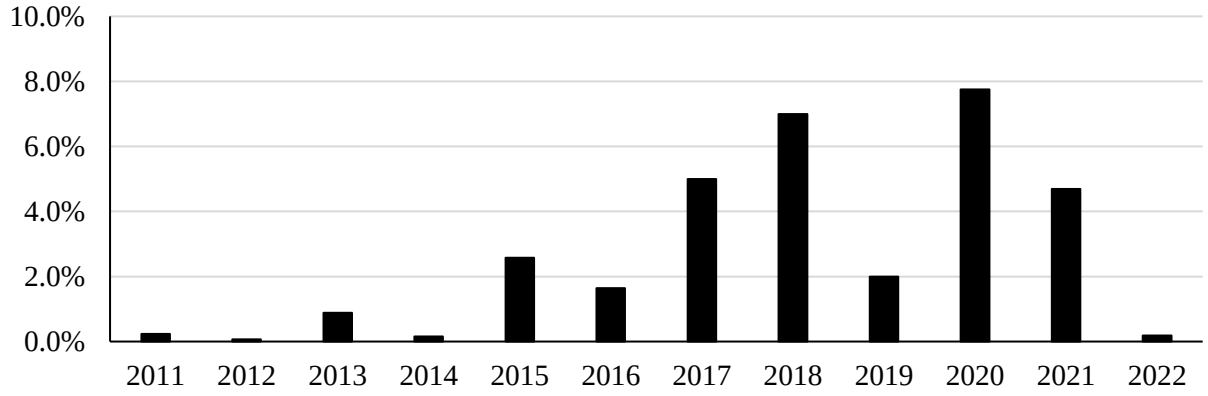


Figure 5.3 Percentage of *Simulium tuberosum* collected in the standard overhead net-sweep monitoring samples, 2011-2022.

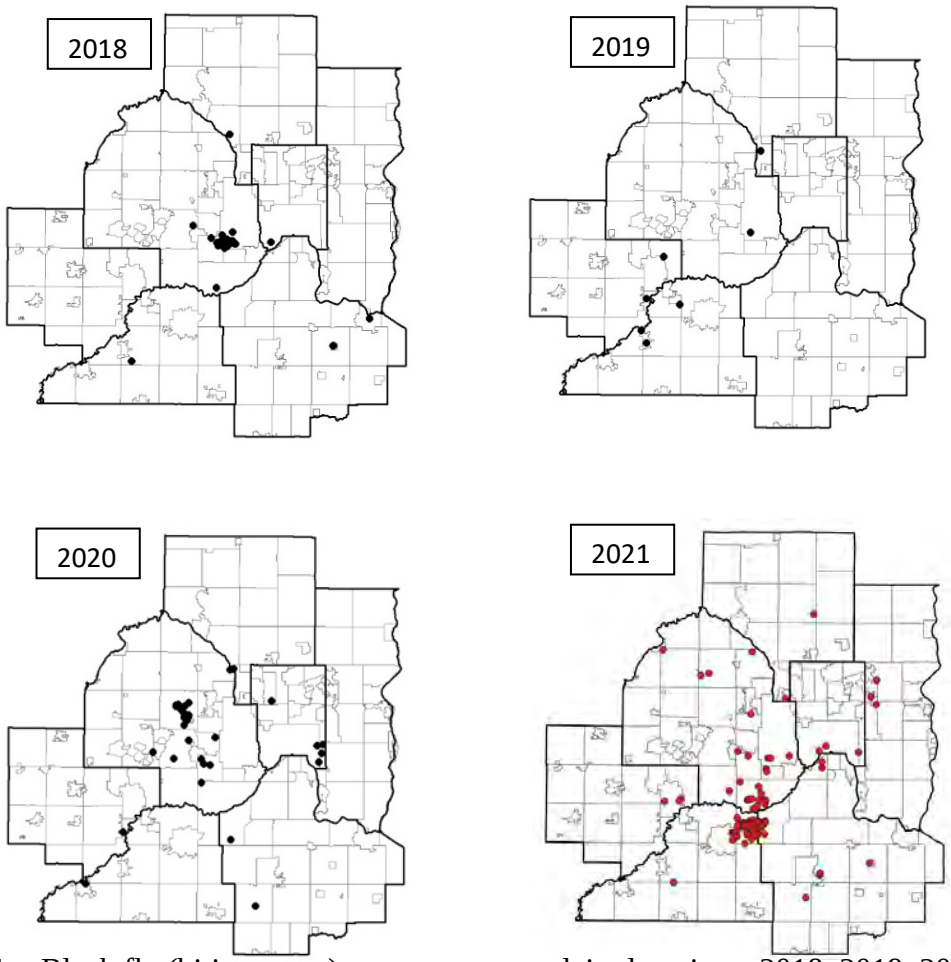


Figure 5.4 Black fly (biting gnats) annoyance complaint locations, 2018, 2019, 2020, and 2021.

Based on the results of the *S. tuberosum* study and pilot treatments in 2021, the District's 2022 MNDNR permit allowed for up to two *Bti* treatments for *S. tuberosum* at any permitted small stream site when the treatment threshold was met. This was the first year since the increased populations of *S. tuberosum* began in 2015 that treatments were allowed on any of the permitted small stream sites where the threshold was met, including neighborhoods near the Credit River in Savage and Nile Mile Creek in Bloomington where *S. tuberosum* production was particularly high. A total of 15 treatments for *S. tuberosum* were done on the Credit River and Nine Mile Creek between May 5 and June 17 in 2022. Subsequently, the number of black fly annoyance complaints received by the District in 2022 was 11 compared with the record high of 151 in 2021, when only one site on Nine Mile Creek was treated (Figure 5.5). The percentage of adult *S. tuberosum* collected in the sweep samples in 2022 was 0.18%, which is close to the levels found prior to 2015 (Figure 5.3). Both 2021 and 2022 were drought years so the low number of *S. tuberosum* adults in 2022 could be due to various factors, such as drought or the success of *Bti* treatments for reducing larval abundance.

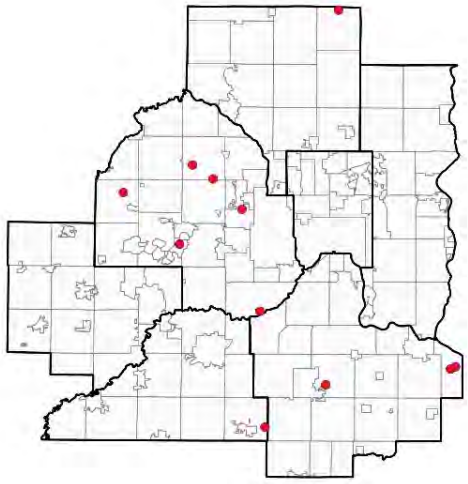


Figure 5.5 Black fly (biting gnats) annoyance complaint locations, 2022.

Monday Night CO_2 Trap Collections Black flies captured in District-wide weekly CO_2 trap collections were counted and identified to family level in 2022. 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 5.6. The areas in dark gray and black represent the highest numbers collected, ranging from 250 to more than 500 per trap. High to moderate levels of black flies were observed in May through mid-June in parts of Carver, Scott, and Dakota counties (Figure 5.6). The peak average number of black flies occurred on June 14 (Figure 5.7). The average number of black flies was below the 15-year average the entire season.

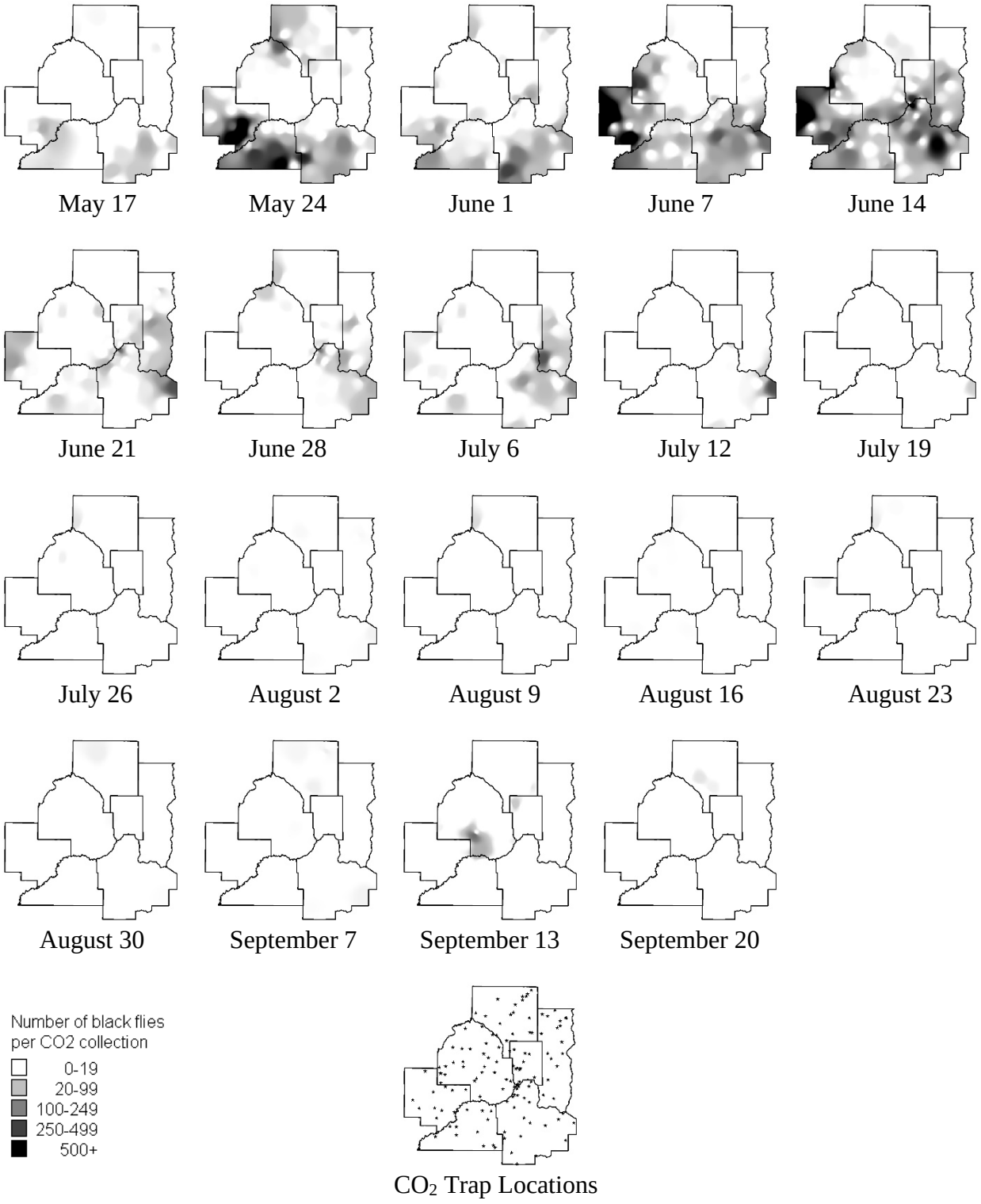


Figure 5.6 Number of black flies collected in mosquito surveillance District low (5 ft) and elevated (25 ft) CO_2 traps, 2022. The number of traps operated per night varied from 114-133. Inverse distance weighting was the algorithm used for shading of maps.

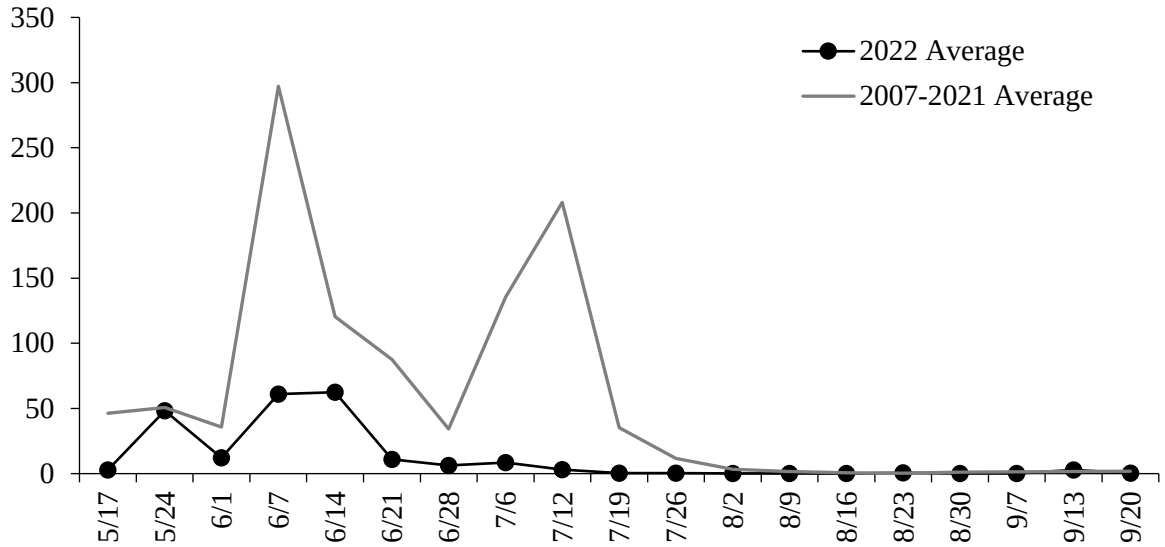


Figure 5.7 Average number of black flies per Monday Night Network CO_2 low trap, 2022 vs. 15-year average (2007-2021).

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 is a long-term assessment of the macroinvertebrate community in *Bti*-treated reaches of the Mississippi River within the MMCD. Results compiled from the thirteen separate years that monitoring samples were collected biennially between 1995 and 2019 indicate that no large-scale changes have occurred in the macroinvertebrate community in the *Bti*-treated reaches of the Mississippi River.

The drought in the spring and summer of 2021 led to flows in the Mississippi River that were too low for proper deployment of the Hester-Dendy multiplate macroinvertebrate samplers for the scheduled biennial non-target sampling study. The MMCD consulted with the MNDNR about this situation, and it was mutually agreed to delay sampling until 2022. The monitoring samples were collected in 2022. These samples are being processed and a report is scheduled to be submitted to the MNDNR in spring 2024.

2023 Plans – Black Fly Program

2023 will be the 39th year of black fly control in the District. The primary goal in 2023 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. The 2023 black fly control permit application will be submitted to the MNDNR in February. Processing of Hester-Dendy multiplate samples collected in 2022 for the non-target invertebrate monitoring program on the Mississippi River will continue.

Studies on the distribution, abundance, and ecology of immature and adult *S. tuberosum* will continue to increase the District's understanding of this species. The MMCD will continue to communicate cooperatively with the MNDNR to develop an effective and environmentally sound strategy to reduce the impacts on humans that has been caused by the recent increase in the numbers and range of this species in the Twin Cities area. Program development will continue to emphasize improvements in effectiveness, surveillance, and efficiency.

Chapter 6 Product & Equipment Tests

2022 Highlights

- 5-lb/acre dosages of VectoBac® G *Bti* achieved limited control of spring *Aedes* and *Aedes vexans* in air sites
- Two automated systems for identifying and sorting mosquitoes were reviewed by Technical Services

2023 Plans

- Collect more efficacy data to evaluate spring *Aedes* and *Aedes vexans* treatments in air sites
- Evaluate the resized MetaLarv® granule in our operations
- Evaluate two 7-day products: Natular® G and Duplex™
- Evaluate expansion of our drone program as it is utilized in multiple facilities
- Evaluate the DJI Agras T10 drone platform
- We will work with various workgroups over the winter, and they may have some recommendations to address in the 2023 season

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.

2022 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 conducted certification testing of one larvicide. Our goal is to determine that different larvicides can control two or more target mosquito species (i.e., nuisance or disease vector) in multiple control situations. These additional control materials 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".

The manufacturer's certificates of analysis at the time of manufacture for samples of all control materials shipped to MMCD in 2022 were all within acceptable limits (Table 6.1).

Table 6.1 AI content of methoprene products: Altosid® briquets, Altosid® P35 granules, and MetaLarv® S-PT granules, 2022

		AI content		
Product evaluated	No. samples analyzed	Label claim	Analysis average	SE
Altosid® XR-briquets	5	2.10%	2.23%	0.0279
Altosid® P35 granules	22	4.25%	4.24%	0.0184
MetaLarv® S-PT granules	6	4.25%	4.33%	0.0466

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. Due to no additional adulticide purchases, MMCD did not sample adulticide products or save 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 2022. Aerial *Bti* treatments to control the spring *Aedes* brood began on May 6, thirteen days later than in 2020 and 2021. All applications used the 5 lb/acre rate to conserve funds. In 2022, aerial *Bti* treatments averaged 78.3% control (Table 6.2), comparable to 84.8% in 2021, 88.0% in 2020, 85.9% control in 2019, 88.0% control in 2018, 84.5% control in 2017, 86.0% control in 2016, 83.7% control in 2015, and 90.4% control in 2014. Percent mortality was calculated by comparing pre- and post-treatment dip counts.

Table 6.2 Efficacy of aerial VectoBac® G applications (5 lb/acre) during the 2022 mosquito season (n = number of sites dipped)

Time period	Dosage rate	n	Mean mortality	±SE*
April 22-August 31	5 lb/acre	371	78.3%	1.8%

*SE= standard error

The lower control rate in 2022 was noted by staff in our first spring application. An investigation of low control rates was initiated in our North region. Drought conditions created dry overhanging vegetation that shielded the open water, and it was theorized that the *Bti* granules did not reach the water surface at a rate high enough to provide adequate control. Low water temperatures most likely contributed to slow mosquito feeding activity which may have factored into the lower control rates. Staff was asked to conduct additional checkbacks during this early spring period. A workgroup will be reviewing this issue and will plan an evaluation for 2023.

New Control Material Evaluations

The District, as part of its continuous quality improvement philosophy, strives to continually improve its control methods. Testing in 2022 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. The reduced number of seasonal employees hired because of the COVID-19 pandemic limited the amount of research testing that could be completed in 2022.

Larval Control

In 2022, in addition to reduced staffing levels, control material research was limited due to the availability of new control materials that would meet our operational needs. Teams were restructured in 2022, a new Technical Services Manager was hired, and most of the staff time was used to revisit and update our IPM plans. Therefore, there was a limited focus on product evaluations during the 2022 season.

MetaLarv® S-PT granules Valent BioSciences informed MMCD that the current base granule size would be unavailable in the 2023 season. Their vendor will no longer be producing this size granule and it is not available in the marketplace. Therefore, Valent will be using a smaller granule in their base matrix. Valent approached MMCD with two size options. The change of the size of the granule would have the greatest impact in our helicopter applications and an evaluation was set-up to characterize the swath patterns of these material options in Le Sueur, MN. Both products were evaluated and both products were able to provide adequate swath patterns at a 3 lb/acre rate. The larger of the two options was chosen for the new product matrix. This larger granule was viewed to be less affected by wind conditions which would limit product drift during helicopter operations. MMCD purchased their remaining 2022 product and will run direct comparisons with the new 2023 product during the upcoming season.

Natular® G30 granules MMCD staff requested an updated evaluation of the Natular G30 product to review its efficacy in field operations. An evaluation protocol was developed but dry conditions limited the ability to collect relevant data on the 30-day duration of the product. Further evaluation was postponed until environmental conditions improved.

Adulticide Tests

We did not complete any tests of adulticides in 2022 because of staff limitations due to the COVID-19 related issues and drought conditions producing low number of adult mosquitoes.

Equipment Evaluations

Automated Systems for Insect Identification and Pooling MMCD reviewed two automated systems for assistance with taxonomic identification and sample separation. Two companies visited our entomology lab and provided detailed overviews of their technology.

Vectech (www.vectech.io)

This compact unit (MosID) identifies mosquito species in a 24-sample tray. The tray is slid into the bottom of the unit and imaged. The tray is inverted and re-imaged. The photos are analyzed, and a species is determined using algorithms. The algorithms are based upon their inputted data on targeted species. The device connects to a computer via Wi-Fi and images/ID are downloaded automatically. The software can be customized to provide multiple data management options. Future updates include a conveyer option to view more samples without loading individual trays. Currently, the available mosquito species for this system were very limited and did not include many of our Midwest species. Therefore, the demonstrated IDs were not very accurate because many species were not in their database. While this is advanced technology, the capacity is not there currently to be helpful to MMCD on an operational scale.

Senecio Robotics (www.senecio-robotics.com/robotic-surveillance)
The Senecio Robotics automated identification and pooling system is a more advanced piece of imaging and sorting equipment. The device has multiple cameras that image insects moving down a conveyer belt and can sort and pool them by a pneumatic arm. The images are identified by algorithms built by their species database. We did not see a live demonstration but did see video presentations of the ID and sorting processes. The device is quite large with an 8 ft by 3 ft footprint and would require compressed air (either compressor or air tanks). The device connects to a computer via Wi-Fi and images/ID are downloaded automatically. The system has more advanced software options to link data with maps, data management, and other customized options. The system had a much broader range of inputted species data but did not include all the regional species. The company would need species samples to expand their database and requires about 1,000 identified insects to train their algorithm for each species. The instrument currently only IDs one sample at the time but a 12-sample carousel will be a future option. With this option, multiple samples could be automatically run overnight after the employees have completed their workday.

The technology is in its early stages of development. Neither system can currently identify adult black flies, ticks, or mosquito larvae. That may be a future option. A fully operational system that can identify all our species would be considered but staff could not justify the current benefits, significant expense, or the time and effort expended to help develop the vendor's products. MMCD may assist vendors by providing identified specimens to build their species databases.

Helicopter Swath Analysis and Calibration Procedures for Larvicides Technical Services and field staff conducted four aerial calibration sessions for dry, granular materials during the 2022 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 Le Sueur Municipal Airport in Le Sueur, MN and at Benson Airport in White Bear Lake, MN. Staff completed swath characterizations for seven different operational and experimental control materials. In total, six Jet Ranger helicopters were calibrated, and each helicopter was configured to apply an average of five different control materials.

Technical Services and Valent BioSciences technical staff conducted evaluations for a new matrix for MetaLarv® granules, (see page 3). Field applications and efficacy will be evaluated in 2023.

Drone Swath Analysis and Calibration Procedures for Larvicides Technical Services aided in aerial calibration sessions for the PrecisionVision 22 aerial treatment drone for dry, granular materials in field sites. Staff completed swath characterizations for two control materials applied in 2022 (Altosid® P35 granules and VectoLex® FG granules). The PrecisionVision 22 drone we utilized for aerial treatments has a hopper system that can manipulate the swath of the material applied by adjusting the voltage to the hopper. The hopper voltage, combined with the flight speed of the drone, and variously sized flow restrictors affect the swath characterization for the different control materials.

Malvern Laser: ULV Droplet Evaluations Technical Services continued the spray equipment workgroup to evaluate truck-mounted, UTV-mounted, backpack, and handheld ULV generators. We constructed a 20 ft x 40 ft indoor spray booth where we evaluate adulticide application equipment. Using the Malvern laser, staff continued to improve sampling procedures and techniques to evaluate the multiple types of spray equipment. MMCD analyzed the spray characteristics of all our ULV equipment and optimized each spray system with its respective control material. In 2022, Technical Services did not complete any spray evaluations. Due to the low numbers of adult mosquitoes the past two seasons, the spray equipment did not exceed the recommended hours of use for droplet characterization, but all product flow rates were verified prior to use.

Optimizing Efficiencies and Waste Reduction

Recycling Insecticide Containers MMCD continued to use the Minnesota Department of Agriculture's (MDA) insecticide container recycling program. The Ag Container Recycling Council program focuses on properly disposing of agricultural insecticide waste containers, thereby protecting the environment from related insecticide 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 the Rosemount warehouse for pickup by the MDA contractor, Consolidated Container. MMCD staff collected 82 jugs for this recycling program. The low number of containers were properly stored for future disposal. The control materials that use plastic 2.5-gallon containers are Anvil® 2-2 (8 jug), Zenivex® E4 RTU (3 jugs), and *Bti* liquid (71 jugs). A majority of the *Bti* liquid came in bulk totes, and the reduced overall use of adulticides due to the low mosquito numbers significantly reduced the number of jugs generated in 2022.

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.

Recycling Insecticide Pallets In 2022, MMCD produced over 266 empty hardwood pallets used in control material transport. Our warehouse staff worked with our vendors and arranged to return the pallets to the manufacturer for re-use. In doing so, MMCD reduced the need for the production of new pallets and helped to maintain lower control material costs for the District.

We are continuing to work with Valent BioSciences to explore using the recycled materials of our empty *Bti* and VectoLex FG bags to make plastic pallets. These reusable pallets would eventually replace the need for wood pallets and be more environmentally sustainable.

Bulk Packaging of Control Materials MMCD continued incorporating 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. We would like to eliminate a significant portion of these unrecyclable insecticide bags. Staff is attempting to keep these bags out of landfills, and instead directing them to garbage burner facilities where some public benefit of the generated waste can be realized.

The District continues to expand use of refillable totes in the helicopter loading operations. MMCD is working with three manufacturers to ship bulk larvicides in reusable pallet sized totes. In 2022, Central Life Sciences shipped Altosid® P35 granules (63,600 lb) in 53 totes and reduced the packaging by 1,590 bags. Valent sent MetaLarv® granules (44,000 lb) in bulk totes and reduced the packaging by 1,100 bags. Valent also sent VectoBac® 12-AS liquid (3,168 gallons) in bulk totes and reduced the packaging by 1,267 jugs. Staff was able to spend less time dealing with waste, and the District eliminated 3,957 containers from entering the waste stream. MMCD is attempting to reduce the amount of time and effort spent handling packaging after the product is used, allowing staff to focus more time on our primary missions.

Return of Packaging Waste In 2022, Valent BioSciences agreed to take back all of their products' waste packaging. Due to the quantity of *Bti* and VectoLex FG granules used (410,213 lb) and high bulk density of their products, Valent packaging is a significant portion of the waste produced annually by the District. This waste included product bags, pallets, boxes, and stretch wrap. All waste was packaged on specialized pallets and the manufacturer picked up these pallets periodically at our facility locations. Valent is working to recycle these multi-layered insecticide bags and thus, keep them out of landfills. MMCD greatly reduced waste disposal services and an estimated 14,306 lb was eliminated from the waste stream.

2023 Plans – Product and Equipment Testing

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 ensure 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 our mosquito control equipment.

We will review spring helicopter treatments to explore options to improve control. Dependent upon the outcome of workgroup recommendations, options may include changes in application rates, review of other control material options and use patterns, changes in flight parameters, or additional workgroup recommendations.

We will evaluate the new MetaLarv® granular size. A direct comparison will be conducted between the established 2022 formulation and the smaller 2023 formulation. Efficacy, product duration, and operational applicability will be reviewed.

We will evaluate two seven-day duration control materials: Natular® G (spinosad) and Duplex™ (*Bti* and methoprene). We will review their applicability in our operations and use in dry conditions where a shorter duration material may be a better economic choice.

We will attempt to collect additional efficacy data on our current operational control materials and provide more quality information to staff on which to base decisions.

MMCD purchased a second drone (DJI Agras T10) and will evaluate this different drone platform in our operations. The District will be expanding the operational drones to two or more facilities in 2023.

Chapter 7 Supporting Work

2022 Highlights

- Created two new seasonal positions for UAS (drone) pilots
- Number of larvicide treatments from a drone in regular operations doubled
- Rebuilt Mobile Map for field data and expanded map entry of new sites
- Built new catch basin treatment map and data system for mobile use
- Finished transition of desktop map software to QGIS
- Started major upgrade of field data system software interface
- Public Web Map use hit a new monthly high in June
- Calls requesting adult treatment were low again with low numbers of mosquitoes
- Many public events returned, and school visits expanded

2023 Plans

- Expand drone-based control applications with new 2nd treatment drone
- Continue major upgrade of data system interface and Mobile Map
- Continue consultations on northern long-eared bat and prepare for addressing other endangered species concerns

2022 Projects

Unmanned Aircraft Systems (Drones)

Unmanned aircraft systems (UAS) are used by many mosquito control agencies to check difficult-to-access mosquito habitats, capture aerial imagery, and apply insecticides. This technology is rapidly evolving, and rules and regulations are in place to protect the privacy and safety of humans and their property.

The drone workgroup at MMCD has coordinated staff training and explored options for drone use within the District. MMCD received a COA (Certificate of Waiver or Authorization) from the FAA in 2020 which grants us the ability to apply control materials from our treatment drone, and we renew that every two years. Currently, 10 full-time staff members are certified as UAS pilots under the FAA's Part 107 regulation for commercial use drones weighing less than 55 pounds. In addition, two obtained their Category B license (pesticide application with an aircraft) to treat sites via UAS in Minnesota.

In 2022, we continued to use our three, small quadcopters (Fig. 7.1) to update aerial photos in areas of recent construction and to investigate some wetlands difficult to explore on foot. They have also been used to make internal videos, take staff photos, and inspect unusual mosquito habitats like unmaintained swimming pools and water accumulating on rooftops.

Figure 7.1 DJI Mavic drone

We created two new seasonal positions (UAS Mosquito Technician) specifically for employees to utilize the treatment drone. These employees worked under the guidance of our current treatment drone pilots and obtained all necessary certifications to pilot and aerially apply insecticides in Minnesota.

In general, small sites (1-3 acres) were targeted for ground treatments. Some smaller and larger sites that are treacherous or very difficult to gain access were also treated by UAS. The treatment drone was calibrated for both Altosid® P35 and VectoLex® (see Chapter 6: Product & Equipment Tests).

In 2022, we doubled the number of treatments using Altosid® P35 compared to 2021 treating ~300 acres with slightly less than 900 lb of material (Table 7.1). VectoLex® treatments rebounded to 2020 levels with ~40 acres treated with ~650 lb of material. Staff remain enthusiastic about the treatment drone's ability to provide a quality treatment without the physical challenge of ground-based applications, especially in sites with high vegetation.

Table 7.1 Treatments by UAS for Altosid® P35 and VectoLex®, 2020-2022

	Altosid® P35			VectoLex		
Year	No. treatments	Acres treated	Pounds used	No. treatments	Acres treated	Pounds used
2020	34	48.19	127.72	29	39.50	592.45
2021	114	160.55	479.44	18	22.34	335.00
2022	228	299.53	882.79	29	43.47	651.20
3-yr Avg.	125.3	169.42	496.65	25.3	35.10	526.22

Use of drones can facilitate cost savings for the District by increasing efficiency of larval treatments through decreasing staff time in cumbersome sites and replacing costly briquet treatments at hard-to-treat cattail sites. Using drones to treat difficult and dangerous sites we believe has significant safety advantages as well as improving employee morale.

Plans for 2023 At the end of 2022, in preparation for the 2023 season, we purchased a second treatment drone, a DJI Agras T10. Having a second treatment drone should significantly increase the number of sites we can treat in a timely manner in 2023. We will continue using photo drones to update aerial imagery and to scout sites as needed. We would like to find better ways to determine water extent, which can be difficult to see in dense vegetation, but would facilitate partial treatments of large wetlands. Photo drones continue to be useful for investigating water holding areas and taking informational videos and provide staff with good practice at operating drones (from mission planning to flying to taking new imagery and incorporating these images into their maps).

Our primary activity for 2023 is continuing site treatments by drone and finding ways to expand the number of treatment pilots in a way that fits with our seasonal needs and hiring practices. We plan to continue testing under which scenarios UAS treatments are most advantageous; this includes continuing to replace briquet sites and seeing how helpful drone treatments are for pre-hatch control. Tests in 2020 suggested that drone use has the most benefit for increased staff efficiency when used on 1-3 acre sites. Smaller sites can often be done easily by ground, and larger sites can be done by helicopter. We tested the efficiency of drone treatments by comparing the time it takes to treat by drone versus traditional methods and estimate that drone treatments have the potential to treat ~90% more acreage than sites treated by hand in the same amount of time. In 2022, further comparisons of Altosid® P35 treatments by drone compared to by hand or by backpack revealed that it is over three times faster per acre to treat by drone. We may also

gather data on the uniformity of these treatments in 2023, but it appears that drone treatments provide a more uniform application of material across a site.

Data Systems & Mapping

In 2022, we continued upgrading our web-based enterprise data system "Webster" developed by Houston Engineering Inc.

- Our phone-optimized "Mobile Map" is becoming more central to users. It was rewritten on a different software base to improve performance, and now provides better ways to add new sites and photos, as well as access inspection and treatment information. It has expanded tools for sharing field information such as hazards, beehives, and dip locations. It provides easy access to driving directions for surveillance and treatment sites.
- We track over 300,000 catch basin treatments every year. This year we shifted individual catch basin treatment records from paper maps to a new digital map-based system. This allowed easier data input and access to treatment history, and improved monitoring and planning work (Fig. 7.2). Treatment entries are visible to other staff using the app, enabling new ways to coordinate work. The system was introduced at the beginning of the season and revised based on user feedback throughout the year. We also upgraded the catch basin editor map to the new map software base.
- The Webster interface and underlying database are on cloud-based servers. This year we continued to have issues with using an expandable server design ("serverless") and switched to fixed size, which has improved performance reliability but increased costs.
- We are expanding use of QGIS, our desktop mapping software, to access data in the Webster cloud database. For example, field staff were able to add their day's helicopter treatment sites to the real-time helicopter tracking map visible in the mobile app and see the current treatment status while the pilots were flying.

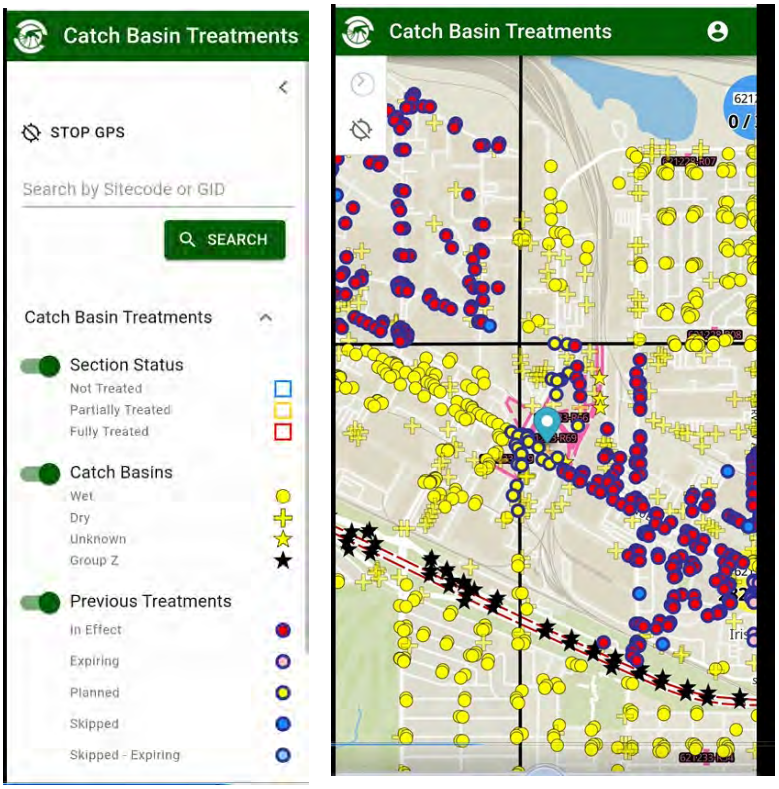


Figure 7.2 Catch basin treatment map interface in Webster

As part of an overall planning process, we were able to meet with data managers from five major California Mosquito Abatement Districts and compare our data systems. The results of this analysis of capabilities and costs was presented to MMCD Management Team, along with a proposal to expand upgrades for parts of the Webster interface that have been in service for over seven years. Interface upgrades started in the fall and will continue in 2023.

We are starting an internal wiki to make it easier to store, manage, share, find, and update information about MMCD data systems and other topics within MMCD. We are using the same software as used by Wikipedia, the open-source package MediaWiki. This is expected to be a major project in 2023. We hope to use it in part as an aid for knowledge transfer for new staff.

We continue to work toward QA and standardization of our extensive amounts of older data and look for better query and visualization tools to make new and historic data useful. This data is important for both our own evaluations and for sharing data with other researchers and practitioners regionally and beyond. For example, MMCD reached a data sharing agreement with a disease ecologist at Texas Tech University with the hope of relating *Culex* vector control operations within the District to quantify reductions of mosquito populations and WNV infection rates in mosquitoes.

Field staff completed switching their desktop geographic information system (GIS) for creating field maps to the open-source program QGIS, ending use of MapInfo. This has been a major re-learning effort, and we continued creating and using in-house training documentation and videos, as well as using extensive support available on the web. We are exploring the opportunities QGIS provides for new map products as well as desktop interaction with our cloud database. We are also working on ways to coordinate new Mobile Map site edit functionality and our desktop mapping.

We continue to support work-from-home options for many workers, especially in the off-season, through IT-managed remote access, through choosing platform-independent interfaces, and through choosing open-source options to simplify license issues.

Public Web Map MMCD's public access map on https://mmcd.org/district-maps/ continues to let people see wetland inspection and treatment activity on over 80,000 sites in real time and access history back to 2006. Inspection and treatment information is updated automatically from our data system. Web stats showed 3,578 access clicks, suggesting somewhat higher use than telephone calls, and a small decline from the 3,837 clicks in 2021. Over a third of 2022's visits to the District maps page came in June where we tracked 1,220 access clicks, which is the highest for any single month since the new website launched in Fall of 2019.

GIS Community MMCD staff participate in the MetroGIS collaborative, and we benefit from work by many other units of government. We are pleased to be getting access to 2022 spring aerial photos collected by metro-area counties for our wetland mapping. MMCD staff also participate in the Governor's Advisory Council Image Service Sustainability Committee. MMCD uses basemap and geocoder services from the Metropolitan Council and share our wetland data through MnGeo's Geospatial Commons.

Spring Degree Day Study

Spring temperatures described using degree-day (DD) accumulations continue to be a useful estimator for control activities. The DD model uses 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) gives the 'heat units' accumulated each day for that base (DD_{base}). These are then summed from an assumed start date of January 1.

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

Figure 7.3 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 1993-2022. 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 outlined box each year marks the first week with ≥ 200 DD, a number (chosen empirically from these data) approximating when spring *Aedes* larvae have sufficiently developed to warrant aerial treatment.

In 2022, the DD_{40F} total went over 200 in week 18 (ending May 7), relatively late compared to most dates in the last 20 years. Temperatures stayed warm after that, and summer *Aedes* egg hatch quickly followed. Aerial treatments for spring *Aedes* (gray boxes) began the week ending May 7 and were completed by May 21. Aerial treatments are not started until a sufficient number of sites are over threshold, seasonal technicians are hired, and helicopters have been calibrated.

Evaluating and Reducing Nontarget Risks

Previous Nontarget Work At the direction of the TAB, MMCD has done studies over the years on possible nontarget effects of the control materials we use. Studies on Natular® (spinosad) in vernal pools and cattail marshes done in 2014-2015 have been discussed in previous Annual Reports, and a publication based on that work was released in 2021. 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 website at https://mmcd.org/non-target-impact-studies/ and web use stats show it was downloaded 143 times in 2022 (about the same rate as most previous years).

Pollinators and Mosquito Control Pollinator populations (e.g., honeybees, native bees, butterflies, flies, beetles, etc.) are a matter of concern, and MMCD continues efforts to minimize negative effects on pollinators. Our larval control materials pose no risk to bees. The pyrethroids we use as fog or vegetation spray to control adult mosquitoes have label restrictions that protect pollinators and, when used correctly, are relatively low risk for bees. Staff are trained to recognize areas where pollinators may be active so they can adjust operations to minimize exposure. Beekeepers register hives through "BeeCheck", and we train our staff to check for those hives on DriftWatch (https://mn.driftwatch.org/map). MMCD staff watch for hive locations when doing field work and modify adulticide treatments as needed.

- 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	2016	2017	2018	2019	2020	2021	2022	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	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	0	0	0	0	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	0	0	0	0	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	0	0	0	0	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	0	0	0	0	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	0	0	0	0	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	0	13	0	0	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	6	41	0	0	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	6	41	0	0	0	0	0	LAST date
10	0	4	5	0	0	17	0	104	0	8	3	2	13	4	0	0	1	4	0	18	0	0	47	20	60	0	0	4	31	0	in week
11	0	9	61	12	0	17	2	104	0	8	19	3	13	4	20	2	30	49	6	135	0	3	76	104	60	0	0	16	39	8	(2022)
12	3	22	69	12	0	72	8	150	0	8	55	56	13	4	54	2	54	70	7	**306**	0	3	76	113	68	0	2	17	74	29	Mar 26
13	17	32	72	12	20	95	83	184	0	16	85	81	68	27	148	2	54	174	12	358	7	3	130	138	112	1	19	34	114	34	Apr 2
14	26	41	79	12	80	158	143	**209**	23	16	104	132	187	58	156	30	64	**236**	70	450	16	14	154	147	182	1	33	59	**234**	35	Apr 9
15	44	100	100	37	80	**234**	181	233	66	75	146	**209**	**300**	**209**	162	34	166	356	134	497	21	87	**290**	**244**	**268**	3	67	106	267	61	Apr 16
16	106	199	129	81	100	335	**231**	268	115	**220**	**233**	292	405	318	**281**	82	**249**	461	144	554	21	102	325	376	352	12	125	116	298	102	Apr 23
17	185	**245**	184	109	162	436	350	388	**213**	243	327	385	424	416	415	173	328	576	**200**	640	63	167	440	432	418	80	**222**	184	379	133	Apr 30
18	**331**	310	**273**	158	**225**	571	486	586	367	295	439	492	508	521	566	**213**	460	646	271	786	146	196	599	571	502	76	278	**316**	465	**221**	May 7
19	474	448	385	**220**	312	753	601	710	494	356	537	611	607	629	740	321	567	719	411	913	**267**	**302**	707	657	646	**241**	352	393	572	422	May 14
20	564	627	515	347	372	939	754	809	699	440	664	746	725	762	914	437	765	896	554	1112	434	378	812	790	785	400	483	483	774	565	May 21
21	689	796	637	492	490	1114	899	973	778	539	775	848	869	951	1075	545	923	1146	692	1280	570	527	979	1002	914	585	583	631	931	689	May 28
22	791	977	810	627	616	1210	1069	1111	910	755	939	1005	1059	1205	1274	690	1071	1341	905	1442	733	748	1148	1093	1095	808	748	823	1166	877	Jun 4

286 Average CumDD40 Aerial Treatment Start (1993-2022)
(we started treatments as early as 5 days prior to "Last date in week")

Figure 7.3 Cumulative Degree Days (base 40°F, 4.4°C) from January 1, MSP Airport.

Rusty Patched Bumble Bee - MMCD consulted with the U.S. Fish and Wildlife Service (FWS) in 2018 about the rusty patched bumble bee (*Bombus affinis*), an endangered species listed in 2017. Based on the bee's biology and the timing, location, and materials MMCD uses, the overall risk of MMCD's operations to the bee was very low (see report at https://www.mmcd.org/docs/publications/RustyPatchedBumblebeeReview.pdf). We continue to update our information about the bee and its habitats as that becomes available.

Monarch Butterfly - In December 2020, the FWS announced that the monarch was a candidate for listing under the Endangered Species Act, and its status would be reviewed annually. MMCD has been in active conversation with Monarch Joint Venture (MJV), a national nonprofit partnership of agencies and organizations working to protect monarch migration across the U.S. In 2020, we provided information on MMCD operations in relation to monarch protection that they used to revise their website F.A.Q. In July 2021, we provided a webinar for their group on the topic of "Aligning mosquito control with pollinator protection". That same month an education coordinator for MJV presented about monarch migration for MMCD staff at our annual pesticide applicator recertification workshop.

Northern Long-eared Bat - In December 2022, the FSW listed the northern long-eared bat (*Myotis septentrionalis*) as endangered under the Endangered Species Act. MMCD started consulting with the FSW in order to determine any potential impacts MMCD's control operations may have on the health of the northern long-eared bat. A complete list of the insecticides authorized for use by MMCD was supplied, and we are currently awaiting further consultation.

MMCD staff stay in communication with organizations such as the Beekeepers Association and MJV to update information and practices as needed.

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 insecticides to water, and Minnesota Pollution Control Agency (MPCA) procedures for pesticide NPDES permits are described at https://www.pca.state.mn.us/water/pesticide-npdes-permit-program. The checklist for mosquito control permits is given at https://www.pca.state.mn.us/sites/default/files/wq-wwprm9-05b.pdf.

MMCD's Pesticide Discharge Management Plan (PDMP), first submitted in 2011, describes contact people, target pests and data sources, thresholds and management, and steps to be taken to respond to various types of incidents. 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 website.

U.S. Fish & Wildlife Service – Mosquitoes and Refuges MMCD works with the 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." An annual analysis of adult mosquito counts around the MVNWR is done by MMCD staff based on the CO_2 trap locations in Figure 7.4.

Culex pipiens and *Cx. restuans* serve as the enzootic or maintenance vectors of WNV. Birds that move between the refuge and the surrounding area can be infected with WNV on or off the refuge then carry the virus to other areas and subsequently infect other mosquitoes on or near the refuge. As in 2021, drought conditions benefitted *Cx. pipiens* and *Cx. restuans*. While collections of the two species were not as high in 2022 as in 2021 in traps near the refuge, there were still a few collections of ten or more from traps 0.8 miles or further from the refuge. Larval habitats for these species include wetlands, stormwater management structures, and back yard containers. The mosquitoes likely originated near the traps where they were captured as both species have relatively short flight ranges.

The primary target species for surveillance on the MVNWR is *Culex tarsalis,* a competent vector of WNV to humans. *Culex tarsalis* adult captures across most of the MMCD service area were very low in 2022 with a season average of 0.41 per CO_2-baited light trap. The season's mean collection in traps near MVNWR was higher at 1.25, which is still quite low compared to other years. Trap H291 averaged 4.1 *Cx. tarsalis* per collection night for the season, no other trap averaged more than two *Cx. tarsalis* for the season. Larval habitats for this species tend to be larger wetlands with grassy borders where water stands for more than one week. The adult flight range is much longer than that of *Cx. pipiens* or *Cx. restuans.*

Mean collections of *Aedes vexans* near MVNWR in CO_2-baited light traps were lower than during most years due to dry conditions. The peak rate of capture occurred on June 7 at 814.13 per trap. The five trapping dates in June produced the five highest mean captures of *Ae. vexans* of the year for traps near MVNWR. Collections of *Ae. vexans* were greatest within one mile of the refuge.

Mosquitoes collected from traps near MVNWR were tested for WNV from the beginning of June through the end of September. There was one WNV positive sample, made up of six *Cx. tarsalis* collected on August 30. This is less than 2021 (four samples positive) but more than 2020, when no samples from the area tested positive for WNV.

Because the *Cx. tarsalis* population remained low and drought conditions persisted in 2022, MMCD did not request permission to conduct larval mosquito surveillance within the Minnesota Valley National Wildlife Refuge.

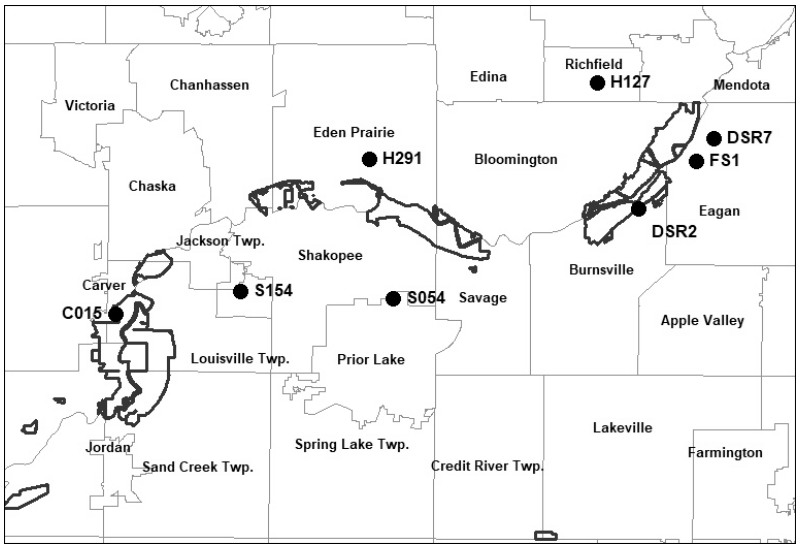


Figure 7.4 CO_2 trap locations (circles) near the Minnesota Valley National Wildlife Refuge. Solid, black lines delineate refuge boundaries.

Integrated Pest Management Plans

In 2021, MMCD reorganized its team structure in an effort to better use staff to provide service. As part of this process we re-focused on integrated pest management (IPM) and developed more species-specific IPM plans as a way to:

- Ensure a common understanding of what we do and why
- Show the basis for our surveillance and control practices
- Have a quick intro for new employees
- Help discover what's going well and what to improve

The plans' structure was based on resources such as state and national pesticide applicator training, AMCA "Best Practices," and basic problem-solving steps. Each plan documents our understanding of the information needed to understand a problem and develop and evaluate control strategies. We also prepared a brief "Pest Alert" format (Fig. 7.5) that uses the same outline but provides an overview aimed at training new staff.

Figure 7.5 IPM Pest Alert example

Each species group plan covers the following questions:

1. Why is this species (or group) a problem?
2. What are the tolerance levels?
3. Where and when are those levels exceeded
4. What action can we take to reduce the problem? (and not cause more problems)
   - Public Education
   - Prevention
   - Treatment (action thresholds, dose, targeting, timing, materials, resistance)
5. How do we know we've reduced the problem, and show that to the public?

The plans are designed to promote communication, encourage staff to explore new solutions, and evaluate effectiveness.

Technical Services and Field Operations staff worked together to develop IPM plans and "Pest Alerts" for the following species groups: Spring *Aedes*, Floodwater Mosquitoes, Cattail Mosquito, Vector Mosquitoes (container *Aedes*, *Culiseta melanura*, *Culex restuans/pipiens*, *Cx. tarsalis*, *Cx. salinarius*), Black Flies (*Simulium johannseni*, *S. luggeri*, *S. meridionale*, *S. tuberosum*, *S. venustum*) and Ticks (*Ixodes scapularis*). We reviewed the plans before the field season started and set up evaluation criteria to monitor progress. We are in the process of revisiting the plans and evaluating what changes might be helpful. Developing the plans helped make sure field and technical staff had a common understanding of the processes for managing each species group.

Public Communication

Notification of Control The District continues to post daily adulticide information on its website and e-mail notification is available through Granicus (formerly GovDelivery). Aerial larvicide treatment schedules (helicopter activity) are also posted on the website and posted on Twitter, Facebook, and Instagram.

Calls Requesting Service Due to dry weather and a low population of annoyance mosquitoes throughout July, August, and September of 2022, calls requesting treatment were very low. In 2022, the number of these calls peaked the week of June 6, which coincides with the peak of mosquitoes collected in sweeps (Figure 7.6). Calls declined quickly at the end of June and remained low throughout most of the rest of the season, thanks in part to less rain and lower mosquito counts.

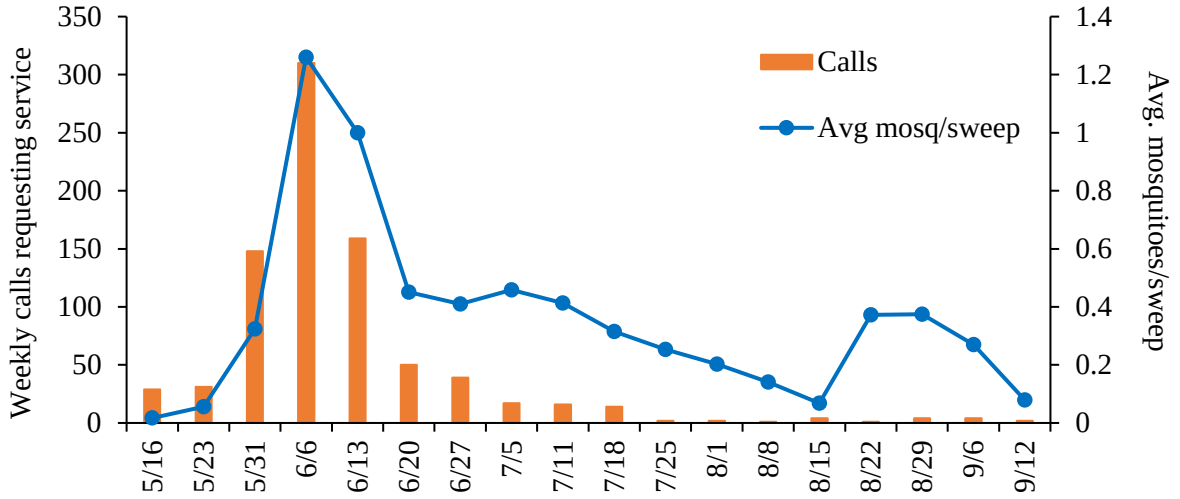


Figure 7.6 Calls requesting service and sweep net counts, by week, 2022.

Requests specifically asking for adult mosquito treatment or to check breeding sites in 2022 were up compared to 2021, but down significantly compared to the previous ten years (Table 7.2). From 2011-2020, the average number of calls to request adult mosquito treatments was 1,566 per year and in 2022 MMCD received only 384 calls. The drop can largely be explained by the lack

of annoyance mosquitoes during peak months. Requests for treatment at public events continued to increase in 2022 as many in-person events returned after taking 2020 and 2021 off due to concerns surrounding the COVID-19 pandemic. Tire pick up calls and requests for limited or no treatment remained about the same as in previous years.

Table 7.2 Yearly call totals (including e-mails) by service request type, 2012-2022

	Number of calls by year										
Service request type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Check a larval site	539	609	1,068	447	886	1,151	601	802	438	234	472
Request adult treatment	1,413	1,825	2,454	1,633	2,499	1,157	1,212	1,144	1,030	176	384
Public event, request treatment	61	70	93	91	105	101	91	71	12	43	61
Request tire removal	417	351	429	366	377	363	325	411	411	374	377
Request or confirm limited or no treatment	54	[a]136	[b]146	139	158	126	75	69	76	73	79

[a] Historic restriction "calls" moved into new system
[b] Beehive locations added into call system to track restrictions

Website In 2019, MMCD launched a revised website with more information and improved systems for interactions with the public. In 2022, mmcd.org had 44,735 unique visitors which was up from 32,383 in 2021.

In 2021, a new contact form was implemented on the MMCD website called "Submit a Tip" where residents can submit informational items or requests for service that are then routed directly to field staff through the MMCD call system. There were 337 requests that came in through the new contact form in 2022, which was similar to the 353 requests that came in 2021.

Community and School Presentations After two years of limited opportunities for appearances in schools and the community, MMCD was able to return to many in-person events in 2022. Throughout 2022 we delivered classroom presentations in 22 schools across the District serving elementary, middle, and high school students. We also returned to large educational events like the Children's Water Festival in St. Paul and Environmental Education Days in Buffalo, two events that served hundreds of students.

MMCD staff delivering presentations at the Children's Water Festival (left) and Anoka-Hennepin Schools (right).

Public Events MMCD's attendance at events continued to increase in 2022 after a year off in 2020 followed by a small increase in 2021. The biggest event of the year was the Minnesota State Fair where District staff had conversations with over 7,900 people during the 12-day event. MMCD also attended county fairs in Anoka, Dakota, Carver, Scott, and Washington counties and several city events. We participated in sixteen parades throughout the District where we featured our mosquito mascot "Vectoria."

Social Media As part of an ongoing effort to notify residents when and where treatment is to take place and to offer another point of contact for the District, MMCD has maintained a presence on Facebook, Twitter, and Instagram. MMCD currently has 938 Twitter followers, up from 863 followers at the end of 2021; 1,779 page followers on Facebook, up from 1,733 in 2021; and 401 followers on Instagram, up from 332 at the end of 2021.

MMCD also uses Granicus to give advance notification to District residents of adult mosquito treatments, and to distribute press releases and make announcements about job openings. 2022 ended with 8,928 individual subscribers who opted in to receiving some sort of communications from MMCD, which is up from 8,224 at the end of 2021.

Sustainability Initiative

MMCD's Sustainability Initiative began in 2013 and examines the economic, environmental, and social impacts of adopting sustainable practices throughout District operation. We keep sustainability in mind with all operations, and our Sustainability Team leads many efforts and brings suggestions to other teams. Some activities have been scaled back since COVID-19, but most processes developed in previous years were carried forward.

Reducing Energy Usage For electricity, we are continuing the transition to LED lights and are seeing significant energy and cost savings. We continue to assess fleet vehicle options that reduce both fuel costs and our carbon footprint. Off-season work-from-home and an increase in virtual meeting capacity have increased overall savings.

Reducing Waste We continue our pesticide container recycling and reuse program in cooperation with manufacturers. Bulk containers have become the standard for the delivery of many of our control materials (see Chapter 6 for more details). Composting and recycling are available at all our facilities.

Renewable Energy Six of our seven offices continue to receive electricity from solar gardens through solar programs that will also reduce our electricity cost.

Social Responsibility and Wellness This area includes how we give back to and take care of our community and promote the health of our staff. We continue to participate in donation drives for food and goods and have also started vegetable gardens and/or native plantings at most facilities.

Professional Association Support

American Mosquito Control Association MMCD staff members continued to provide support for the national association. Mark Smith serves as a member of the AMCA Science and Technology Committee and represents the North Central Mosquito Control Association at the AMCA regional associations' presidents meeting. Kirk Johnson is on the Federal Lands Subcommittee of the Legislative and Regulatory Committee.

Midwest Center of Excellence for Vector-borne Disease The MCE-VBD brings together academic and public health expertise from Illinois, Iowa, Michigan, Minnesota, and Wisconsin. Scott Larson and Kirk Johnson collaborate with the MCE-VCD as experts in tick-borne and mosquito-borne disease, respectively. Collaborations have led to the identification of Jamestown Canyon virus (JCV) in adult mosquito samples collected in Anoka County and northern Washington County. Larval *Aedes provocans* collections from Minnesota have shown that the virus can be transmitted from adult mosquitoes to their progeny (transovarial transmission). The ultimate goal is to identify which species vector JCV to humans. Investigating potential insecticide resistance is also a goal for the MCE-VBD with colleagues across the region conducting bioassay tests for resistance. Also, weekly conference calls with regional partners allow for the dissemination of trends in vector populations and for relaying results of research.

North American Black Fly Association John Walz serves as President and Carey LaMere maintains the association's website, https://nabfa.org/. Due to COVID-19, the 2022 meeting was canceled. NABFA plans to meet in February 2023.

North Central Mosquito Control Association Mark Smith and Scott Larson served on the Board of Directors of this regional association for Minnesota, North Dakota, South Dakota, Wisconsin, Iowa, and the central provinces of Canada. The 2022 annual meeting was held as a virtual meeting and was free to attend. The 2023 annual meeting is planned as a hybrid event for April 5, 2023. The meeting qualifies attendees for pesticide applicator re-certification for Minnesota and North Dakota. Visit their website to learn more at http://north-central-mosquito.org/.

Scientific Publications, Presentations, and Posters

MMCD staff attend a variety of scientific meetings throughout the year and publish scientific studies. Following is a list of publications released and papers and posters presented during 2022 and talks that are planned in 2023.

Publications
No publications in 2022.

2022 Presentations & Posters

Johnson, K. 2022. Impacts of climate change and weather extremes on mosquito-borne disease. Minnesota Structural Pest Management Conference, March 7, 2022 (virtual).

Johnson, K. 2022. The 2020 EHD Outbreak at the Minnesota Zoo. North Central Mosquito Control Association, April 6, 2022 (virtual).

Larson, S.R. 2022. How drought impacts mosquito populations in the Metropolitan Mosquito Control District. North Central Mosquito Control Association, April 6, 2022 (virtual).

Larson, S.R. 2022. Invasion and extirpation: Changes in mosquito community composition over time in the Twin Cities metropolitan area, USA. Entomological Society of America 70th Annual Meeting, November 13-16, 2022 (Vancouver, BC, Canada).

Manweiler, S. 2022. *Simulium tuberosum*, the newest biting gnat problem in the Greater Minneapolis – Saint Paul area. Annual Meeting of the Michigan Mosquito Control Association, February 2, 2022 (virtual).

Manweiler, S. 2022. Mosquito control and the Endangered Species Act. Minnesota Structural Pest Management, March 7, 2022 (virtual).

Parent, M. 2022. Partial site treatments by helicopter. American Mosquito Control Association Annual Meeting, February 28, (Jacksonville, Florida).

Read, N. 2022. How are we doing? Real-time maps for IPM plans. MN GIS/LIS Annual Conference, October 14 (Bemidji MN).

Smith, M. 2022. Review of your IPM plan can refocus your organization. American Mosquito Control Association Annual Meeting, February 28 (Jacksonville, Florida).

2023 Presentations & Posters

LaMere, C.L. 2023. *Simulium tuberosum,* the newest biting gnat problem in the greater Minneapolis-St. Paul area. North American Black Fly Association Annual Meeting, February 9-10, (Flemington, NJ).

Larson, S.R. 2023. Program highlights and current operations at the Metropolitan Mosquito Control District. Annual Meeting of the Michigan Mosquito Control Association, February 2, 2023 (East Lansing, Michigan).

Smith, M. 2023. Overview of the Metropolitan Mosquito Control District's *Coquillettidia perturbans* control program. Annual Meeting of the American Mosquito Control Association, February 27-March 3 (Reno, Nevada).

Smith, M. 2023. Overview of applied research at the Metropolitan Mosquito Control District. Annual Meeting of the American Mosquito Control Association, February 27-March 3 (Reno, Nevada).

Walz, J. 2023. MMCD black fly program history and overview. North American Black Fly Association Annual Meeting, February 9-10, (Flemington, NJ).

Appendices

APPENDIX A Mosquito and Black Fly Biology and Species List

Mosquito Biology

There are 53 species of mosquitoes in Minnesota, although one species is introduced yearly via the tire trade. Forty-five species are detected regularly 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 (spring *Aedes*), summer floodwater species (summer *Aedes*), the cattail mosquito, permanent water species, 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 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.

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 et al. 2015), 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 CO_2 traps and New Jersey light traps.

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

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 (15 species in the District) 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 net) or CO_2-baited trapping is recommended.

Summer Floodwater *Aedes* Eggs of summer floodwater *Aedes* (5 common 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 common 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.

***Psorophora* Species** Larvae of this genus develop in floodwater areas. The adults will feed on humans. Numerous viruses have been isolated from species in this genus, however, there is no confirmation that these species transmit pathogens that cause human disease in the District. Four species occur here: *Psorophora 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 *Ps. ciliata* is the largest mosquito found in the District, and its larvae are predacious and even cannibalistic, feeding on other mosquito larvae.

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 nets.

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 as well as *Uranotaenia sapphirina.* These mosquitoes are multi-brooded and lay their eggs in rafts on the surface of the water. Adults prefer to feed on birds or livestock but will bite humans (except for *Ur. sapphirina* which feeds exclusively on annelids and *Cx. territans* which feeds on amphibians and snakes). They overwinter in places like caves, hollow logs, stumps, or buildings.

Rare Species or Invasive

Orthopodomyia signifera is a treehole and container-breeding mosquito that is rarely encountered in collections made by MMCD. *Aedes albopictus*, discussed above, is an invasive species that almost certainly cannot overwinter in the District and is reintroduced each year.

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, South Fork 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, adults emerge and ride 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 conducted by MMCD show that the majority of black flies in the region lay only one egg batch. The following biologic information for specific black fly species is based on Adler et al. (2004).

Targeted Species

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 can 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. 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.

Simulium tuberosum develops in a wide range of flowing waters from small streams to large rivers. In the District, it has been found primarily in small stream samples but can occur in large river samples as well. It is assumed multivoltine and females are presumably mammalophilic.

Non-Targeted Species

Simulium vittatum develops in a wide range of flowing waters from small streams to large rivers. Larvae are tolerant of extreme temperatures, low oxygen, pollution, and a wide range of current velocities. It is not targeted for treatment, because adults are not known to bite humans. Hosts include large mammals such as horse and cattle.

Reference Cited

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Species Code and Significance/Occurrence of the Mosquitoes 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*	uncommon/rare
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-summer	311.	*An.* unidentifiable		
7.		*cinereus*	common, spring-summer				
8.		*communis*	rare, spring	32.	*Culex*	*erraticus*	uncommon
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*	rare, spring	37.		*territans*	common
14.		*implicatus*	uncommon, spring	371.	*Cx.* unidentifiable		
15.		*intrudens*	rare, spring	372.	*Cx.*	*pipiens/restuans*	when inseparable
16.		*nigromaculis*	uncommon, summer				
17.		*pionips*	rare, spring, northern MN spp.	38.	*Culiseta*	*inornata*	common
18.		*punctor*	common, spring	39.		*melanura*	uncommon, EEE
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,LAC	471.	*Ps.* unidentifiable		
52.		*japonicus*	common, summer				
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* (adult samples only)				501. Unidentifiable mosquito			
263. Non-*vexans Aedes* (larval airwork)				601. Non-mosquito insect (ex. phantom midge)			
264. Summer *Aedes* (adult samples only)							

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

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

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

Code	Genus	species	Significance/Occurrence/Treated or non-treated
Black Flies			
91.	*Simulium*	*luggeri*	common, summer, treated
92.		*meridionale*	common, summer, treated
93.		*johannseni*	common, spring, treated
94.		*vittatum* spp group	common, spring/summer, non-treated
95.		*venustum* spp group	common, spring, treated
96.	Other Simuliidae		can use to speed small stream ids, used pre-2019 for codes 98-112
97.	Unidentifiable Simuliidae (family level)		too small to id, or damaged
98.	*Simulium*	*annulus*	rare, spring, non-treated
99.		'aureum' spp group	rare, spring/summer, non-treated
100.		*croxtoni*	rare, spring, non-treated
101.		*excisum*	rare, spring, non-treated
102.		*decorum*	uncommon, spring/summer, non-treated
103.		*rugglesi*	uncommon, spring/summer, non-treated
104.		*silvestre*	rare, spring, non-treated
105.		*tuberosum* spp group	common, spring/summer, treated
106.		*verecundum* spp group	rare spring/summer, non-treated
107.	*Cnephia*	*dacotensis*	common, spring, non-treated
108.		*ornithophilia*	rare, spring, non-treated
109.	*Ectemnia*	*invenusta*	rare, spring, non-treated
110.	*Heledon*	*gibsoni*	uncommon, spring, non-treated
111.	*Prosimulium*	unidentifiable	rare, spring, non-treated
112.	*Stegoptera*	*mutata/emergens*	uncommon, spring, non-treated

APPENDIX B Average Number of Common Mosquitoes Collected per Night in Four Long-term NJ Light Trap Locations and Average May to September Rainfall, 1965-2022. Trap 1, Trap 9, Trap 13, and Trap 16 have run yearly since 1965. Trap 1 was discontinued in 2015.

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
2016	0.01	0.03	0.01	1.65	24.53	0.06	4.80	33.44	27.76
2017	0.01	0.08	0.09	0.17	25.71	0.05	9.62	37.85	22.27
2018	0.02	0.04	0.18	0.26	15.21	0.05	1.88	20.76	22.54
2019	0.02	0.03	0.03	0.19	5.86	0.02	0.89	8.27	26.67
2020	0.09	0.05	0.12	0.21	10.52	0.01	3.88	16.49	20.00
2021	0.01	0.00	0.00	0.00	1.37	0.06	0.66	3.79	15.43
2022	0.05	0.14	0.09	0.05	3.45	0.02	0.36	6.09	13.84

*Trap 1 discontinued in 2015 due to operator retirement; averages after 2014 are from three traps used since 1965: Trap 9, Trap 13, and Trap 16.

APPENDIX C Total Number of Mosquitoes by Species Collected per Night in 15 Long-term CO_2 Trap Locations, 2022

	Trap Code, Location, and Number of Collections																
	A120	A183	C013	D063	D181	DSR4	E001	E004	H284	H291	H566	H625	S139	S154	SF02	All
	Ajawah EEE	Innsbruck Park	Watertown	Thompson Co. Pk	Miesville	Eureka (Rice Lk)	Stillwater	Forest Lake	Dayton	Eden Prairie	Eagle Ridge	Ft. Snelling Golf	Credit River	Jackson Town Hall	Grandstand	
Species	19	17	19	17	19	19	19	18	19	19	19	17	16	18	17	272
Ae. abserratus	837	0	8	0	0	1	8	24	14	0	0	0	0	0	0	892
atropalpus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aurifer	13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	14
canadensis	266	13	0	0	0	2	6	5	3	0	0	0	0	0	1	296
cinereus	438	40	98	0	0	70	26	261	99	4	83	1	0	0	2	1,122
diantaeus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dorsalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
excrucians	86	31	2	2	0	1	24	21	124	0	17	0	0	0	1	309
fitchii	0	5	0	0	0	0	5	4	15	0	0	0	0	0	0	29
hendersoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
implicatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
japonicus	3	0	0	0	0	1	1	1	9	1	1	0	0	0	0	17
nigromaculus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
punctor	136	0	1	0	0	2	3	10	1	0	0	0	0	0	0	153
riparius	6	1	0	0	0	0	0	0	5	0	0	0	0	0	0	12
spencerii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sticticus	46	6	14	13	1	7	6	10	111	2	0	33	2	0	0	251
stimulans	140	89	0	9	0	5	21	110	132	1	9	1	1	0	5	523
provocans	8	0	0	0	0	0	7	1	2	0	0	0	0	0	0	18
triseriatus	0	3	0	0	0	2	0	0	5	1	1	20	0	0	0	32
trivittatus	13	3	41	21	0	24	25	11	56	64	14	13	10	3	0	298
vexans	571	229	683	352	1	556	94	160	1,422	1,022	689	101	228	63	70	6,241
abserratus/punctor	1,166	2	24	0	0	6	9	31	14	0	0	0	0	0	0	1,252
Aedes unidentifiable	15	2	4	13	0	0	9	2	5	2	9	1	2	3	0	67
Spring *Aedes* unident.	52	12	0	3	0	1	18	16	31	0	14	0	1	0	1	149
Summer *Aedes* unident.	4	3	0	0	0	0	0	2	1	0	0	1	0	0	1	12
An. barberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
earlei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
punctipennis	152	15	4	8	0	12	5	11	41	39	13	5	5	3	1	314
quadrimaculatus	48	10	5	15	0	46	13	35	50	88	11	14	22	24	1	382
walkeri	12	1	0	0	0	0	0	0	0	0	0	2	0	0	0	15
An. unidentifiable	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	4
Cx. erraticus	0	4	0	1	0	4	1	0	0	1	0	0	6	1	0	18
pipiens	5	1	1	34	2	2	0	9	10	38	2	44	0	8	8	164
restuans	2	3	0	3	3	22	1	9	32	7	2	3	1	4	6	98
salinarius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
tarsalis	0	2	4	1	3	3	0	8	7	77	2	43	2	5	9	166
territans	2	0	0	1	0	0	0	0	2	0	0	0	1	0	0	6
Cx. unidentifiable	0	0	0	2	0	0	1	1	2	1	0	3	0	1	0	11
Cx. pipiens/restuans	4	6	2	29	0	23	2	14	36	35	2	60	0	9	14	236
Cs. inornata	4	4	0	0	0	0	0	0	2	1	1	1	0	1	0	14
melanura	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
minnesotae	7	0	0	0	0	0	0	8	0	0	0	0	0	0	0	15
morsitans	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
Cs. unidentifiable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cq. perturbans	985	47	27	9	0	15	278	100	34	73	105	5	18	81	0	1,777
Or. signifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ps. ferox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
horrida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ps. unidentifiable	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Ur. sapphirina	1	4	0	0	0	0	2	0	6	0	0	0	0	0	0	13
Unidentifiable	2	0	0	4	0	1	0	0	3	0	2	1	0	0	0	13
Total	5,029	538	918	521	10	806	565	865	2,274	1,460	978	352	299	206	120	14,941

APPENDIX D Description of Control Materials Used by MMCD in 2022

The following is an explanation of the control materials currently used by MMCD. The specific names of products used in 2022 are given. The generic products will not change in 2022, although the specific formulation 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 granules — Central Life Sciences
Altosid® P35 — EPA# 89459-95

Altosid® P35 consists of methoprene formulated in a spherical granule. Altosid® P35 provides 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 3-5 lb per acre for *Cq. perturbans* control. Helicopter applications done in sites that are greater than three acres will be at the same rate as ground sites, primarily for *Cq. perturbans* control. Sites smaller than three acres may be treated with drones at a rate of 3 lb per acre.

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 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 3-4 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.

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 5-8 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. Drones may conduct fall applications at a rate of 15 lb per acre and would be conducted on sites less than three acres.

***Bacillus thuringiensis israelensis* (*Bti*) & methoprene granules** Valent BioSciences
VectoPrime® FG EPA# 73049-501

VectoPrime® is a corn cob formulation with both methoprene and *Bti*. VectoPrime® corn cob may be applied in all types of larval habitat. The duplex material controls existing larvae with *Bti* and has a seven-day residual control duration with methoprene. This residual control activity allows staff to work in other areas if additional rains immediately reflood the site. Another possible advantage is that it may be effective to control late fourth instar larvae. These larvae slow their feeding activity as they get ready to pupate and therefore are less susceptible to *Bti*. According to the manufacturer, the reintroduction of juvenile hormone stimulates new feeding activity in later fourth instars causing them to ingest more *Bti*. Additionally, the methoprene can disrupt metamorphosis and thereby kill mosquito pupae. This material can be applied at 4 lb per acre (0.243 lb/acre *Bti* and 0.004 lb/acre methoprene). In evaluations, the material is applied to pockety sites with cyclone seeders or power backpacks.

***Bacillus thuringiensis israelensis* (*Bti*) & methoprene granules** Central Life Sciences
Duplex™-G EPA# 89459-93

Duplex™-G is a sand formulation with both methoprene and *Bti*. Duplex™-G may be applied in all types of larval habitat. The combination material controls existing larvae with *Bti* and has a seven-day residual control duration with methoprene. This residual control activity allows staff to work in other areas if additional rains immediately reflood the site. Another possible advantage is that it may be effective to control late fourth instar larvae. These larvae slow their

feeding activity as they get ready to pupate and therefore are less susceptible to *Bti*. According to the manufacturer, the reintroduction of juvenile hormone stimulates new feeding activity in later fourth instars causing them to ingest more *Bti*. Additionally, methoprene can disrupt metamorphosis and thereby kill mosquito pupae. This material can be applied at 4 lb per acre (0.21 lb/acre *Bti* and 0.06 lb/acre methoprene). In evaluations, the material is applied to pockety sites with cyclone seeders or power backpacks.

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

Natular® G30 is a sand formulation of spinosad, a biological toxin extracted from the soil bacterium *Saccharopolyspora spinosa*, that was developed for larval mosquito control. Spinosad has been used by organic growers since 2003. Natular® G30 is formulated as extended-release granules (30-day) and can be applied to dry or wet sites.

Natular® (spinosad) 7-14-day Residual Clarke
Natular® G EPA# 8329-80

Natular® G is a corn cob formulation of spinosad, a biological toxin extracted from the soil bacterium *Saccharopolyspora spinosa*, that was developed for larval mosquito control. Spinosad has been used by organic growers for almost 20 years. Natular® G is formulated as a residual 7-14-day granule that can be applied to dry or wet sites.

Pyrethrin Adulticides

Natural Pyrethrin Clarke
Merus™ 2.0 Mosquito Adulticide EPA# 8329-94

Merus™ is the first and only adulticide listed with the Organic Materials Review Institute (OMRI), for wide-area mosquito control in and around organic gardens and farms and meets the USDA's Natural Organic Program (NOP) standards for use on organic crops. Its active ingredient, pyrethrin, is a botanical insecticide. The product has no chemical synergist. It is OMRI and NOP listed for use in environmentally sensitive areas.

Merus™ is used by the District to treat adult mosquitoes in known areas of concentration or nuisance where crop restrictions (organic growers) prevent treatments with resmethrin or sumithrin. Merus™ 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. Merus™ is applied at a rate of 1.5 oz per acre (0.0048 lb AI per acre). Merus™ is a non-restricted use compound.

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.

Pyrethroid Adulticides

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

Zenivex® is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Zenivex® 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. Zenivex® is applied at a rate of 1.0 oz of mixed material per acre (0.0023 lb AI per acre). Zenivex® is a non-restricted use compound.

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 providing a shaded, moist area for mosquitoes to rest during the daylight hours. 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).

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 rates of 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.

APPENDIX E 2022 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 (lb)	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® P35	Methoprene	4.25	2.5 lb	0.1063	30
			3 lb	0.1276	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	0.60	5 lb	0.0300	7-14
VectoBac® G	*Bti*	0.20	5 lb	0.0100	1
			8 lb	0.0160	1
VectoLex® FG	*Bs*	7.50	8 lb	0.6000	7-28
			15 lb	1.1250	7-28
			0.044 lb* (20 g)	0.0034*	7-28
VectoLex® WSP***	*Bs*	7.50	0.022 lb** (10 g)	0.0017**	7-28
VectoPrime® FG***	*Bti* and methoprene	6.07 *Bti* 0.10 methoprene	4 lb	0.2428 *Bti* 0.0040 methoprene	7 single flood
Duplex-G	*Bti* and methoprene	5.35 *Bti* 1.60 methoprene	4 lb	0.2100 *Bti* 0.0600 methoprene	7 single flood
Permethrin 57%OS [b]	Permethrin	5.70	25 fl oz	0.0977	5
Zenivex® E4 [c]	Etofenprox	4.00	1.0 fl oz	0.0023	<1
Anvil® [d]	Sumithrin	2.00	3.0 fl oz	0.0035	<1
Pyrocide® [e]	Pyrethrins	2.50	1.5 fl oz	0.00217	<1
Merus™ [f]***	Pyrethrins	5.00	1.5 fl oz	0.0048	<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 has 5.0 lb AI per 128 fl oz)
[c] 0.30 lb AI per 128 fl oz (1 gal)
[d] 0.15 lb AI per 128 fl oz (1 gal)
[e] 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)
[f] 0.4096 lb AI per 128 fl oz (1 gal)
* Catch basin treatments—dosage is the amount of product per catch basin.
** Catch basin treatments—dosage is the amount of product per pouch, catch basins can be treated with one or two pouches.
***Experimental

APPENDIX F Acres Treated with Control Materials Used by MMCD for Mosquito and Black Fly Control, 2014-2022.The actual geographic area treated is smaller because some sites are treated more than once

Control Material	2014	2015	2016	2017	2018	2019	2020	2021	2022
Larvicides									
Altosid® XR Briquet 150-day	193	186	168	166	167	162	180	141	133
Altosid® XRG	52	0	0	0	0	0	0	0	0
Altosid® Pellets 30-day	26,179	31,494	19,173	17,939	10,202	12,020	729	0.16	0
Altosid® Pellets catch basins (count)	239,829	248,599	240,806	252,694	262,851	265,915	264,399	13,550	0
Altosid® P35 30-day	0	0	0	0	0	0	26,784	26,511	22,068
Altosid® P35 Catch basins (count)	0	0	0	0	0	0	11,648	270,810	301,352
MetaLarv® S-PT	18,073	21,126	33,409	23,740	23,574	23,003	18,408	19,431	19,295
Natular® G30	14,950	8,840	13,023	12,271	15,662	17,277	8,946	19,968	13,468
Altosid® XR Briquet catch basins (count)	437	450	448	445	509	476	470	414	316
VectoLex® FG granules	3,064	3,777	6,076	4,773	4,660	5,036	1,858	5,255	4,234
VectoBac® G *Bti* corn cob granules	255,916	258,148	234,120	136,173	134,926	156,089	139,006	78,992	70,309
VectoBac® 12 AS *Bti* liquid (gal used) Black fly control	4,349	4,351	3,112	3,621	3,234	4,362	4,085	1,172	3,609
Adulticides									
Permethrin 57% OS Permethrin	8,887	6,093	8,128	5,038	3,771	3,367	1,742	113	333
Scourge® 4+12 Resmethrin/PBO	44,890	19,767	23,072	2,090	0	0	0	0	0
Anvil® 2 + 2 Sumithrin/PBO	31,381	27,183	16,399	11,683	7,790	3,665	584	257	663
Pyrocide® Adulticide	5,338	3,605	0	0	0	0	0	0	0
Zenivex® Etofenprox	0	10,380	34,984	23,097	26,918	15,289	4,124	2,166	703

APPENDIX G Graphs of Larvicide, Adulticide, and ULV Fog Treatment Acres, 1984-2022

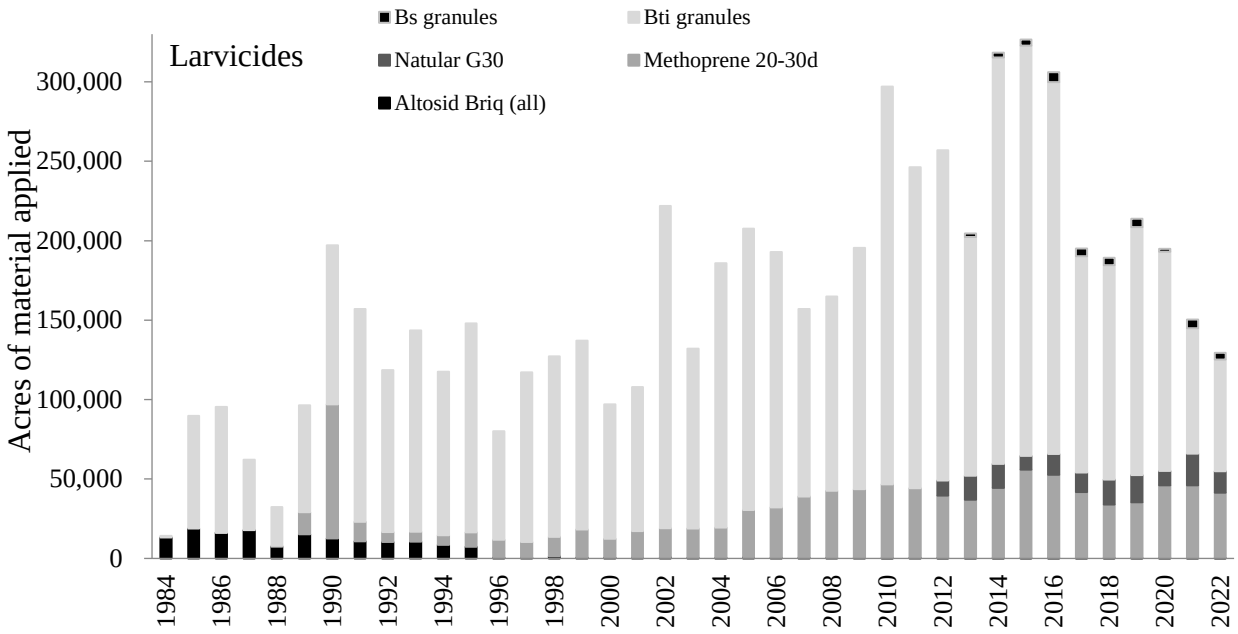

Figure G.1 Summary of total acres of larvicide treatments applied per year since 1984. For materials that are applied to the same site more than once per year, actual geographic acreage treated is less than that shown.

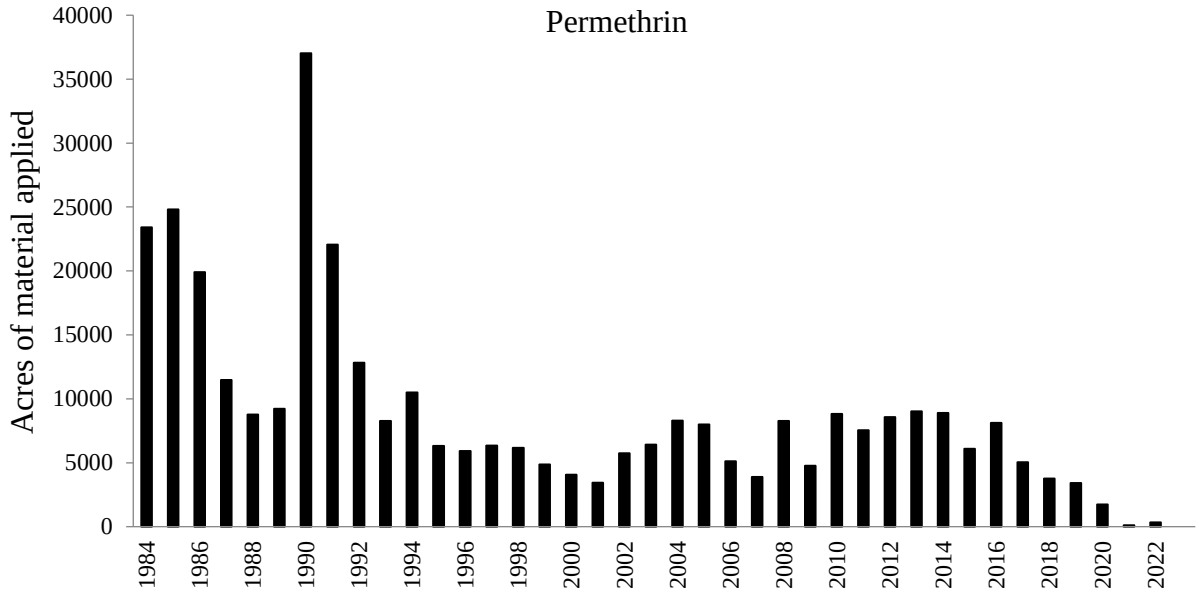

Figure G.2 Summary of total acres of permethrin treatments applied per year since 1984. This material may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

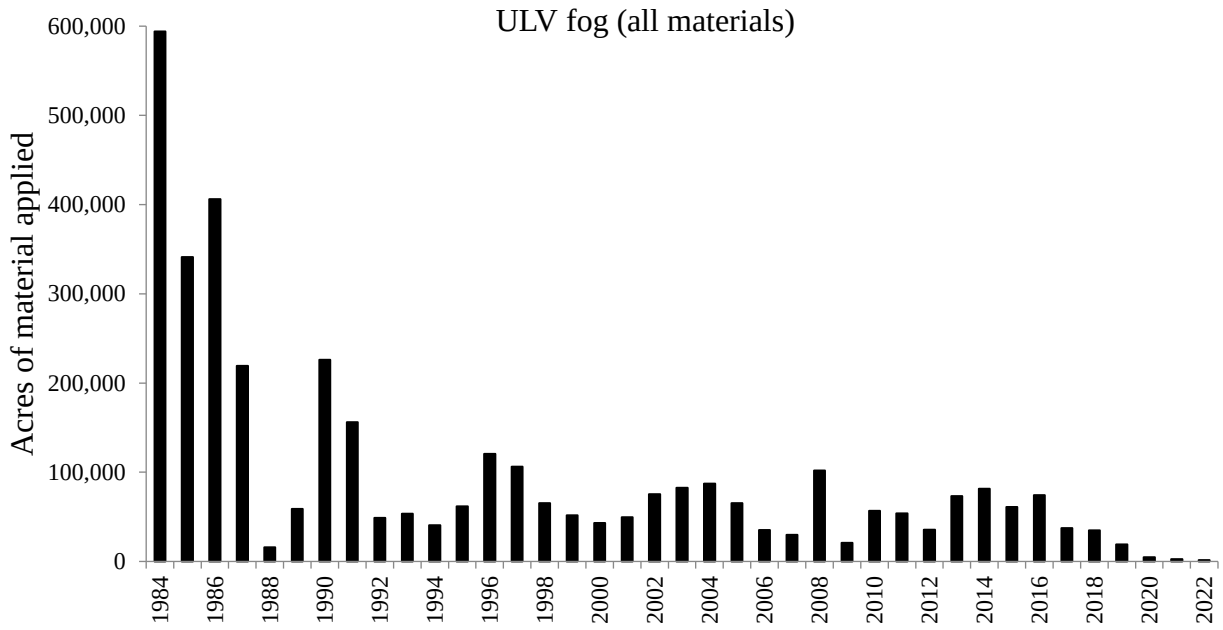

Figure G.3 Summary of total acres of ULV fog treatments applied per year since 1984. This material may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

APPENDIX H Control Material Labels

Altosid® XR Extended Residual Briquets (EPA# 2724-421)

Altosid® Pellets (EPA# 2724-448)

Altosid® P35 (EPA# 89459-95)

MetaLarv® S-PT (EPA# 73049-475)

VectoBac® 12AS (EPA# 73049-38)

VectoBac® G (EPA# 73049-10)

VectoLex® FG (EPA# 73049-20)

VectoLex® WSP (EPA# 73049-20)

Natular® G (EPA# 8329-80)

Natular® G30 (EPA# 8329-83)

Permethrin 57% OS (EPA# 8329-44)

Anvil® 2+2 ULV (EPA# 1021-167-8329)

Zenivex® E4 RTU (EPA# 2724-807)

Merus™ 2.0 RTU (EPA# 8329-94)

A SUSTAINED RELEASE PRODUCT TO PREVENT ADULT MOSQUITO EMERGENCE
(INCLUDING THOSE WHICH MAY TRANSMIT WEST NILE VIRUS)

SPECIMEN LABEL

ACTIVE INGREDIENT:

(S)-Methoprene (CAS #65733-16-6)) (Dry Weight Basis):	2.1%
OTHER INGREDIENTS:	97.9%
Total	100.0%

EPA Reg. No. 2724-421
EPA Est. No. 2724-TX-1

KEEP OUT OF REACH OF CHILDREN
CAUTION
SEE ADDITIONAL PRECAUTIONARY STATEMENTS

INTRODUCTION

ALTOSID® XR BRIQUETS are designed to release effective levels of (S)-Methoprene insect growth regulator over a period up to 150 days in mosquito breeding sites. Release of (S)-Methoprene insect growth regulator occurs by dissolution of the briquet. Soft mud and loose sediment can cover the briquets and inhibit normal dispersion of the active ingredient. The product may not be effective in those situations where the briquet can be removed from the site by flushing action.

ALTOSID® XR BRIQUETS prevent the emergence of adult mosquitoes including: *Anopheles, Culex, Culiseta, Coquillettidia,* and *Mansonia* spp., as well as those of the floodwater mosquito complex (*Aedes, Ochlerotatus,* and *Psorophora* spp.) from treated water. Treated larvae continue to develop normally to the pupal stage where they die.

NOTE: (S)-Methoprene insect growth regulator has no effect on mosquitoes which have reached the pupal or adult stage prior to treatment.

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS - CAUTION

Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling.

FIRST AID Call a poison control center or doctor for treatment advice.	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-248-7763 for emergency medical treatment information.	

ENVIRONMENTAL HAZARDS

Do not contaminate water when disposing of unused product.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

APPLICATION TIME

Place **ALTOSID® XR BRIQUETS** at or before the beginning of the mosquito season. Apply **ALTOSID® XR BRIQUETS** prior to flooding when sites are dry, or on snow and ice in breeding sites prior to spring thaw. Under normal conditions, one application will last the entire mosquito season, or up to 150 days, whichever is shorter. Alternate wetting and drying will not reduce their effectiveness.

APPLICATION RATES

***Aedes, Ochlerotatus,* and *Psorophora* spp.:** For control in non-(or low-) flow shallow depressions (≤ 2 feet in depth), treat on the basis of surface area, placing one **ALTOSID® XR BRIQUET** per 200 ft². Place briquets in the lowest areas of mosquito breeding sites to maintain continuous control as the site alternately floods and dries up.

***Culex, Culiseta* and *Anopheles* spp.:** Place one **ALTOSID® XR BRIQUET** per 100 ft².

Coquillettidia and *Mansonia* spp.: For application to cattail marshes and water hyacinth beds. For control of these mosquitoes, place one **ALTOSID® XR BRIQUET** per 100 ft².

***Culex* sp. in storm water drainage areas, sewers, and catch basins:** For catch basins, place one **ALTOSID® XR BRIQUET** into each basin. In cases of large catch basins, follow the chart below to determine the number of briquets to use. For storm water drainage areas, place one briquet per 100 ft² of surface area up to two ft deep. In areas that are deeper than two feet, use one additional briquet per two feet of water depth.

Water flow pressure increases the potential dissolution of the briquet. Conduct regular inspections (visual or biological) in areas of water flow to determine if the briquet is still present. Adjust the retreatment interval based on the results of an inspection.

ALTOSID® XR BRIQUETS Application Chart

Number of Briquets	Catch Basin Size (Gallons)	Surface Area/ Water Depth (ft)
1	0 – 1500	0 – 2
2	1500 – 3000	2 – 4
3	3000 – 4500	4 – 6
4	4500 – 6000	6 – 8

APPLICATION SITES

ALTOSID® XR BRIQUETS are designed to control mosquitoes in treated areas. Examples of application sites are: storm drains, catch basins, roadside ditches, fish ponds, ornamental ponds and fountains, other artificial water-holding containers, animal watering troughs, cesspools and septic tanks, waste treatment and settling ponds, flooded crypts, transformer vaults, abandoned swimming pools, tires, construction and other manmade depressions, cattail marshes, water hyacinth beds, vegetation-choked phosphate pits, pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, treeholes, woodland pools, floodplains, and dredging spoil sites. For application sites connected by a water system, i.e., storm drains or catch basins, treat all of the water-holding sites in the system to maximize the efficiency of the treatment program.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

STORAGE: Store in a cool place. Do not reuse empty container.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Completely empty bag into application equipment. Then offer for recycling, if available, or dispose of empty container in a sanitary landfill or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

WARRANTY AND CONDITIONS OF SALE

Seller makes no warranty, expressed or implied, concerning the use and handling of this product other than indicated on the label. To the extent permitted by law, Buyer assumes all risks of use and handling of this material when such use and handling are contrary to label instructions.

For information, or in case of an emergency, call 1-800-248-7763.

www.altosid.com

Wellmark International
1501 East Woodfield Road 200W
Schaumburg, Illinois 60173

ZOËCON. Professional Products

300507286

May, 2010
Schaumburg, IL

A GRANULAR PRODUCT TO PREVENT ADULT MOSQUITO EMERGENCE *(INCLUDING THOSE WHICH MAY TRANSMIT WEST NILE VIRUS)*

SPECIMEN LABEL

ACTIVE INGREDIENT:
(S)-Methoprene (CAS #65733-16-6) 4.25%
OTHER INGREDIENTS: 95.75%
Total 100.00%

EPA Reg No. 2724-448 EPA Est. No. 39578-TX-1

KEEP OUT OF REACH OF CHILDREN
CAUTION

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
CAUTION

Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling.

FIRST AID	
Call a poison control center or doctor for treatment advice.	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-248-7763 for emergency medical treatment information.	

ENVIRONMENTAL HAZARDS

Do not contaminate water when disposing of rinsate or equipment washwaters.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

INTRODUCTION

ZOËCON® ALTOSID® Pellets (ALTOSID® Pellets) release **ALTOSID®** Insect Growth Regulator as they erode. **ALTOSID® Pellets** prevent the emergence of adult standing water mosquitoes, including *Anopheles, Culex, Culiseta, Coquillettidia,* and *Mansonia* spp., as well as adults of the floodwater mosquitoes such as *Aedes, Ochlerotatus,* and *Psorophora* spp. from treated sites.

GENERAL DIRECTIONS

ALTOSID® Pellets release effective levels of **ALTOSID®** Insect Growth Regulator for up to 30 days under typical environmental conditions. Continue treatment through the last brood of the season. Treated larvae continue to develop normally to the pupal stage where they die. **NOTE:** This insect growth regulator has no effect on mosquitoes which have reached the pupal or adult stage prior to treatment.

APPLICATION SITES AND RATES

Use lower application rates when water is shallow, vegetation and/or pollution are minimal, and insect populations are low. Use higher rates when water is deep (>2 ft), vegetation, pollution, and/or organic debris or water flow are high, and insect populations are high. In instances of high organic debris and water flow, residual activity may be diminished.

MOSQUITO HABITAT	RATE (LB/ACRE)
Floodwater sites	
Pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, cattail marshes, woodland pools, floodplains, tires, other artificial water-holding containers	2.5–5
Dredging spoil sites, waste treatment and settling ponds, ditches and other manmade depressions	5–10
Permanent water sites	
Ornamental ponds and fountains, fish ponds, cattail marshes, water hyacinth beds, flooded crypts, transformer vaults, abandoned swimming pools, construction and other manmade depressions, treeholes, other artificial water-holding containers	2.5–5
Storm drains, catch basins, roadside ditches, cesspools, septic tanks, waste settling ponds, vegetation-choked phosphate pits	5–10

APPLICATION METHODS

Mosquitoes: Apply **ALTOSID® Pellets** up to 15 days prior to flooding, or at any stage of larval development after flooding or in permanent water sites. Fixed wing aircraft or helicopters equipped with granular spreaders capable of applying rates from 2.5 to 10 lb/acre may be used to apply **ALTOSID® Pellets.** The pellets may also be applied using ground equipment which will achieve good, even coverage at the above rates. Apply **ALTOSID® Pellets** to artificial containers such as tires and catch basins, etc.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal. Store closed containers of **ALTOSID® Pellets** in a cool, dry place.

PESTICIDE DISPOSAL

Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER HANDLING

Nonrefillable container. Do not reuse or refill this container. Triple rinse (or equivalent). Then offer for recycling, if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

WARRANTY AND CONDITIONS OF SALE

Seller makes no warranty, expressed or implied, concerning the use and handling of this product other than indicated on the label. Buyer assumes all risks of use and handling of this material when such use and handling are contrary to label instructions.

For information or in case of an emergency, call **1-800-248-7763.**

www.altosid.com

Wellmark International
1501 East Woodfield Road 200W
Schaumburg, Illinois 60173

ZOECON Professional Products

300506948

Made in the U.S.A.

May, 2010
Schaumburg, IL

An extended residual INSECT GROWTH REGULATOR GRANULAR PRODUCT TO PREVENT ADULT MOSQUITO EMERGENCE *(including those mosquitoes which may transmit diseases, including West Nile virus, Dengue, Chikungunya, and the Zika virus)*

Controls mosquitoes for up to 35 days of continuous wet conditions

Dust free formula

Controls *Aedes, Culex, Psorophora, Anopheles, Coquillettidia, Mansonia, Ochlerotatus,* and other mosquitoes

Consistent size granule

May be applied to both crop and non-crop sites

SPECIMEN LABEL

ACTIVE INGREDIENT:

(S)-Methoprene (CAS #65733-16-6).....	4.25%
OTHER INGREDIENTS:.....	95.75%
TOTAL:.....	100.00%

EPA REG. NO. 89459-95 EPA EST. NO. 2724-TX-1

KEEP OUT OF REACH OF CHILDREN

CAUTION

SEE ADDITIONAL PRECAUTIONARY STATEMENTS

Causes moderate eye irritation. Avoid contact with eyes or clothing. Due to the size and abrasiveness of the granule, use protective eyewear and clothing to minimize exposure during loading and handling. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse.

FIRST AID	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-248-7763 for emergency medical treatment information.	

ENVIRONMENTAL HAZARDS

Do not contaminate water when disposing of rinsate or equipment washwaters.

INTRODUCTION

Zoecon® Altosid® P35 (Altosid® P35) larvicide is used against mosquito larvae in a variety of habitats. **Altosid® P35** provides consistent release of the Insect Growth Regulator (IGR), S-Methoprene to provide residual control for multiple broods for up to 35 days of continuous wet conditions. **Altosid® P35**, when applied to the water column releases effective levels of the IGR to begin affecting larval development thereby preventing adult mosquito emergence. **Altosid® P35** controls the major species of mosquitoes including: *Aedes, Anopheles, Psorophora, Culex, Culiseta, Ochlerotatus, Coquillettidia* and *Mansonia* spp.

DIRECTIONS FOR USE: It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

GENERAL DIRECTIONS: Altosid® P35 begins releasing effective levels of IGR soon after application to inhibit and prevent the emergence of adult mosquitoes for up to 35 days after application. Continue applications throughout the entire season to maintain control. IGR treated larvae continue to develop normally to the pupal stage where they die.

Rotary and fixed-wing aircraft equipped with granular spreaders capable of applying rates listed below may be used to apply **Altosid® P35**. Ground equipment which will achieve even coverage at these rates may also be used. Apply **Altosid® P35** uniformly and repeat application as necessary.

NOTE: Altosid® P35 has no effect on mosquitoes which have reached the pupal or adult stage prior to treatment.

APPLICATION TIMING: Apply **Altosid® P35** at any stage of larval mosquito development. Granules may be applied 7 to 15 days prior to flooding (i.e., "pre-hatch" or "pre-flood") in areas which flood. In such areas, one application of **Altosid® P35** can prevent adult mosquito emergence from several subsequent wetting events. The actual length of control depends on the duration and frequency of wetting events.

APPLICATION RATES: **Altosid® P35** controls the major species of mosquitoes including: *Aedes, Anopheles, Psorophora, Culex, Culiseta, Coquillettidia* and *Mansonia* spp. Apply **Altosid® P35** at 2.5 - 20 lb/acre (5.6 - 11.2 kg/ha). Within these ranges, use lower rates when water is shallow [< 6"-12"] and vegetation and/or organic matter are minimal. Use higher rates when water is deep [> 1 foot] and/or vegetation and organic matter are heavy. In water depths greater than 2 feet, double the application rate for each subsequent foot of water. Depending on water depth and degree of organic matter, lower use rates may provide less IGR residual. Application of **Altosid® P35** to sites subject to water flow or exchange will diminish the product's effectiveness and residual activity, which may require higher application rates and/or more frequent applications.

APPLICATION SITES: **Altosid® P35** may be applied to both crop and non-crop areas as directed above to temporary and permanent sites which support mosquito larval development. Examples of such sites include: snow pools, salt and tidal marshes, freshwater swamps and marshes (cattail, red cedar, white maple marshes), woodland pools and meadows, dredging spoil sites, drainage areas, ditches, wastewater treatment facilities, livestock runoff lagoons, retention ponds, harvested timber stacks, swales, storm water drainage areas, sewers, catch basins, tree holes, animal watering troughs, water-holding receptacles (e.g., tires, urns, bird baths, flower pots, cans, and other containers), irrigated and non-irrigated pastures, hoof prints and other natural and manmade water-holding sites, containers and depressions. Examples of crop areas include: irrigated croplands, pastures, rangeland, vineyards, rice fields (domestic and wild), date palm, citrus, fruit and nut orchards, berry fields, bogs and row crops.

STORAGE AND DISPOSAL: Do not contaminate water, food or feed by storage or disposal. **Pesticide Storage:** Store closed containers in a cool, dry place. Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. **Container Handling (Paper/Plastic Bags):** Nonrefillable container. Do not reuse or refill this container. Completely empty container into application equipment. Then offer for recycling if available or dispose of empty bag in a sanitary landfill or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

(For refillable totes): Refillable container. Refill this container with this product only. Do not reuse this container for any other purpose. Return empty container to Central Garden & Pet Company [Central Life Sciences] for cleaning and recycling. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the refiller. If the container is not returned, completely empty container by tapping sides and bottom to loosen material. Then offer for recycling if availabale or dispose of in a sanitary landfill or by other procedures approved by state and local authorities.

WARRANTY

IMPORTANT: READ BEFORE USE

Read the entire Directions for Use, Conditions of Warranties and Limitations of Liability before using this product. If terms are not acceptable, return the unopened product container at once.

By using this product, user or buyer accepts the following Conditions, Disclaimer of Warranties and Limitations of Liability.

CONDITIONS: The Directions for Use of this product are believed to be adequate and must be followed carefully. However, it is impossible to eliminate all risks associated with the use of this product. Ineffectiveness or other unintended consequences may result because of such factors as weather conditions, presence of other materials, or the manner of use or application, all of which are beyond the control of Central Garden & Pet Company. All such risks shall be assumed by the user or buyer.

DISCLAIMER OF WARRANTIES: To the extent consistent with applicable law, Central Garden & Pet Company makes no other warranties, express or implied, of merchantability or of fitness for a particular purpose or otherwise, that extend beyond the statements made on this label. No agent of Central Garden & Pet Company is authorized to make any warranties beyond those contained herein or to modify the warranties contained herein. To the extent consistent with applicable law, Central Garden & Pet Company disclaims any liability whatsoever for special, incidental or consequential damages resulting from the use or handling of this product.

LIMITATIONS OF LIABILITY: To the extent consistent with applicable law, the exclusive remedy of the user or buyer for any and all losses, injuries, or damages resulting from the use or handling of this product, whether in contract, warranty, tort, negligence, strict liability or otherwise, shall not exceed the purchase price paid or at Central Garden & Pet Company's election, the replacement of product.

For information, call **1-800-248-7763** or visit our Web site: **www.centralmosquitocontrol.com**

Manufactured for

Central Garden & Pet Company
1501 East Woodfield Road 200W
Schaumburg, Illinois 60173

ZOECON Professional Products

VEC 18-001

October 2017
Schaumburg, IL

MetaLarv® S-PT

MOSQUITO GROWTH REGULATOR

PELLET

ACTIVE INGREDIENT:
(S)-Methoprene (CAS # 65733-16-6) 4.25%
OTHER INGREDIENTS..... 95.75%
TOTAL 100.00%

EPA Reg. No. 73049-475
EPA Est. No. 33762-IA-001 List No. 05765

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0

FIRST AID	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
HOT LINE NUMBER	
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact (PROSAR service) 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call Valent BioSciences 1-800-323-9597.	

2.0 PRECAUTIONARY STATEMENTS

2.1 Hazards To Humans and Domestic Animals

CAUTION

Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with eyes, skin, or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

2.2 Environmental Hazards

Do not contaminate water when cleaning equipment or disposing of equipment washwaters or rinsate.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Introduction

MetaLarv S-PT is formulated to release S-Methoprene insect growth regulator for up to 42 days. MetaLarv S-PT prevents the emergence of *Aedes*, *Ochlerotatus*, and *Psorophora* spp., (adult floodwater mosquitoes) and *Anopheles*, *Culex*, *Culiseta*, *Coquillettidia*, and *Mansonia* spp (adult standing water mosquitoes).

NOTE: MetaLarv S-PT prevents development of mosquito larvae into adults. MetaLarv S-PT has no effect on mosquitoes that have reached the pupal or adult stage prior to treatment.

4.0 APPLICATION DIRECTIONS

Apply MetaLarv S-PT to mosquito breeding sites at any time during the mosquito season. One application will control adult emergence for up to 42 days. Continue treatment through the last brood of the season. Treated larvae continue to develop normally to the pupal stage where they die.

Apply MetaLarv S-PT to breeding sites that will be intentionally flooded and to sites that will naturally flood, up to 28 days prior to flooding. Periods of greater than 28 days between application and flooding will provide shorter residual control and will need reapplication based on local program threshold requirements.

Apply the pellets evenly over the entire habitat that is flooded and/or expected to be flooded to maintain continuous control as the site alternately floods and dries. Alternate wetting and drying will not reduce pellet effectiveness.

MetaLarv S-PT can be applied to areas that contain fish, other aquatic life, and plants. MetaLarv S-PT can be applied to areas used by or in contact with humans, pets, horses, livestock, birds, or wildlife.

4.1 Application Sites And Rates

Use lower application rates when water is shallow, vegetation and/or pollution are minimal, and mosquito populations are low. Use higher rates when water is deep (> 2 ft), vegetation, pollution, and/or organic debris or water flow are high, and mosquito populations are high. Application of MetaLarv S-PT to sites subject to high organic pollution and water flow or exchange will diminish the product's effectiveness.

Use Sites	Rate Range (lbs/acre)
Floodwater sites	
Pastures, meadows, freshwater swamps and marshes, salt and tidal marshes, cattail marshes, woodland pools, flood-plains, grassy swales, bogs, tires, and artificial water-holding containers.	2.5-5
Dredge spoil sites, waste treatment and settling ponds, ditches, natural and manmade hollows or sinkhole (that retain water).	5-10
Permanent water sites	
Ornamental ponds and fountains, fish ponds, cattail marshes, water hyacinth beds, flooded crypts, transformer vaults, abandoned swimming pools, treeholes, manmade craters and pits, and artificial and natural water-holding containers.	2.5-5
Storm drains, catch basins, roadside ditches, cesspools, septic tanks, waste settling ponds, vegetation-choked phosphate pits.	5-10

MetaLarv S-PT should be broadcast applied as a dry product. Applications can be made using fixed wing aircraft, helicopter, boat, tractor mounted spreader, handheld or backpack spreader. Fixed wing aircraft or helicopters equipped with granular spreaders capable of applying rates from 2.5-10 lb/acre may be used to apply MetaLarv S-PT. The pellets may also be applied using ground equipment that will achieve good, even coverage at rates from 2.5-10 lb/acre.

5.0

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Do not contaminate water when disposing of equipment washwaters.

Pesticide Storage: Store any unused product in original container. Ensure that container is tightly closed then store in a cool, dry place.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Handling: Nonrefillable container. Do not reuse or refill this container. Offer for recycling, if available. Completely empty bag into application equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.

6.0 WARRANTY STATEMENT

To the extent consistent with applicable law, seller makes no warranty, express or implied, of merchantability, fitness or otherwise concerning use of this product other than as indicated on the label. To the extent consistent with applicable law, user assumes all risks of use, storage or handling not in strict accordance with accompanying directions.

MetaLarv is a registered trademark of Valent BioSciences Corporation.

VectoBac® 12AS

BIOLOGICAL LARVICIDE

AQUEOUS SUSPENSION

Active Ingredient:

Bacillus thuringiensis, subsp. *israelensis*, strain AM 65-52, fermentation solids and solubles	11.61%
Other Ingredients	88.39%
Total	100.00%

Potency: 1200 International Toxic Units (ITU) per mg
(Equivalent to 4.84 billion ITU per gallon, 1.279 billion ITU per liter)

There is no direct relationship between intended activity (potency) and the Percent Active Ingredient by Weight.

EPA Reg. No.73049-38
EPA Est. No. 33762-IA-001 List No. 05605

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0 FIRST AID

If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 HAZARD TO HUMANS (AND DOMESTIC ANIMALS)

CAUTION

Harmful if absorbed through skin. Causes moderate eye irritation. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash contaminated clothing before reuse.

Mixer/loaders and applicators not in enclosed cabs or aircraft must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization.

2.2 Physical and Chemical Hazards

Diluted or undiluted VectoBac 12AS can cause corrosion if left in prolonged contact with aluminum spray system components. Rinse spray system with plenty of clean water after use. Care should be taken to prevent contact with aluminum aircraft surfaces, structural components and control systems. In case of contact, rinse thoroughly with plenty of water. Inspect aluminum aircraft components regularly for signs of corrosion.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply directly to finished drinking water reservoirs or drinking water receptacles when water is intended for human consumption.

Do not apply when weather conditions favor drift from treated areas. Do not apply to metallic painted objects, such as automobiles, as spotting may occur. If spray is deposited on metallic painted surfaces, wash immediately with soap and water to avoid spotting.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment- and weather-related factors determine the potential for spray drift. The applicator and the treatment coordinator are responsible for considering all these factors when making decisions.

3.1 Chemigation

Do not apply this product through any type of irrigation system unless labeling on chemigation is followed.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

STORAGE: Store in a cool, [less than 86° F (30° C)], dry place.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Once cleaned, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke. Do not reuse container.

CONTINUED

5.0 APPLICATION DIRECTIONS

Do not apply when wind speed favors drift beyond the area of treatment.

Mosquito Habitat	Suggested Rate Range*
(Such as the following examples): Irrigation ditches, roadside ditches, flood water, standing ponds, woodland pools, snow melt pools, pastures, catch basins, storm water retention areas, tidal water, salt marshes and rice fields.	0.25 - 2 pts/acres
In addition, standing water containing mosquito larvae, in fields growing crops such as: Alfalfa, almonds, asparagus, corn, cotton, dates, grapes, peaches and walnuts, may be treated at the recommended rates.	
When applying this product to standing water containing mosquito larvae in fields growing crops, do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.	
Polluted water (such as sewage lagoons, animal waste lagoons).	1 - 2 pts/acre

*Use higher rate range in polluted water and when late 3rd and early 4th instar larvae predominate, mosquito populations are high, water is heavily polluted, and/or algae are abundant.

Blackflies Habitat	Suggested Rate Range
Streams	
Stream water† (= ppm) for 1 minute exposure time	0.5 - 25 mg/liter
Stream water† (= ppm) for 10 minutes exposure time	0.05 - 2.5 mg/liter

†Use higher rate range when stream contains high concentration of organic materials, algae, or dense aquatic vegetation.

†Discharge is a principal factor determining carry of Bti. Use higher rate or increase volume by water dilution in low discharge rivers or streams under low volume (drought) conditions.

6.0 NUISANCE FLIES

For control of nuisance flies (*Psychoda* spp., *Chironomus* spp.) in sewage treatment facilities utilizing trickling filter systems.

APPLICATION DIRECTIONS

Nuisance Fly Habitat	Suggested Rate Range*
Trickling filter system of wastewater treatment plants	10 - 20 mg/liter a.(0.833-1.67 ml) per liter of wastewater feed to the filter per 30 minutes

* Use high rate for control of *Chironomus* spp. Apply undiluted with pre-calibrated pump or other device into the wastewater feeding into the filters for a period of 30 minutes. Repeat applications as needed after 2-4 weeks. Control of *Chironomus* spp. may take up to 2 weeks.

7.0 NUISANCE AQUATIC MIDGES

For control of *Chironomine* midges (*Chironominae: Chironomini*) inhabiting shallow, manmade and natural lakes or ponds.

APPLICATION DIRECTIONS

Nuisance Midge Habitat	Suggested Rate Range*
Shallow Lakes and Ponds per sewage oxidation ponds (less than acre 6 feet deep)	1 gallon (3,785.5 ml) per acre

* Apply diluted with water in total volume of 5 gallons/acre by pouring or spraying over the surface to be treated with pre-calibrated device. Repeat application as needed after 2-4 weeks. Control of *Chironomine* midges may take up to 2 weeks.

8.0 GROUND AND AERIAL APPLICATION

VectoBac 12AS may be applied in conventional ground or aerial application equipment with quantities of water sufficient to provide uniform coverage of the target area. The amount of water will depend on weather, spray equipment, and mosquito habitat characteristics. Do not mix more VectoBac 12AS than can be used in a 72-hour period.

For most ground spraying, apply in 5-100 gallons of water per acre using hand-pump, airblast, mist blower, etc., spray equipment.

For aerial application, VectoBac 12AS may be applied either undiluted or diluted with water. For undiluted applications, apply 0.25 to 2.0 pt/acre of VectoBac 12AS through fixed wing or helicopter aircraft equipped with either conventional boom and nozzle systems or rotary atomizers.

For diluted application, fill the mix tank or plane hopper with the desired quantity of water. Start the mechanical or hydraulic agitation to provide moderate circulation before adding the VectoBac 12AS. VectoBac 12AS suspends readily in water and will stay suspended over normal application periods. Brief recirculation may be necessary if the spray mixture has sat for several hours or longer. AVOID CONTINUOUS AGITATION OF THE SPRAY MIXTURE DURING SPRAYING.

Rinse and flush spray equipment thoroughly following each use.

For blackfly aerial applications, VectoBac 12AS can be applied undiluted via fixed wing or helicopter aircraft equipped with either conventional boom and nozzle systems or open pipes. Rate of application will be determined by the stream discharge and the required amount of VectoBac 12AS necessary to maintain a 0.5 - 25 ppm concentration in the stream water. VectoBac 12AS can also be applied diluted with similar spray equipment. Do not mix more VectoBac 12AS than can be used in a 72-hour period.

9.0 SMALL QUANTITY DILUTION RATES

Gallons Spray Solution/Acre (Ounces Needed per Gallon of Spray)

VectoBac 12AS Rate in Pints Per Acre	10 Gal/A	25 Gal/A	50 Gal/A
0.25 (4 oz)	0.4	0.16	0.08
0.5 (8 oz)	0.8	0.32	0.16
1.0 (16 oz)	1.6	0.64	0.32
2.0 (32 oz)	3.2	1.28	0.64

CONTINUED

10.0 CHEMIGATION

Apply this product through flood (basin) irrigation systems. Do not apply this product through any other type of irrigation system.

Crop injury, lack of effectiveness, or illegal pesticide residues in the crop can result from nonuniform distribution of treated water.

If you have any questions about calibration, you should contact State Extension Service Specialists, equipment manufacturers or other experts.

A person knowledgeable of this chemigation system and responsible for its operation, or under the supervision of the responsible person, shall shut the system down and make necessary adjustments should the need arise.

10.1 RICE-FLOOD (BASIN) CHEMIGATION

Systems using a gravity flow pesticide dispensing system must meter the pesticide into the water at the head of the field and downstream of a hydraulic discontinuity such as a drop structure or weir box to decrease potential for water source contamination from backflow if water flow stops.

VectoBac 12AS is metered or dripped into rice floodwater at application stations positioned at the point of introduction (levee cut) of water into each rice field or pan. Two to three pints of VectoBac 12AS are diluted in water to a final volume of 5 gallons. The diluted solution is contained in a 5 gallon container and metered or dispersed into the irrigation water using a constant flow device at the rate of 80 ml per minute. Introduction of the solution should begin when 1/3 to 1/2 of the pan or field is covered with floodwater. Delivery of the solution should continue for a period of approximately 4-1/2 hours. Floodwater depth should not exceed 10-12 inches to prevent excessive dilution of VectoBac 12AS which could result in reduced larval kill.

Agitation is not required during the period in which the VectoBac 12AS solution is being dispersed.

Application of VectoBac 12AS into rice floodwater is not permitted using a pressurized water and pesticide injection system.

11.0 NOTICE TO USER

Seller makes no warranty, express or implied, of merchantability, fitness or otherwise concerning use of this product other than as indicated on the label. User assumes all risks of use, storage or handling not in strict accordance with accompanying directions.

VectoBac is a registered trademark of Valent BioSciences Corporation.

VectoBac® G

BIOLOGICAL LARVICIDE

GRANULE

ACTIVE INGREDIENT:

Bacillus thuringiensis, subspecies *israelensis*, strain AM 65-52, fermentation solids, spores, and insecticidal toxins	2.80%
OTHER INGREDIENTS	97.20%
TOTAL	100.00%

Potency: 200 International Toxic Units (ITU) per mg
(Equivalent to 0.091 billion potency: ITU per pound)

The percent active ingredient does not indicate product performance and potency measurements are not Federally standardized.

EPA Reg. No. 73049-10
EPA Est. No. 33762-IA-001 List No. 05108

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0 FIRST AID

If in Eyes	• Hold eyes open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eyes. • Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 HAZARD TO HUMANS (AND DOMESTIC ANIMALS)

CAUTION

Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling.

Mixers/loaders and applicators not in enclosed cabs or aircraft must wear a dust/mist respirator meeting NIOSH standards of at least N-95, R-95 or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization.

2.2 ENVIRONMENTAL HAZARDS

Do not contaminate water when cleaning equipment or disposing of equipment washwaters. Do not apply directly to treated, finished drinking water reservoirs or drinking water receptacles when the water is intended for human consumption.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

4.0 APPLICATION DIRECTIONS

VectoBac G is an insecticide for use against mosquito larvae.

Mosquitoes Habitat (Such as the following examples):	**Suggested Range Rate***
Irrigation ditches, roadside ditches, flood water, standing ponds, livestock watering ponds and troughs, woodland pools, snow melt pools, pastures, catch basins, storm water retention areas, tidal water, salt marshes and rice fields	2.5 - 10 lbs. / acre

In addition, standing water containing mosquito larvae, in fields growing crops such as alfalfa, almonds, asparagus, corn, cotton, dates, grapes, peaches, sugar cane and walnuts may be treated at the recommended rates.

* Use 10-20 lbs. / acre when late 3rd and early 4th instar larvae predominate, mosquito populations are high, water is heavily polluted (sewage lagoons, animal waste lagoons), and/or algae are abundant.

Apply uniformly by aerial or ground conventional equipment.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determine the potential for spray drift. The applicator and the treatment coordinator are responsible for considering all of these factors when making decisions.

A 7 to 14 day interval between applications should be employed.

5.0 STORAGE AND DISPOSAL

Do not contaminate potable water, food or feed by storage or disposal.

Storage: Store in a cool [59-86°F (15-30°C)], dry place.

Pesticide Disposal: Completely empty bag into application equipment. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Nonrefillable container. Do not reuse or refill this container. Once cleaned, some agricultural plastic pesticide containers can be taken to a container collection site or picked up for recycling. To find the nearest site, contact your chemical dealer or manufacturer, or contact Ag Container Recycling Council at 202-861-3144 or www.acrecycle.org. If recycling is not available dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

6.0 NOTICE TO USER

Seller makes no warranty, express or implied, of merchantability, fitness or otherwise concerning the use of this product other than as indicated on the label. User assumes all risks of use, storage or handling not in strict accordance with accompanying directions.

VectoBac is a registered trademark of Valent BioSciences Corporation.

VALENT BIOSCIENCES CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 USA
PH: 800-323-9597

VectoLex® FG

BIOLOGICAL LARVICIDE

FINE GRANULE

ACTIVE INGREDIENT:

Bacillus sphaericus 2362, Serotype H5a5b, strain ABTS 1743 fermentation solids, spores, and insecticidal toxins	7.5%
OTHER INGREDIENTS	92.5%
TOTAL	100.0%

Potency: This product contains 50 BsITU/mg or 0.023 Billion BsITU/lb.
Expiration Date: (Two years from the date of manufacture).

The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

EPA Reg. No.73049-20
EPA Est. No. 33762-IA-001 List No. 05722

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0 FIRST AID

If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth if possible. • Call a poison control center or doctor for further treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Causes moderate eye irritation. Harmful if absorbed through the skin or inhaled. Avoid contact with skin, eyes or clothing. Wear protective eyewear. Avoid breathing dust. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse.

Mixers/loaders and applicators not in enclosed cabs or aircraft, must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitizations.

2.2 Environmental Hazards

Do not apply directly to treated, finished drinking water reservoirs or drinking water receptacles when the water is intended for human consumption.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

For use only by federal, state, tribal or local government officials responsible for public health or vector control, or by persons certified in the appropriate category or otherwise authorized by the state or tribal lead pesticide regulatory agency to perform mosquito control applications, or by persons under their direct supervision. IN CALIFORNIA: This product is to be applied by County Health Department, State Department of Health Services, Mosquito and Vector Control or Mosquito Abatement District personnel, or persons under contract to these entities only.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Do not contaminate water when disposing of equipment washwaters.

Pesticide Storage: Store in a cool, dry place.

Pesticide Disposal: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

Container Handling: Nonrefillable container. Do not reuse or refill this container. Completely empty bag into application equipment, then offer for recycling if available or dispose of empty bag in a sanitary landfill or by incineration or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

5.0 DIRECTIONS FOR USE - VECTOLEX FG

5.1 Application Directions

MOSQUITO CONTROL

VectoLex® FG Biological Larvicide Fine Granule (hereafter referred to as VectoLex FG) is a selective microbial insecticide for use against mosquito larvae in a variety of habitats. VectoLex FG can be applied to areas that contain fish, other aquatic life, and plants. VectoLex FG can be applied to areas used by or in contact with humans, pets, horses, livestock, birds, or wildlife.

CONTINUED

I. For control of mosquito larvae species* in the following non-crop sites:

Habitat	Rate Range
Wastewater: Sewage effluent, sewage lagoons, oxidation ponds, septic ditches, animal waste lagoons, impounded wastewater associated with fruit and vegetable processing.	5-20 lbs/acre**
Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, retention ponds, detention ponds and seepage ponds.	5-20 lbs/acre**
Marine/Coastal Areas: Salt marshes, mangroves, estuaries.	5-20 lbs/acre**
Water Bodies: Natural and manmade aquatic sites such as lakes, ponds, rivers, canals, streams and livestock watering ponds and troughs.	5-20 lbs/acre**
Dormant Rice Fields: Impounded water in dormant rice fields. (For application only during the interval between harvest and preparation of the field for the next cropping cycle.)	5-20 lbs/acre**
Waste Tires: Tires stockpiled in dumps, landfills, recycling plants, and other similar sites.	0.5-2 lbs/ 1000 sq. ft.

II. For the control of mosquito larvae species* in the following agricultural/crop sites where mosquito breeding occurs:

Habitats:	Rate Range
Rice, pastures/hay fields, orchards, citrus groves, irrigated crops.	5-20 lbs/acre**

Apply VectoLex FG uniformly by aerial or conventional ground equipment. Reapply VectoLex FG as needed after 1 to 4 weeks.

* Mosquito species effectively controlled by VectoLex FG, including many of those known to carry/transmit West Nile virus:

Culex spp.
Aedes vexans
Ochlerotatus melanimon (*Aedes melanimon*)
Ochlerotatus stimulans (*Aedes stimulans*)
Ochlerotatus nigromaculis (*Aedes nigromaculis*)
Psorophora columbiae
Psorophora ferox
Ochlerotatus triseriatus (*Aedes triseriatus*)
Ochlerotatus sollicitans (*Aedes sollicitans*)
Anopheles quadrimaculatus
Coquillettidia perturbans

**Use higher rates (10 to 20 lbs/acre) in areas where extended residual control is necessary, or in habitats having deep water or dense surface cover.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determine the potential for spray drift. The applicator and the treatment coordinator are responsible for considering all these factors when making decisions.

6.0 NOTICE TO USER

To the extent consistent with applicable law, seller makes no warranty, express or implied, of merchantability, fitness or otherwise concerning the use of this product other than as indicated on this label. To the extent consistent with applicable law, user assumes all risks of use, storage or handling not in accordance with accompanying directions.

VALENT BIOSCIENCES CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 USA
PH: 800-323-9597

VectoLex® WSP

BIOLOGICAL LARVICIDE

WATER SOLUBLE POUCH

ACTIVE INGREDIENT:
Bacillus sphaericus 2362, Serotype H5a5b, strain ABTS 1743 Technical Powder (670 BsITU/mg) 7.5%
OTHER INGREDIENTS 92.5%
TOTAL 100.0%

Potency: This product contains 50 BsITU/mg or 0.023 Billion BsITU/lb.

Expiration Date: (Two years from the date of manufacture).

The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

EPA Reg. No. 73049-20 List No. 05722
EPA Est. No. 33762-IA-001 (Lot No. Suffix 'N8')
EPA Est. No. 33967-NJ-1 (Lot No. Suffix 'Q5')

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0

FIRST AID	
If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 HAZARDS TO HUMANS AND DOMESTIC ANIMALS
CAUTION

Harmful if absorbed through the skin. Causes moderate eye irritation. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling.

2.2 ENVIRONMENTAL HAZARDS

Do not contaminate water when disposing of equipment washwaters or rinsate. Do not apply directly to treated, finished drinking water reservoirs or drinking water receptacles when the water is intended for human consumption.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Do not contaminate water when disposing of equipment washwaters.

Pesticide Storage: Store in a cool, dry place.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Non refillable container. Do not reuse or refill this container. Offer for recycling if available. Completely empty bag into application equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke. For Water Soluble Pouches, dispose of empty outer foil bag in trash.

Continued

5.0 DIRECTIONS FOR USE - VECTOLEX WATER SOLUBLE POUCHES (WSP)

Once the foil bag containing Water Soluble Pouches is opened, use pouches within one day.

5.1 APPLICATION DIRECTIONS

MOSQUITO CONTROL

VectoLex WSP is a selective microbial insecticide for use against mosquito larvae in a variety of habitats. VectoLex WSP can be applied to areas that contain fish, other aquatic life, and plants. VectoLex WSP can be applied to areas used by or in contact with humans, pets, horses, livestock, birds or wildlife.

1. **For control of mosquito larvae species* in the following non-crop sites:**

Habitat		Rate Range
Drainage/Drainage Systems:		
Storm drains, catch basins, retention, detention and seepage ponds.		1 pouch/50 sq.ft.(1)
Treatment Areas (For Use In)(1):		
Ponds	Standing water	Unused swimming
Lagoons	Storm water	pools or spas
Water gardens	retention areas	Flooded basements
Hollow trees and	Catch basins	Pool covers
tree holes	Birdbaths	Gutters and drains
Urns	Fountains	Wheelbarrows
Rain barrels	Flowerpots	Garbage cans
Livestock watering	and planters	and covers
troughs/ponds/tanks	Snowmelt pools	Discarded tires
Irrigation ditches	Abandoned	
Roadside ditches	swimming pools	
Flood water		

Any location where water accumulates and remains standing for periods of time, except treated, finished drinking water for human consumption.

(1) Treat on basis of surface area of potential mosquito breeding sites by placing one (1) VectoLex Soluble Pouch for up to 50 square feet of treatment area. Re-apply as needed after 1 to 4 weeks.

5.1 APPLICATION DIRECTIONS (cont'd)

Longer periods of mosquito population suppression may result where sufficient numbers of non-target aquatic invertebrate parasites and predators are present since these are not affected by the product and contribute to mosquito population reduction.

* Mosquito species effectively controlled by VectoLex WSP, including many of those known to carry/transmit West Nile Virus:

Culex spp.	
Aedes vexans	
Ochlerotatus melanimon	*(Aedes melanimon)*
Ochlerotatus stimulans	*(Aedes stimulans)*
Ochlerotatus nigromaculis	*(Aedes nigromaculis)*
Psorophora columbiae	
Psorophora ferox	
Ochlerotatus triseriatus	*(Aedes triseriatus)*
Ochlerotatus sollicitans	*(Aedes sollicitans)*
Anopheles quadrimaculatus	
Coquillettidia perturbans	

6.0 NOTICE TO USER

To the fullest extent permitted by law, seller makes no warranty, express or implied, of merchantability, fitness or otherwise concerning the use of this product other than as indicated on the label. User assumes all risks of use, storage or handling not in strict accordance with accompanying directions.

VALENT BIOSCIENCES CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 USA
PH: 800-323-9597

clarke

NATULAR® G

Mosquito Larvicide Granule

Controls larvae of mosquitoes which may transmit Zika, Dengue, or Chikungunya.
To be used in governmental mosquito control programs, by professional pest control operators, or in other mosquito or midge control operations.

Active Ingredient:	
Spinosad (a mixture of Spinosyn A and Spinosyn D)	0.5%
Other Ingredients	99.5%
Total	100.0%

Group	5	INSECTICIDE

KEEP OUT OF REACH OF CHILDREN

Precautionary Statements

Environmental Hazards

This product is toxic to aquatic invertebrates. Non-target aquatic invertebrates may be killed in water where this pesticide is used. Do not contaminate water when cleaning equipment or disposing of equipment washwaters. Do not apply when weather conditions favor drift from treated areas. Drift from treated areas may be hazardous to aquatic organisms in neighboring areas. Apply this product only as specified on the label.

Directions For Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read all Directions for Use carefully before applying.

Product Information

NATULAR® G is a product for killing mosquito and midge larvae. This product's active ingredient, spinosad, is biologically derived from the fermentation of *Saccharopolyspora spinosa*, a naturally occurring soil organism. NATULAR® G may be applied with suitable ground or aerial application equipment.

Use Precautions

Integrated Pest Management (IPM) Programs

NATULAR® G is intended to kill mosquito and midge larvae. Mosquitoes are best controlled when an IPM program is followed. Larval control efforts should be managed through habitat mapping, active adult and larval surveillance, and integrated with other control strategies such as source reduction, public education programs, harborage or barrier adult mosquito control applications, and targeted adulticide applications.

Insecticide Resistance Management (IRM)

NATULAR® G contains a Group 5 insecticide. Insect biotypes with acquired resistance to Group 5 insecticides may eventually dominate the insect population if appropriate resistance management strategies are not followed. Currently, only spinetoram and spinosad active ingredients are classified as Group 5 insecticides. Resistance to other insecticide groups is not likely to impact the effectiveness of this product. Spinosad may be used in rotation with all other labeled products in a comprehensive IRM program.

To minimize the potential for resistance development, the following practices are recommended:

- Base insecticide use on comprehensive IPM and IRM programs.
- Routinely evaluate applications for loss of effectiveness.
- Rotate with other labeled effective mosquito larvicides that have a different mode of action.
- In dormant rice fields, standing water within agricultural/crop sites, and permanent marine and freshwater sites, do not make more than 20 applications per year.
- Use insecticides with a different mode of action (different insecticide group) on adult mosquitoes so that both larvae and adults are not exposed to products with the same mode of action.
- Contact your local extension specialist, technical advisor, and/or Clarke representative for insecticide resistance management and/or IPM recommendations for the specific site and resistant pest problems.
- For further information or to report suspected resistance, you may contact your local Clarke representative by calling 800-323-5727.

Spray Drift Management

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determines the potential for spray drift. The applicator is responsible for considering all these factors when making decisions. Where states have more stringent regulations, they should be observed.

Application

Proper application techniques help ensure adequate coverage and correct dosage necessary to obtain optimum kill of mosquito and midge larvae. Apply NATULAR® G prior to flooding as a prehatch application to areas that breed mosquitoes, or at any stage of larval development after flooding in listed sites. The following recommendations are provided for ground and aerial application of NATULAR® G.

Ground Application

Use conventional ground application equipment and apply NATULAR® G at the designated rate for the targeted site.

Spot Treatment

Apply NATULAR® G as a spot treatment to areas where mosquitoes are breeding at rates appropriate for the treatment site habitat and conditions.

Aerial Application

Equipment used in the application of NATULAR® G should be carefully calibrated before use and checked frequently during application to be sure it is working properly and delivering a uniform distribution pattern. Avoid overlaps that will increase NATULAR® G dosage above recommended limits.

Application Sites and Rates

The rates listed are typical for efficaciously killing mosquito and midge larvae in the listed habitat sites. Within this range, use lower rates when water is shallow, vegetation and/or pollution are minimal, and mosquito populations are low. Do not use less than labeled minimum rate. NATULAR® G may be applied at rates up to 20 lb per acre in waters high in organic content (such as polluted water, sewage lagoons, animal waste lagoons, and waters with high concentrations of leaf litter or other organic debris), deep-water mosquito habitats or those with dense surface cover, and where monitoring indicates a lack of kill at typical rates. Do not re-apply within 7 days of the initial application unless monitoring indicates that larval populations have reestablished or weather conditions have rendered initial treatments ineffective. Do not apply to water intended for irrigation.

AL0537

For killing mosquito larvae species in the following non-crop sites:

Non-Crop Site	NATULAR® G lb/acre (lb ai/acre)
Temporary Standing Water: Woodland pools, snow pools, roadside ditches, retention ponds, freshwater dredge spoils, tire tracks and other natural or man-made depressions, rock holes, pot holes and similar areas subject to holding water **Other Freshwater Sites:** Natural and manmade aquatic sites, edges of lakes, ponds, canals, stream eddies, creek edges, detention ponds	3.5 - 6.5 (0.018 - 0.033)
Freshwater Swamps and Marshes: Mixed hardwood swamps, cattail marsh, common reed wetland, water hyacinth ponds, and similar freshwater areas with emergent vegetation **Marine/Coastal Areas:** Intertidal areas above the mean high water mark, mangroves, brackish water swamps and marshes, coastal impoundments and similar areas	9 (0.045)
Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, and similar areas **Wastewater:** Sewage effluent, sewers, sewage lagoons, cesspools, oxidation ponds, septic ditches and tanks, animal waste lagoons and settling ponds, livestock runoff lagoons, wastewater impoundments associated with fruit and vegetable processing, and similar areas	6.5 - 9 (0.033 - 0.045)
Dormant Rice Fields: Impounded water in dormant rice fields (for application only during the interval between harvest and preparation of the field for the next cropping cycle)	3.5 - 6.5 (0.018 - 0.033)
Natural and Artificial Containers: Tree holes, bromeliads, leaf axils, and other similar natural water holding containers, cemetery urns, bird baths, flower pots, rain barrels, buckets, single tires, tires stockpiled in dumps, landfills, recycling plants and other similar areas, abandoned swimming pools, ornamental ponds, flooded roof tops and similar water holding sites. Landfill containers, salvage yards, abandoned vehicles Do not apply to natural or artificial containers of water intended for consumption by people, animals, or livestock.	3.5 - 9 (0.018 - 0.045) For small to medium size containers, apply 1/8 teaspoon (about 0.37 g) of Natular G per 10-20 gallons of water. For very small containers, apply a pinch of Natular G (0.02 g) per ½ - 1 gallon of water. This is approximately 7 - 9 granules per ½ - 1 gallon of water.

Agricultural/Crop Sites Where Mosquito Breeding Occurs:

Apply NATULAR® G at the rate of 3.5 to 9 lb per acre in standing water within agricultural/crop sites where mosquito breeding occurs: pastures/hay fields, rangelands, orchards, vineyards, and citrus groves. Do not apply to waters intended for irrigation.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

Pesticide Storage: Store in original container only. In case of leak or spill, contain material with absorbent materials and dispose as waste.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site according to label use directions or at an approved waste disposal facility.

Container Handling for Non-Refillable Bag: Nonrefillable container. Do not reuse or refill this container. Completely empty bag into application equipment. Offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures allowed by state and local authorities.

Container Handling for Rigid Refillable Tote: Refillable container. Refill this container with granular spinosad pesticide formulation only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment. Use a sprayer with water to quickly and completely rinse the interior of the container. Ensure the top, bottom, and all sides are rinsed. A high pressure sprayer with a rinsing nozzle could provide a thorough rinse of the interior. Drain and collect rinsate from the container into a collection system for later disposal. Drain the container dry so no water remains. Return to point of sale. Then offer for recycling if available or reconditioning if appropriate or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures approved by State and local authorities.

Warranty

To the extent consistent with applicable law CLARKE MOSQUITO CONTROL PRODUCTS, INC. makes no warranty, express or implied, concerning the use of this product other than as indicated on the label. Buyer assumes all risk of use/handling of this material when use and/or handling is contrary to label instructions.

Natular® is a Registered Trademark of Clarke Mosquito Control Products, Inc.

IN CASE OF MEDICAL EMERGENCY, CALL THE INTERNATIONAL POISON CONTROL CENTER 1-800-214-7753

Manufactured By:
CLARKE MOSQUITO CONTROL PRODUCTS, INC.
159 North Garden Avenue
Roselle, IL 60172, U.S.A.
1-800-323-5727

EPA Reg. No.: 8329-80 NET WEIGHT: _____

EPA Est. No.: LOT: _____

AL0537

SPINOSAD	GROUP	5	INSECTICIDE

NATULAR® G30

Mosquito Larvicide / Extended Release Granule

Controls larvae of mosquitoes which may transmit Dengue, Chikungunya, or Zika.

To be used in governmental mosquito control programs, by professional pest control operators, or in other mosquito or midge control operations.

Active Ingredient (dry weight basis):	
Spinosad (a mixture of Spinosyn A and Spinosyn D)	2.5%
Other Ingredients	97.5%
Total	100.0%

U.S. Patent No. 5,362,634 and 5,496,931
Natular® G30 is a 2.5% extended release granule.

KEEP OUT OF REACH OF CHILDREN

CAUTION

Precautionary Statements

Hazards to Humans and Domestic Animals

Harmful if swallowed. Causes moderate eye irritation. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco. Avoid contact with eyes or clothing. Wear protective eyewear (such as goggles, face shield, or safety glasses).

First Aid	
If swallowed:	• Call a poison control center or doctor immediately for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything to an unconscious person.
If in eyes:	• Hold eye open and rinse slowly and gently with warm water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing. • Call a poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center or doctor or going for treatment. You may also contact 1-800-214-7753 for emergency medical treatment information.	

Environmental Hazards

This product is toxic to aquatic organisms. Non-target aquatic invertebrates may be killed in waters where this pesticide is used. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

Directions For Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Read all Directions for Use carefully before applying.

Product Information

Natular® G30 is a product for killing mosquito and midge larvae. This product's active ingredient, spinosad, is biologically derived from the fermentation of Saccharopolyspora spinosa, a naturally occurring soil organism. Natular® G30 releases effective levels of spinosad for up to 30 days under typical environmental conditions. Natular® G30 may be applied with ground or aerial equipment.

Use Precautions

Integrated Pest Management (IPM) Programs

Natular® G30 is intended to kill mosquito and midge larvae. Mosquitoes are best controlled when an IPM program is followed. Larval control efforts should be managed through habitat mapping, active adult and larval surveillance, and integrated with other control strategies such as source reduction, public education programs, harborage or barrier adult mosquito control applications, and targeted adulticide applications.

Insecticide Resistance Management (IRM)

Natular® G30 contains a Group 5 insecticide. Insect biotypes with acquired resistance to Group 5 insecticides may eventually dominate the insect population if appropriate resistance management strategies are not followed. Currently, only spinetoram and spinosad active ingredients are classified as Group 5 insecticides. Resistance to other insecticides is not likely to impact the effectiveness of this product. Spinosad may be used in rotation with all other labeled products in a comprehensive IRM program.

To minimize the potential for resistance development, the following practices are recommended:

- Base insecticide use on comprehensive IPM and IRM programs.
- Monitor after application for unexpected target pest survival. If the level of survival suggests the presence of resistance, consult with your local university specialist or Clarke representative.
- Rotate with other labeled effective mosquito larvicides that have a different mode of action.
- In dormant rice fields, standing water within agricultural/crop sites, and permanent marine and freshwater sites, do not make more than 5 applications per year.
- Use insecticides with a different mode of action (different insecticide group) on adult mosquitoes so that both larvae and adults are not exposed to products with the same mode of action.
- Contact your local extension specialist, technical advisor, and/or Clarke representative for insecticide resistance management and/or IPM recommendations for this specific site and resistant pest problems.
- For further information or to report suspected resistance, you may contact your local Clarke representative by calling 800-323-5727.

Application

Proper application techniques help ensure adequate coverage and correct dosage necessary to obtain optimum kill of mosquito and midge larvae. Apply Natular® G30 prior to flooding as a prehatch application to areas that breed mosquitoes, or at any stage of larval development after flooding in listed sites. Do not allow this product to drift onto neighboring crops or non-crop areas or use in a manner or at a time other than in accordance with label directions.

Ground Application

Use conventional ground application equipment that provides even coverage at labeled rates.

Aerial Application

Fixed wing aircraft or helicopters equipped with granular spreaders capable of applying rates from 5 to 20 lb per acre may be used to apply Natular® G30. Aerial application equipment should be carefully calibrated before use to be sure it is working properly and delivering a uniform distribution pattern. Avoid flight path overlaps while dispensing granules. Do not exceed labeled limits.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determine the potential for spray drift. The applicator and the treatment coordinator are responsible for considering all these factors when making application decisions.

Application Sites and Rates

Apply Natular® G30 at rates (see table) for the targeted treatment site. Within these rate ranges apply at a rate appropriate to site habitat and conditions at the time of application. Use lower labeled rate when water is shallow, vegetation and/or pollution are minimal, and mosquito populations are low. Do not use less than labeled minimum rate. Within the labeled rate range, use higher rates when water is deep, vegetation and/or pollution are high, and mosquito populations are high in number.

Natular® G30 may be applied at rates up to 20 lb per acre in waters high in organic content, deep-water mosquito habitats or those with dense surface cover, and where monitoring indicates a lack of kill at typical rates.

Reapply after 30 days, if needed for extended control in continuously flooded habitat. More frequent applications may be made if monitoring indicates that larval populations have reestablished or weather conditions have rendered initial treatments ineffective.

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Treatment Area	Natular® G30
Temporary Standing Water: Woodland pools, snow pools, roadside ditches, retention ponds, freshwater dredge spoils, tire tracks and other natural or manmade depressions, rock holes, pot holes and similar areas subject to holding water. **Other Freshwater Sites:** Natural and manmade aquatic sites; edges of lakes, ponds, canals, stream eddies, creek edges, and detention ponds. **Dormant Rice Fields:** Impounded water in dormant rice fields (for application only during the interval between harvest and preparation of the field for the next cropping cycle). **Freshwater Swamps and Marshes:** Mixed hardwood swamps, cattail marsh, common reed wetland, water hyacinth ponds, and similar freshwater areas with emergent vegetation. **Marine/Coastal Areas:** Intertidal areas above the mean high water mark, mangroves, brackish water swamps and marshes, coastal impoundments and similar areas.	Apply 5 to 12 lbs per acre (5.6 to 13.5 kg per hectare). Rate is equivalent to 5 to 12 g per 100 sq. ft. of water.
Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, and similar areas. **Wastewater:** Sewage effluent, sewers, sewage lagoons, cesspools, oxidation ponds, septic ditches and tanks, animal waste lagoons and settling ponds, livestock runoff lagoons, wastewater impoundments associated with fruit and vegetable processing, and similar areas.	Apply 5 to 20 lbs per acre (5.6 to 22.4 kg per hectare). Rate is equivalent to 5 to 20 g per 100 sq. ft. of water.
Natural and Artificial Containers: Tree holes, bromeliads, leaf axils, and other similar natural water holding containers; cemetery urns, bird baths, flower pots, rain barrels, buckets, single tires, tires stockpiled in dumps, landfills, recycling plants and other similar areas, abandoned swimming pools, ornamental ponds, flooded roof tops and similar water holding sites; landfill containers, salvage yards, abandoned vehicles. Do not apply to natural or artificial containers of water intended for consumption by people, animals, or livestock.	Apply 5 to 20 lbs per acre (5.6 to 22.4 kg per hectare). Rate is equivalent to 5 to 20 g per 100 sq. ft. of water. For small to medium size containers, apply 0.15 g of Natular G30 per 10-25 gallons of water. For very small containers, apply a pinch of Natular G30 (about 0.02 g) per 5 liters (1.3 gallons) of water. This is approximately 8-10 granules per 5 liters of water.
Agricultural Crop Sites Where Mosquito Breeding Occurs Apply Natular® G30 to standing water within agricultural crop sites where mosquito breeding occurs to kill mosquito larvae species, including: pasture/hay fields, rangeland, orchards, vineyards, and citrus groves. Do not apply to waters intended for irrigation.	Apply 5 to 20 lbs per acre (5.6 to 22.4 kg per hectare). Rate is equivalent to 5 to 20 g per 100 sq. ft. of water.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage and disposal.

Pesticide Storage: Store in a cool dry place in original container only. Keep away from moisture.

Pesticide Disposal: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

Container Handling for Non-Refillable Bag: Nonrefillable container. Do not reuse or refill this container. Completely empty bag into application equipment. Offer for recycling, if available, or puncture and dispose of in a sanitary landfill or by incineration, or by other procedures approved by state and local authorities.

Container Handling for Rigid Refillable Tote: Refillable container. Refill this container with granular spinosad pesticide formulation only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the re-filler. To clean the container before final disposal, empty the remaining contents from this container into application equipment. Use a sprayer with water to quickly and completely rinse the interior of the container. Ensure the top, bottom, and all sides are rinsed. A high pressure sprayer with a rinsing nozzle could provide a thorough rinse of the interior. Drain and collect rinsate from the container into a collection system for later disposal. Drain the container dry so no water remains. Return to point of sale. Then offer for recycling if available or reconditioning if appropriate or puncture and dispose of in a sanitary landfill, or by incineration, or by other procedures approved by State and local authorities.

Warranty: To the extent consistent with applicable law, CLARKE MOSQUITO CONTROL PRODUCTS, INC. makes no warranty, express or implied, concerning the use of this product other than as indicated on the label. Buyer assumes all risk of use/handling of this material when use and/or handling is contrary to label instructions.

Natular® is a Trademark of Clarke Mosquito Control Products, Inc.

Manufactured For:
CLARKE MOSQUITO CONTROL PRODUCTS, INC.
159 North Gardner Avenue
Roselle, IL 60172, U.S.A.
1-800-323-5727

EPA Reg. No.: 8329-83
EPA Est. No.: 8329-IL-03
Net Contents: _____
Lot: _____

AL0807

RESTRICTED USE PESTICIDE
DUE TO TOXICITY TO FISH AND AQUATIC ORGANISMS
For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification.

PERMETHRIN 57% OS

A Synthetic Pyrethroid for Effective Control and Repellency of Adult Nuisance and Vector Mosquitoes, Gnats, Biting and Non-Biting Midges, Blackflies, Deer Flies and Other Biting Flies in Outdoor Residential and Recreational Areas.

Active Ingredient:	
Permethrin (3-Phenoxyphenyl) methyl (+/-) cis, trans-3-(2,2 dichlorethenyl)-2,2-dimethyl-cyclopropane carboxylate	57.00%
Other Ingredients*	43.00%
TOTAL	100.00%

Contains 5 lb/gal Permethrin
*Contains petroleum distillates
Cis/trans isomers ratio: min. 35% (+) cis and max. 65% (+) trans.

KEEP OUT OF REACH OF CHILDREN

CAUTION

FIRST AID

Have product container or label with you when calling a poison control center or doctor, or going for treatment. For medical emergency information, call the International Poison Control Center at 1-800-214-7753.

IF SWALLOWED:	Immediately call a poison control center or doctor. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give any liquid to the person. Do not give anything by mouth to an unconscious person.

Note to physicians: Contains petroleum distillate. Vomiting may cause aspiration pneumonia.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION. Harmful if swallowed. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

Personal Protective Equipment (PPE): Mixers, loaders, applicators and other handlers must wear: Long-sleeve shirt and long pants, shoes plus socks, and chemical-resistant gloves made of any waterproof material. Mixers/loaders, persons cleaning equipment, and persons exposed to the concentrate must wear a chemical-resistant apron.

User Safety Requirements: Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them.

User Safety Recommendations

Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet. Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

This product is extremely toxic to fish and aquatic organisms, including fish and invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not apply when weather conditions favor drift from treated areas. Drift and runoff from treated areas may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment wash waters. Under some conditions, it may also have a potential for transport into surface water runoff (primarily absorbed to suspended soil particles), for several months or more after application. These include poorly draining or wet soils with readily visible slopes toward adjacent surface waters, frequently flooded areas, and areas overlying extremely shallow groundwater, areas with in-field canals or ditches that drain to surface water, areas not separated from adjacent surface waters with vegetated filter strips, and areas over-lying tile drainage systems that drain to surface waters.

This pesticide is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment areas.

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of the National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Precautions and Restrictions

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

Not for use in outdoor residential misting systems. Not for use in metered release systems.

Use in handheld thermal foggers is prohibited. Not for application by stationary fogger.

Do not make applications during rain. Apply when wind speed is greater than 1 mph.

Except when applying to building foundations, all outdoor applications to impervious surfaces such as sidewalks, driveways, patios, porches and structural surfaces (such as windows, doors, and eaves) are limited to spot and crack-and-crevice application only. When applying sprays to building foundations, apply spray to a maximum height of 3 feet.

Do not allow spray treatment to drift onto cropland, poultry ranges or potable water supplies. Do not use on crops used for food or forage.

Do not apply within 25 feet of aquatic habitats (such as, but not limited to, lakes, reservoirs, rivers, streams, marshes, natural ponds, estuaries, and commercial fish ponds).

Spray Drift Requirements

Only apply this product if the wind direction favors on-target deposition. Do not apply when the wind velocity exceeds 15 mph. Wind speed must be measured adjacent to the application site on the upwind side, immediately prior to application.

Do not make applications into temperature inversions. Inversions are characterized by stable air and increasing temperatures with height above the ground. Mist or fog may indicate the presence of an inversion in humid areas. The applicator may detect the presence of an inversion by producing smoke and observing a smoke layer near the ground surface.

AL0271

Use only Medium or coarser spray nozzles according to ASAE (S572) definition for standard nozzles, and that produce a droplet spectrum of 150-300 microns VMD. In conditions of low humidity and high temperatures, applicators should use a coarser droplet size.

General Information

PERMETHRIN 57% OS provides residual control of adult nuisance and vector mosquitoes and other listed pests on plant and other surfaces where these pests may rest (harbor) for up to 14 days in shaded areas. Secondary activity of a "barrier"-type application is through repellency.

PERMETHRIN 57% OS is approved for use as a residual barrier/harborage spray in vegetation and around structures in residential and recreational areas and other areas these insects occur. Typical harborage sites include brush, building foundations, bushes, climbing ivy, grasses, lawns, trees, turf, vegetative groundcover, windbreak vegetation and other such vegetative cover within or surrounding municipal and residential areas such as, but not limited to: athletic fields, campgrounds, collapsed structures (old building foundations, fences), junk yards, large tire piles, log piles, overgrown waste areas, parks, playgrounds, outdoor residential areas, school yards, scrap yards (including abandoned vehicles), wooded park trails, woodlands, woodlots, and woodpiles.

Application Directions

Apply product by ground application with a mist blower, power backpack, pressure sprayer, or ultra-low volume (ULV) cold aerosol generator. If a ULV sprayer is used, adjust pressure to deliver particles of 150-300 microns VMD.

PERMETHRIN 57% OS must be mixed with a non-phytotoxic oil mixture prior to application. The oil mixture is obtained by combining 1 part soybean oil to 2 parts mineral oil. Non-phytotoxic oils must be used to avoid plant damage within treated areas.

To kill or repel mosquitoes, midges, deer flies and other biting flies, mix with enough oil mixture so as to easily apply 0.1 pounds of Permethrin per acre. The following dilution and flow rate is calculated assuming a 2 MPH walking speed and a fifty (50) foot application swath. If a different dilution ratio or walking speed is used, adjust rate accordingly so as to achieve 0.1 pounds of Permethrin per acre.

Dilution			Finished Spray (Permethrin)		Application rate at 2 MPH walking speed		
PERMETHRIN 57% OS	Soybean Oil	Mineral Oil	% / wt	Lb. ai./ gallon	Fl. oz./ Acre	Fl. oz./ Minute	Lb. ai./ Acre
1 Part	3 Parts	6 Parts	5.7 %	0.5	25	5.0	0.1

For optimum results, thoroughly spray vegetation. Do not spray to the point of runoff. For large recreational areas such as football fields, stadiums, racetracks, and public parks, spray the insecticide-oil mixture to all vegetative areas and groundcover and to surrounding harborage areas.

STORAGE & DISPOSAL

Do not contaminate water, food or feed by storage and disposal.

PESTICIDE STORAGE & SPILL PROCEDURES: Do not store at temperatures below 40 °F (4.5 °C). If this material has been exposed to temperatures below 40 °F, there may be precipitation. Check for crystallization. If evident, warm to 80 °F (26.5 °C) and thoroughly mix before using. DO NOT USE OPEN FLAME. Store upright at room temperature. Avoid exposure to extreme temperatures. In case of spill or leakage, soak up with an absorbent material such as sand, sawdust, earth, fuller's earth, etc. Dispose of with chemical waste.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of at an approved waste disposal facility.

CONTAINER HANDLING: Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment or mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into rinsate collection system. Repeat this rinsing procedure two more times. Then offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

FOR MORE INFORMATION CALL: 1-800-323-5727

NOTICE: To the extent consistent with applicable law, seller makes no warranty, expressed or implied, concerning the use of this product other than as indicated on the label. Buyer assumes all risk of use and/or handling of this material when use and/or handling is contrary to label instructions.

MANUFACTURED BY:
CLARKE MOSQUITO CONTROL PRODUCTS, INC.
159 NORTH GARDEN AVE.
ROSELLE, IL 60172
U.S.A.

EPA REG. NO. 8329-44
EPA EST. NO. 8329-IL-01

AVAILABLE CONTAINERS: (NET CONTENTS): 30 GAL
LOT NO. marked on container

AL0271

clarke

ANVIL® 2+2 ULV

Contains an Oil Soluble Synergized Synthetic Pyrethroid for Control of Adult Mosquitoes (Including Organophosphate-Resistant Species) Midges, and Black Flies in Outdoor Residential and Recreational Areas.

For use only by federal, state, tribal or local government officials responsible for public health or vector control, or by persons certified in the appropriate category or otherwise authorized by the state or tribal lead pesticide regulatory agency to perform adult mosquito control applications, or by persons under their direct supervision.

ACTIVE INGREDIENTS:	
3-Phenoxybenzyl-(1RS, 3RS; 1RS, 3SR)-2,2-dimethyl-3-(2-methylprop-1-enyl) cyclopropanecarboxylate	2.00%
*Piperonyl Butoxide	2.00%
**OTHER INGREDIENTS	96.00%
	100.00%

Contains 0.14 lbs. Technical SUMITHRIN®/Gallon and 0.14 lbs. Piperonyl Butoxide/Gallon

* (butylcarbityl)(6-propylpiperonyl) ether and related compounds

**Contains a petroleum distillate

KEEP OUT OF REACH OF CHILDREN

CAUTION

PRECAUCION AL USUARIO: Si usted no lee ingles, no use este producto hasta que la etiqueta haya sido explicado ampliamente

FIRST AID	
IF ON SKIN OR CLOTHING:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
IF SWALLOWED:	• Immediately call a poison control center or doctor. • Do not induce vomiting unless told to do so by a poison control center or a doctor. • Do not give any liquid to the person. • Do not give anything by mouth to an unconscious person.
NOTE TO PHYSICIAN Contains petroleum distillate - vomiting may cause aspiration pneumonia.	
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For information regarding medical emergencies or pesticide incidents, call 1-888-740-8712.	

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION. Harmful if absorbed through the skin. Avoid contact with skin, eyes and clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Some materials that are chemical-resistant to this product are: barrier laminate or Viton. Mixers, loaders, applicators, and other handlers must wear long-sleeve shirt, long pants, shoes and socks. In addition, all handlers except for applicators using motorized ground equipment, pilots, and flaggers, must wear chemical-resistant gloves. See engineering controls for additional requirements.

USER SAFETY REQUIREMENTS

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent material that have been drenched or heavily contaminated with the product's concentrate. Do not reuse them.

ENGINEERING CONTROLS

Pilots must use an enclosed cockpit that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(6)].

USER SAFETY RECOMMENDATIONS

Users should wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. User should remove clothing/PPE immediately if pesticide gets inside, then wash thoroughly and put on clean clothing. User should remove PPE immediately after handling this product. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to aquatic organisms, including fish and aquatic invertebrates. Runoff from treated areas or deposition of spray droplets into a body of water may be hazardous to fish and aquatic invertebrates. Before making the first application in a season, it is advisable to consult with the state or tribal agency with primary responsibility for pesticide regulation to determine if other regulatory requirements exist. Do not apply over bodies of water (lakes, rivers, permanent streams, natural ponds, commercial fish ponds, swamps, marshes or estuaries), except when necessary to target areas where adult mosquitoes are present, and weather conditions will facilitate movement of applied material beyond the body of water in order to minimize incidental deposition into the water body. Do not contaminate bodies of water when disposing of equipment rinsate or wash waters.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply to or allow drift onto blooming crops or weeds when bees are visiting the treatment area, except when applications are made to prevent or control a threat to public and/or animal health determined by a state, tribal or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

USE RESTRICTIONS:

IN CALIFORNIA: This product is to be applied by County Health Department, State Department of Health Services, Mosquito and Vector Control or Mosquito Abatement District personnel only.

IN FLORIDA: Aerial applications of this product require trained personnel to perform industry accepted assays to monitor resistance formation in targeted mosquitoes.

Do not treat a site with more than 0.0036 pounds of Sumithrin® or piperonyl butoxide per acre in a twenty-four hour period. Do not exceed 0.1 pounds of Sumithrin® or piperonyl butoxide per acre in any site in one year. More frequent applications may be made to prevent or control a threat to public and/or animal health determined by a state, tribal or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

NOTE: When rotating products with other insecticides containing PBO, do not exceed 2 lbs PBO per acre per year.

Not for use in outdoor residential misting systems.

USE INFORMATION:

USE AREAS: For use in mosquito adulticiding programs involving outdoor residential and recreational areas where adult mosquitoes are present in annoying numbers in vegetation surrounding parks, woodlands, swamps, marshes, overgrown areas and golf courses. ANVIL 2+2 ULV may be applied over agricultural areas for the control of adult mosquitoes within or adjacent to these areas.

For best results, apply when mosquitoes are most active and weather conditions are conducive to keeping the fog close to the ground. Application in calm air conditions is to be avoided. Apply only when ground wind speed is greater than 1 mph. Air temperature should be greater than 50 °F when conducting all types of applications.

AL0397

NOTE: ANVIL 2+2 ULV cannot be diluted in water. Dilute this product with light mineral oil if dilution is preferred.

SPRAY DROPLET SIZE DETERMINATION

Ground Equipment: Spray equipment must be adjusted so that the volume median diameter (VMD) is less than 30 microns (Dv 0.5 < 30 um) and that 90% of the spray is contained in droplets smaller than 50 microns (Dv 0.9 < 50 um). Directions from the equipment manufacturer or vendor, pesticide registrant, or a test facility using a laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated.

Aerial Equipment: Spray equipment must be adjusted so that the volume median diameter produced is less than 60 microns (Dv 0.5 < 60 um) and that 90% of the spray is contained in droplets smaller than 80 microns (Dv 0.9 < 80 um). The effects of flight speed and, for non-rotary nozzles, nozzle angle on the droplet size spectrum must be considered. Directions from the equipment manufacturer or vendor, pesticide registrant, or a test facility using a wind tunnel and laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated.

GROUND ULV APPLICATION

Apply ANVIL 2+2 ULV through a standard ULV cold aerosol or non-thermal aerosol (cold fog) generator. Consult the following table for examples of various dosage rates using a swath width of 300 feet for acreage calculations. Vary flow rate according to vegetation density and mosquito population. Use higher flow rate in heavy vegetation or when pest populations are high.

ANVIL 2+2 ULV may also be applied undiluted with non-thermal, portable, motorized backpack equipment adjusted to deliver ULV particles of less than 100 microns VMD. Use 1.081 to 3.245 fl. oz. of the undiluted spray per acre (equal to 0.0012 to 0.0036 lb. a.i./acre) as a 50 ft. (15.2 m) swath while walking at a speed of 2 mph (3.2 kph). Do not use hand held equipment for this type of application in enclosed spaces.

Dosage Rate (Lbs. Sumithrin® / acre)	Fl.oz. ANVIL 2+2 ULV per Acre	Flow Rates in fluid oz./minute at truck speeds of:			
		5 MPH	10 MPH	15 MPH	20 MPH
0.0036	3.245	9.8	19.7	29.5	39.3
0.0024	2.163	6.6	13.1	19.7	26.2
0.0012	1.081	3.3	6.6	9.8	13.1

ANVIL 2+2 ULV may be applied through truck mounted thermal fogging equipment. Do not exceed the maximum rates listed above. May be applied at speeds of 5 to 20 mph. To reduce oil requirement and sludge buildup in equipment, use 100-second viscosity mineral "fog" oil. For use with hand-carried foggers, use same rates of active ingredient per acre. Do not wet foliage since oil base formulations may be phytotoxic. Use a clean, well-maintained and properly calibrated fogger. Fog downwind. Do not use hand held equipment for this type of application in enclosed spaces.

AERIAL APPLICATION

ANVIL 2+2 ULV may be applied at rates of 1.081 to 3.245 fluid ounces ANVIL 2+2 ULV per acre by fixed wing or rotary aircraft equipped with suitable ULV application equipment.

RELEASE HEIGHT FOR AERIAL: Fixed Wing: Apply using a nozzle height of no less than 100 feet above the ground or canopy. Rotary Wing: Apply using a nozzle height of no less than 75 feet above the ground or canopy.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage and disposal.

PESTICIDE STORAGE: Store in a cool, dry place. Keep container closed.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with mineral oil and recap. Shake for 10 seconds. Pour rinsate into application equipment or a rinse tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

CONTAINER DISPOSAL: Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning before refilling is the responsibility of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment or mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into rinsate collection system. Repeat this rinsing procedure two more times. Offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

NOTICE: To the extent provided by law, Seller makes no warranty, expressed or implied, concerning the use of this product other than as indicated on the label. Buyer assumes all risk of use and/or handling of this material when use and/or handling is contrary to label instructions.

ANVIL™ is a Trademark of Clarke Mosquito Control Products, Inc.
Sumithrin ® is a Trademark of Sumitomo Company, Ltd.

Manufactured For:
CLARKE MOSQUITO CONTROL PRODUCTS, INC.
159 N. GARDEN AVENUE
ROSELLE, ILLINOIS 60172 U.S.A
FOR MORE INFORMATION CALL: 1-800-323-5727

EPA Reg. No.: 1021-1687-8329

EPA Est. No: _____

NET CONTENTS: [ ] 2.5 GAL [ ] 30 GAL [ ] 55 GAL [ ] 275 GAL

LOT No.: _____

AL0397

Zenivex® E4 RTU

For use only by federal, state, tribal, or local government officials responsible for public health or vector control, or by persons certified in the appropriate category or otherwise authorized by the state or tribal lead pesticide regulatory agency to perform adult mosquito control applications, or by persons under their direct supervision.

- **FOR THE CONTROL OF ADULT MOSQUITOES, NON-BITING MIDGES, AND BLACK FLIES**
- **FOR USE AS A SPACE SPRAY BY AIR AND GROUND APPLICATION TO CONTROL ADULT MOSQUITOES**
- **APPROVED FOR USE OVER AGRICULTURAL CROPS (INCLUDING THOSE INTENDED FOR HUMAN CONSUMPTION), PASTURE AND RANGELAND**
- **READY TO USE WITHOUT DILUTION**
- **CONTROLS ADULT MOSQUITOES THAT MAY CARRY WEST NILE VIRUS, EASTERN EQUINE ENCEPHALITIS, ST. LOUIS ENCEPHALITIS**
- **CONTROLS NON-BITING MIDGES, NUISANCE AND BITING FLIES**
- **QUICK, PERMANENT KNOCKDOWN OF ADULT MOSQUITOES**

SPECIMEN LABEL

ACTIVE INGREDIENT:	
Etofenprox (CAS #80844-07-1).	4%
OTHER INGREDIENTS*:	96%
Total:	100%

*Contains petroleum distillates
Contains 0.30 lbs etofenprox per gallon

EPA Reg. No. 2724-807 EPA Est. No. 2724-TX-1

KEEP OUT OF REACH OF CHILDREN

CAUTION

See additional Precautionary Statements,

PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS AND DOMESTIC ANIMALS CAUTION

Harmful if swallowed. Causes moderate eye irritation. Avoid contact with eyes, skin, or clothing. Applicators and other handlers must wear long-sleeved shirt, long pants, socks and shoes. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove contaminated clothing and launder before reuse. Repeated exposure to etofenprox can cause skin irritation.

FIRST AID

If swallowed • Immediately call a poison control center or doctor. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give any liquid to the person. • Do not give anything by mouth to an unconscious person.

If in eyes • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eyes. • Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor or going for treatment. You may also contact 1-800-248-7763 for emergency medical treatment information.

NOTE TO PHYSICIAN: May pose an aspiration pneumonia hazard. Contains petroleum distillate.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to aquatic organisms, including fish and aquatic invertebrates. Runoff from treated areas or deposition into bodies of water may be hazardous to fish and other aquatic organisms. Do not apply over bodies of water (lakes, rivers, permanent streams, natural ponds, commercial fish ponds, swamps, marshes or estuaries), except when necessary to target areas where adult mosquitoes are

present, and weather conditions will facilitate movement of applied material away from water in order to minimize incidental deposition into the water body. Do not contaminate bodies of water when disposing of equipment rinsate or washwaters.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Time applications to provide the maximum possible interval between treatment and the next period of bee activity. Do not apply to blooming crops or weeds when bees are visiting the treatment area, except when applications are made to prevent or control a threat to public and/or animal health determined by a state, tribal, or local health or vector control agency on the basis of documented evidence of disease-causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

PHYSICAL/CHEMICAL HAZARDS

Combustible. Do not use or store near heat or open flame.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. **READ AND FOLLOW ALL LABEL DIRECTIONS.** Before making the first application of the season, it is advisable to consult with the state or tribal agency with primary responsibility for pesticide regulation to determine if other regulatory requirements exist.

GENERAL

ZENIVEX® E4 RTU is an effective insecticide used at low volumes to control adult mosquitoes, non-biting midges, biting and non-biting flies. Use **Zenivex® E4 RTU** undiluted as UltraLow Volume (ULV) for the control of pest species in or near residential, industrial, commercial, urban, recreational areas, woodlands, golf courses, and other areas where these pests are a problem. **Zenivex® E4 RTU** may be applied over agricultural areas prior to or following harvest for the control of adult mosquitoes within or adjacent to these areas. In the treatment of corrals, feedlots, swine lots, and zoos, cover any exposed drinking water, drinking water fountains, and animal feed before application. Apply **Zenivex® E4 RTU** aerially (both fixed and rotary aircraft) for low volume applications or through mist-blowers, backpack, and handheld sprayers for ground applications. **Zenivex® E4 RTU** will control mosquitoes and flies and can be used as part of a total integrated pest management program for controlling disease vectors. Apply **Zenivex® E4 RTU** at rates from 0.00175 to 0.0070 pounds of etofenprox per acre by ground ULV. Use this product undiluted only; do not mix with water. Apply when wind is ≥ 1 mph. Do not apply when wind speeds exceed 10 mph. A temperature inversion is preferable to keep the fog close to the ground and applications should be made when labeled insects are most active.

Do not spray more than 0.18 lbs etofenprox per acre per site per year. Do not make more than 25 applications per site per year. More frequent treatments may be made to prevent or control a threat to public and/or animal health determined by a state, tribal, or local health or vector control agency on the basis of documented evidence of disease-causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

GROUND APPLICATION

Use a vehicle-mounted cold aerosol ULV sprayer to apply the product. Direct the spray equipment nozzle to provide even distribution of the product. For best results, apply perpendicular to the wind direction using a swath width of 300 ft. Spray equipment must be adjusted so that the volume median diameter (VMD) is between 10-30 microns ($10\mu \leq D_{v0.5} \leq 30\mu$) and that 90% of the spray is contained in droplets smaller than 50 microns ($D_{v0.9} < 50\mu$). Directions from the equipment manufacturer or vendor, pesticide registrant, or test facility using a laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated.

The appropriate application rate can be achieved by using the following table. Refer to the following chart for examples.

Application rate pound A.I. per acre	Flow rates Undiluted Oz/Acre	Flow rates Undiluted Oz/Minute	Vehicle Speed
0.00175	0.75	2.25	5
		4.50	10
		7.00	15
0.00350	1.5	4.50	5
		9.00	10
		13.50	15
0.00700	3.0	9.00	5
		18.00	10

Use the higher label rates when spraying areas where dense vegetation is present. Conduct applications when temperatures are between 50-95° F.

Backpack Sprayer ULV Application

Apply **Zenivex® E4 RTU** undiluted through non-thermal ULV backpack sprayer capable of applying the product in the 10 to 30 micron range. Apply product to the area as evenly as possible. Apply at the rate of 0.00175 to 0.0070 pounds etofenprox per acre.

Urban ULV Mosquito Control Applications

For control of resting or flying adult mosquitoes, biting flies and non-biting midges in areas such as utility

tunnels, sewers, storm drains and catch basins, pipe chases, underground basements, underground passages, parking decks, crawl spaces or uninhabited buildings, apply **Zenivex® E4 RTU** using mechanical foggers, hand-held or truck-mounted ULV equipment, thermal foggers or other spray equipment suitable for this application. Apply **Zenivex® E4 RTU** at rates up to but not exceeding 0.0070 pounds of etofenprox per acre.

Thermal Fogging Application
Apply using a truck, dolly mounted, handheld, or other thermal fogging equipment. Following the equipment manufacturer's instructions, apply this product at a rate of 0.00175 to 0.0070 pounds etofenprox per acre. Direct fog to areas where mosquitoes and other pests are located. The volume median diameter (VMD) of droplets produced by thermal foggers is less than 60 microns ($D_{v0.5}$ < 60μ) and 90% of the spray is contained in droplets smaller than 100 microns ($D_{v0.9}$ < 100μ).

AERIAL APPLICATION
Apply **Zenivex® E4 RTU** aerially, undiluted, by fixed wing or rotary aircraft. Apply at the rate of 0.00175 to 0.0070 pounds of etofenprox per acre. Apply using ULV equipped and capable aircraft. Spray equipment must be adjusted so that the volume median diameter (VMD) produced is less than 60 microns ($D_{v0.5}$ < 60μ) and that 90% of the spray is contained in droplets smaller than 100 microns ($D_{v0.9}$ < 100μ). The effects of flight speed and, for non-rotary nozzles, nozzle angle on the droplet size spectrum must be considered. Directions from the equipment manufacturer or vendor, pesticide registrant, or test facility using a wind tunnel and laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated. Do not apply **Zenivex® E4 RTU** at altitudes below 100 feet. Apply at altitudes from 100-300 feet. Apply when wind speed on the ground is ≥ 1 mph. Apply when labeled insects are most active. For best results, use Global Positioning System (GPS) equipped aircraft.

IN FLORIDA: Do not apply by aircraft except with the approval of the Florida Department of Agriculture and Consumer Services.

APPLICATIONS OVER CROPS OR TO AREAS FAVORING DRIFT OVER CROPS

Zenivex® E4 RTU may be applied over crops (including row, tree, fruit, citrus, pasture and other areas where agricultural enterprises take place) or to areas, where drift over cropland could occur. **Zenivex® E4 RTU** can be applied to these areas by either ground or aerial application. Use label rates and follow directions for use as directed in this label. Applications over crops or where drift may occur over crops are limited to 4 applications per month to the same site but no more than two applications within a seven day interval. Do not apply more than 0.028 pounds of active ingredient per month to the same site within a month. Do not spray more than 0.18 lbs etofenprox per acre per site per year. Do not make more than 25 applications per site per year.

PESTICIDE STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

STORAGE AND SPILL PROCEDURES: Store upright at room temperature. Avoid exposure to extreme temperatures. In case of spill or leakage, soak up with an absorbent material such as sand, sawdust, earth, fuller's earth, etc. Dispose of with chemical waste.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Refillable 30 Gallon Drums, 120 Gallon Mini-Tote and 275 Gallon Tote: Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the refiller. If not refilled, offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration. To clean the container before final disposal, triple rinse (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with mineral oil or other suitable oil diluents. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. **Non-refillable 2.5 gallon containers: Non-refillable container.** Triple rinse (or equivalent), promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or mix tank and drain container for 10 seconds after the flow begins to drip. Fill the container ¼ full of with mineral oil or other suitable oil diluents and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank. Drain container for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Once triple rinsed, recycle if available, or puncture and dispose of in a sanitary landfill, or by incineration.

To the extent consistent with applicable law, seller makes no warranty, expressed or implied, concerning the use of this product other than indicated on the label. Buyer assumes all risks of use and handling of this material when such use and handling are contrary to label instructions.

In case of an emergency or for product use information, call **1-800-248-7763**.

www.zenivex.com

Wellmark International
1501 East Woodfield Road 200W
Schaumburg, Illinois 60173

ZOËCON. Professional Products

VEC 14-006

January, 2014
Schaumburg, IL

clarke

MERUS™ 2.0

FOR USE IN ORGANIC PRODUCTION

For control of adult mosquitoes in Outdoor Residential, Recreational and Agricultural Areas
Contains pyrethrins - a botanical insecticide derived from chrysanthemums

ACTIVE INGREDIENT:	
Pyrethrins, a botanical insecticide	5.0%
OTHER INGREDIENTS*	95.0%
	100.0%

Contains 0.41 pounds Pyrethrins per gallon
* contains petroleum distillate

KEEP OUT OF REACH OF CHILDREN

CAUTION

FIRST AID	
Have product container or label with you when calling a poison control center or doctor, or going for treatment. **For medical emergencies or information on health concerns for this product, you may call 1-800-214-7753.**	
IF SWALLOWED:	• Immediately call a poison control center or doctor. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give **any** liquid to the person. Do not give anything by mouth to an unconscious person.
NOTICE TO PHYSICIAN: Contains petroleum distillate. Vomiting may cause aspiration pneumonia.	

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION. Contains petroleum distillate. Harmful if swallowed. Wash hands thoroughly with plenty of soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

Personal Protective Equipment (PPE): Mixers, loaders, applicators and other handlers must wear the following: long-sleeve shirt, long pants, shoes and socks. In addition, all handlers, except for applicators using truck-mounted or aerial application equipment, must wear chemical resistant gloves (such as barrier laminate, nitrile rubber, neoprene rubber, Viton, Selection Category E). See engineering controls for additional requirements.

User Safety Requirements: Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent materials that have been drenched or heavily contaminated with the product's concentrate. Do not reuse them.

User Safety Recommendations: Users should wash hands before eating, drinking, chewing gum, tobacco, or using the toilet. Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Users should remove PPE immediately after handling this product. As soon as possible, wash thoroughly and change into clean clothing.

Engineering Controls: Pilots must use an enclosed cockpit that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(6)]. Human flagging is prohibited. Flagging to support aerial application is limited to use of the Global Positioning System (GPS) or mechanical flaggers.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to aquatic organisms, including fish and aquatic invertebrates. Runoff from treated areas or deposition of spray droplets into a body of water may be hazardous to fish and aquatic invertebrates. Do not apply over bodies of water (lakes, rivers, permanent streams, natural ponds, commercial fish ponds, swamps, marshes or estuaries), except when necessary to target areas where adult mosquitoes are present, and weather conditions will facilitate movement of applied material away from the water in order to minimize incidental deposition into the water body. Do not contaminate bodies of water when disposing of equipment rinsate or wash waters.

Before making the first application in a season, it is advisable to consult with the state or tribal agency with primary responsibility for pesticide regulation to determine if other regulatory requirements exist.

This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds.

Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area, except when applications are made to prevent or control a threat to public and/or animal health determined by a state, tribal or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes, or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

USE RESTRICTIONS

Apply this product only as specified on this label. This product is not for use in outdoor residential misting systems. Do not apply this product with thermal fogging equipment. Do not apply this product in enclosed spaces using hand-held or portable backpack spray equipment. Do not make applications during rain.

Apply this product only as an aerial or ground ULV (vehicle-mounted, backpack, or hand-held ULV) mosquito adulticide.

For use only by federal, state, tribal or local government officials responsible for public health or vector control, or by persons certified in the appropriate category or otherwise authorized by the state or tribal lead pesticide regulatory agency to perform adult mosquito control applications, or by persons under their direct supervision.

IN CALIFORNIA: This product is to be applied by County Health Department, State Department of Health Services, Mosquito and Vector Control or Mosquito Abatement District personnel, or persons under contract to these entities only.

IN FLORIDA: Aerial applications of this product require trained personnel to perform industry accepted assays to monitor resistance formation in targeted mosquitoes.

The maximum application rate for wide-area mosquito adulticide applications is 0.0025 lb a.i. / acre per day. When targeting *Aedes taeniorhynchus* and other difficult species, applications may be made up to 0.008 lb a.i./acre/day.

Do not apply more than 0.2 lb a.i. per acre per year in any treated area. More frequent treatments may be made to prevent or control a threat to public and/or animal health determined by a state, tribal, or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes or the occurrence of mosquito-borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural disaster recovery effort.

WIND SPEED: Apply only when wind speed is greater than 1 mph.

MERUS 2.0 may be used undiluted or diluted with suitable light mineral oil and applied as an ultra low volume (ULV) non-thermal aerosol (cold fog) or in suitable mechanical spray equipment. MERUS 2.0 cannot be diluted in water.

MERUS 2.0 may be used to control adult mosquitoes in mosquito control programs including residential, industrial, recreational, and agricultural areas, in vegetation surrounding swamps, marshes, overgrown waste areas, roadsides and pastures and other areas adult mosquitoes occur. For best results, treat when mosquitoes are most active. Application during the cool hours of the night or early morning is usually preferable, with a minimum application temperature of 50°F.

SPRAY DRIFT MANAGEMENT for WIDE AREA MOSQUITO ABATEMENT: A variety of factors including weather conditions (e.g., wind direction, wind speed, temperature, relative humidity) and method of application (e.g., ground, aerial) can influence pesticide drift. The applicator must evaluate all factors and make appropriate adjustments when applying this product.

GROUND-BASED WIDE-AREA MOSQUITO ABATEMENT APPLICATION:

Spray equipment must be adjusted so that the volume median diameter is less than 30 microns (Dv 0.5 < 30 µm) and that 90% of the spray is contained in droplets smaller than 50 microns (Dv 0.9 < 50 µm). Directions from the equipment manufacturer or vendor, pesticide registrant, or a test facility using a laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated.

To control mosquitoes, apply MERUS 2.0 using any standard ULV vehicle-mounted applicator capable of producing a non-thermal (cold fog) aerosol spray cloud with appropriately sized droplets. Apply undiluted at a flow rate of 3.0 to 4.7 fluid ounces per minute at an average vehicle speed of 10 mph. If a different vehicle speed is used, adjust rate accordingly. These rates are equivalent to 0.0016 to 0.0025 pounds active ingredient per acre. Within this range, vary flow rate according to vegetation density and mosquito population. Use higher rate in heavy vegetation or when pest population numbers are high.

AL0409

Rates to use MERUS 2.0 Undiluted for mosquito control:

a.i./Acre (lb)	Application Rates (Fl.oz./Minute) at vehicle speeds of:				MERUS 2.0 / Acre (Fl.oz.)
	5 MPH	10 MPH	15 MPH	20 MPH	
0.0025	2.4	4.7	7.1	9.5	0.78
0.0021	2.0	4.0	6.0	7.9	0.66
0.0018	1.7	3.4	5.1	6.8	0.56
0.0016	1.5	3.0	4.5	6.1	0.50

Applications up to 2.50 fl.oz. (0.008 lb a.i.) per acre may be made when targeting *Aedes taeniorhynchus* or other difficult to control species.

a.i./Acre (lb)	Application Rates (Fl.oz./Minute) at vehicle speeds of:				MERUS 2.0/ Acre (Fl.oz.)
	5 MPH	10 MPH	15 MPH	20 MPH	
0.008	7.6	15.1	22.7	30.3	2.50

If dilution is preferred, adjust the flow rate accordingly to achieve 0.0016 to 0.0025 pounds a.i./ Acre. Applicable flow rates for a 1 part concentrate to 1 part oil dilution are presented. If an alternate dilution rate is used, adjust the flow rate accordingly.

Rates to use a 2.5% pyrethrins dilution (1 to 1 dilution ratio) for mosquito control:

a.i./Acre (lb)	Application Rates (Fl.oz./Minute) at vehicle speeds of:				Finished Spray / Acre (Fl.oz.)
	5 MPH	10 MPH	15 MPH	20 MPH	
0.0025	4.7	9.5	14.2	18.9	1.56
0.0021	4.0	7.9	11.9	15.9	1.31
0.0018	3.4	6.8	10.2	13.6	1.12
0.0016	3.0	6.1	9.1	12.1	1.00

Urban ULV mosquito control: for control of resting or flying adult mosquitoes in areas such as utility tunnels, pipe chases, underground basements, underground passages, parking decks, crawl spaces or uninhabited buildings. Apply using handheld or truck-mounted ULV equipment, or other spray equipment suitable for this application. Apply at rates up to but not exceeding 0.0025 pounds a.i. per acre per day (0.78 fluid ounces of undiluted spray per acre per day). Do NOT use hand-held equipment for this type of application in enclosed spaces.

MERUS 2.0 may also be applied with non-thermal, portable, motorized backpack equipment adjusted to deliver ULV particles of less than 100 microns VMD. Use 0.50 to 0.78 fl.oz. of the undiluted spray per acre (equal to 0.0016 to 0.0025 lb.ai./acre) as a 50 ft (15.2 m) swath while walking at a speed of 2 mph (3.2 kph). Dilute with a suitable mineral oil if dilution is preferred. Do NOT use portable backpack equipment for application in enclosed spaces.

AERIAL WIDE-AREA MOSQUITO ABATEMENT APPLICATION:

Spray equipment must be adjusted so that the volume median diameter produced is less than 60 microns (Dv 0.5 < 60 µm) and that 90% of the spray is contained in droplets smaller than 80 microns (Dv 0.9 < 80 µm). The effects of flight speed, and for non-rotary nozzles, nozzle angle on the droplet size spectrum must be considered. Directions from the equipment manufacturer or vendor, pesticide registrant, or a test facility using a wind tunnel and laser-based measurement instrument must be used to adjust equipment to produce acceptable droplet size spectra. Application equipment must be tested at least annually to confirm that pressure at the nozzle and nozzle flow rate(s) are properly calibrated.

Apply using nozzle height of no less than 100 feet for fixed wing aircraft or 75 feet for rotary wing aircraft above the ground or canopy, unless specifically approved by the state or tribe based on public health needs.

Apply by suitable fixed wing or rotary aircraft equipped with nozzles capable of producing a non-thermal (cold fog) aerosol spray cloud with appropriately sized droplets. Flow rate and swath width should be set so as to achieve 0.50 to 0.78 fluid ounces of undiluted MERUS 2.0 per acre.

a.i./Acre (lb)	MERUS 2.0 / Acre (Fl.oz.)
0.0025	0.78
0.0021	0.66
0.0018	0.56
0.0016	0.50

MERUS 2.0 may also be diluted with suitable diluent light mineral oil and applied by suitable aircraft at appropriate flow rates to achieve a dosage of 0.0016 to 0.0025 lb a.i. per acre. Diluted or undiluted, applications up to 2.50 fl.oz. MERUS 2.0 (0.008 lb a.i.) per acre/day may be made when targeting *Aedes taeniorhynchus* or other difficult to control species.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

PESTICIDE STORAGE AND SPILL PROCEDURES: Keep this product in its tightly closed original container when not in use. Store upright at room temperature in a dry (preferably locked) area that is inaccessible to children and animals. Avoid exposure to extreme temperatures. In case of spill or leakage, soak up with an absorbent material such as sand, sawdust, earth, fuller's earth, etc. Dispose of with chemical waste.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

CONTAINER HANDLING:

[For Nonrefillable Containers of 5 gallons or less]

Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with mineral oil and recap. Shake for 10 seconds. Pour rinsate into application equipment or a rinse tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

[For Nonrefillable Containers over 5 gallons]

Nonrefillable container. Do not reuse or refill this container. Triple rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into the application equipment or a mix tank. Fill the container ¼ full with mineral oil. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. Offer for recycling if available or reconditioning if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

[For Refillable Containers]

Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning before refilling is the responsibility of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment or mix tank. Fill the container about 10 percent full with water. Agitate vigorously or recirculate water with the pump for 2 minutes. Pour or pump rinsate into rinsate collection system. Repeat this rinsing procedure two more times. Then offer for recycling, if appropriate, or puncture and dispose of in a sanitary landfill or by other procedures approved by state and local authorities.

NOTICE: To the extent consistent with applicable law, Clarke Mosquito Control Products, Inc. makes no other warranties, express or implied, of merchantability or of fitness for a particular purpose or otherwise, that extend beyond the statements made on this label. To the extent consistent with applicable law, Buyer assumes all risk of use/handling of this material when use and/or handling is contrary to label instructions.

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159 N. GARDEN AVENUE
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Appendix I MMCD Technical Advisory Board Meeting February 7, 2023

TAB Members Present

Elizabeth Schiffman, Chair, MN Department of Health (in person)
Steve Kells, University of Minnesota (online)
John Moriarty, Three Rivers Park District (in person)
Philip Monson, MN Pollution Control Agency (online)
Susan Palchick, Hennepin County Public Health (in person)
Jessica Peterson (interim), MN Dept. of Natural Resources (online)
Vicky Sherry, US Fish and Wildlife Service (online)
Chris Smith, MN Department of Transportation (in person)
Christine Wicks, Minnesota Department of Agriculture (in person)

TAB Members unable to attend:
Don Baumgartner, US EPA

All TAB Members received a draft report of the annual report to the TAB prior to the meeting.

MMCD Staff in Attendance

Mark Smith, Alex Carlson, Diann Crane, Scott Larson, Carey LaMere, Kirk Johnson, Janet Jarnefeld, Jon Peterson, Nancy Read, John Walz

Guests

Allison Goldbeck (MDH), Alex Garvin (MDH), Jordan Mandli (MDH)

Welcome and Call to Order

Chair Elizabeth Schiffman called the meeting to order (in-person at MMCD office, and in virtual meeting room) at 12:30 PM, welcomed everyone to the meeting, and asked all present to introduce themselves. Elizabeth then called on MMCD staff for their presentations.

District Overview
– Mark Smith, MMCD Technical Services Manager

Mark started by giving some background on the purpose of the meeting. The TAB was formed to provide independent review of our programs. In this meeting we are focusing on highlights, the details are in the report. We are also looking for your input on the questions in the agenda.
Our Director retired as planned in 2022, and right now our Business Administrator is serving as Interim Director. We expect the hiring process to be completed in 2023. At the time of establishment of the District, having the Director be an entomologist was important for starting the program. At this time, the Commission is looking to open this position up for people beyond an entomologist. If they do change, we don't see this being detrimental to the program, we have entomologists on staff advising the director. Mark doesn't foresee us hiring someone who would not be supporting science in that role.
The District's 5-year plan established pre-Covid was to expand services, but reserves were used instead for some high-demand years. In the last few dry years, we've been able to rebuild those reserves and are working to return to expansion efforts.

In 2019-2020 we worked with a consultant on some internal issues and started some reorganization. Much of that was slowed by Covid restrictions, but that's reopening now. Many newly hired people are bringing new skills and energy, and we are finding ways to involve more staff. This summer, management visited facilities for open discussions to assess issues and seek innovative ideas. We have started workgroups to discuss issues on this list of topics:

> Sharing of staff across facilities, efficacy and use patterns, standardization of data methods, review of helicopter tracking, helicopter operations, staff training and development, improving evaluation tools, district reports, public surveys & citizen opinions, annual evaluations of IPM plans, adulticiding program, and recruiting of seasonal technicians.

The goal is to clearly identify issues and make recommendations to teams, management, or individuals and move toward positive change.

Mark also reported on TAB membership changes. Gary Montz (DNR) retired, and we thank him for his many years of service. We would like to get some new TAB members such as someone from the CDC-funded Midwest Center of Excellence for Vector-borne Disease, a former director of another mosquito control agency, and a new black fly specialist.

SK – will there be a chance today to talk about whether the Director should be an entomologist?
MS – now is ok. SK – I work with many organizations that do pest control. We are seeing increasing complexity in vector control. As the entomology concepts depart from the lead decision maker, there is a tendency for the prevention and monitoring part to degrade over time as other pressures mount. I'm concerned there could be a tendency to move toward a greater dependence on adulticiding. Going strictly by business management may affect approach. With IPM, monitoring and larviciding are very important. The farther that gets from the lead person who does budgeting and presents to the commission, the more risk that funding for these important parts of the program will diminish. That's my cautionary tale and I've seen this time and again.
CS – I work with other DOTs across the country on pollinator protection. Others are concerned about working with mosquito control, and I point to what MMCD is doing with larvicides as a good thing. If what SK mentioned happened here, that would be alarming.
CW – I concur with that, we deal with complaints regarding pollinator protection and human health and other impacts, we support minimizing the impacts of adulticides.
MS – our employees are concerned about impacts and will be studying the role of adulticides.
SP (arrived) – I had concern about taking away the entomologist requirement. I talked to Commissioner Anderson this morning about this, he reassured me that they would be changing the bylaws to require professional entomologists on staff.
MS – in the past, when Exec. Director was not an entomologist, Dr. Stephen Manweiler (an entomologist) was the Director of Operations.
SK – as long as there are stopgaps in place to make sure the biology does not get lost in the budgeting. As soon as the budgeting becomes primary, you start losing the prevention aspects and become reactive instead. We want to make sure that the prevention part is always conserved in the budget, that's my main concern. This has happened in both municipal and private companies. We need to make sure to keep the biology piece that makes MMCD a jewel in North America.
PM – agree with SK, MPCA has hundreds of staff, many layers of management. MMCD is unique in that it is a very technical organization, not that big, and very efficient. Maintaining top

leadership with at least a solid science background is important, even if they have colleagues with more technical skills, you want someone that understands that. Having leadership that speaks the same scientific and technical language is important.
MS – Thanks for your comments, I will carry your concerns to the Management Team.

Weather Impact and Mosquitoes
– Diann Crane, MMCD Entomologist
Diann Crane described the temperature and precipitation patterns for 2022, especially the drought in the metro region. Spring was cold with above normal precipitation, but summer was warmer than normal and exceptionally dry, resulting in "flash drought." This was the third consecutive year of lower-than-normal precipitation. In 2022, the drought was more focused in the metro and the Minnesota River valley. There was only one major summer floodwater brood, plus two medium and six small broods. The drought and lower hiring due to Covid resulted in fewer larval mosquito samples collected. Diann described our adult monitoring and testing, and the abundance of mosquitoes collected. The spring *Aedes* numbers were higher than average, but summer *Aedes* and *Cq. perturbans* mosquito adult collections were very low for almost all of the season. The adult numbers in Priority Zone 1 (P1) that gets full larval treatment was mostly much lower than in Priority Zone 2 (P2) where there is little larval control. Minnesota River flooding in May was related to a peak of floodwater mosquitoes in that area of P1.
SP – asked about pockets of P1 status that were shown on the map. DC – Those satellite areas are areas with higher human population levels classified as P1 so they receive larval treatment.
Diann continued with the *Cq. perturbans* prediction model. Based on the rainfall and prior populations, it predicts that the cattail mosquito population will be a record low. Although our metro service area is still classified as moderate drought, the seasonal outlook suggests normal precipitation for the next three months of 2023.

SP – how do you use the *Cq. perturbans* model? Does it affect your treatment decisions? JP – yes, this predicted low level of *Cq. perturbans* for 2023 has allowed us to reassign material for other uses; however, we will again place these materials in the budget for 2024 if upon inspection later this year the water levels in the cattail sites have risen.
JMandli – what factors are included in your model? SL – We use the overall averages for rainfall and *Cq. perturbans*. JM – is average a good value to use? SL – yes, it averages out. For example, in some areas with good quality habitat we may collect one thousand *Cq. perturbans* and in another area with no habitat we collect very few. JP – we are able to treat farther out in P2 this year because of the low numbers in P1. SP – 4th of July was pleasant last year.
SK – do you have confidence limits on these models? SL – I can share our model with you.
SK – are there locations that have higher populations *An. quadrimaculatus*? I am wondering if they are close to human populations that might be carrying malaria. DC, SL – we had made a map of those locations in 2019 and can pull the map up for the TAB members to see.

Mosquito Control Operations
– Mark Smith, MMCD Technical Services Manager
Mark Smith presented an overview of control operations in 2022 and plans for 2023. As Diann had stated during her presentation earlier, most of year was dry. Our intent was to expand treatments back to areas treated in 2017 (map) in P2, but that did not happen because of drought. Both larvicide and adulticide use was down from average. Note again that adulticide use is being

examined by a workgroup this year, but in general, adulticide use has decreased in recent years. The number of seasonal technicians decreased from 234 in 2017 to 179 in 2022. Some of this was due to Covid and our requirement to have only one person per truck. An unexpected benefit to this requirement was that it had shown efficiencies. The techniques that had increased efficiency may be continued now that the requirement has been lifted. We've also found that summer staff may not stay on as long as they had in the past, so we need to find additional ways to get work completed with fewer available staff.
Workgroups have been created and are looking at various ways to accomplish our goals, and to do it efficiently with the possibility of achieving them with fewer available staff.
Some examples of workgroups:
1 – Problems with efficacy in spring treatments – cold water, stiff vegetation caused lower than expected efficacy. We are considering raising the *Bti* rate from 5 lb to 8 lb and intend to do more research on that this year.
2 – Using prehatch materials differently – potentially apply them more often in the early spring and also in fall; periods where it is more difficult to have enough staff to complete these tasks.
3 – Using prehatch in different locations to improve efficiency.
4 – Evaluating some new formulations – 7-day Spinosad, duplex (*Bti* + methoprene 7-10 day)
5 – Expanding services back to 2017 levels (that had been reclassified to P2).
We are also looking at our adulticiding operations, including an evaluation of how adulticiding fits with our IPM plans, standardizing procedures and our interactions with the public, understanding citizen concerns, revisiting efficacy trials (which will help newer staff understand the value of limited adulticiding), and incorporating employee values.

JMoriarty – as the amount of acres in your adulticiding program goes down, I have noticed that the number of Mosquito Squad signs advertising their services has gone up. What is the regulation on private companies that offer mosquito adulticiding services? What materials do they use? MS – many of those companies have had their staff join our staff at a regional conference to receive training, so in this area a lot of those companies are making sure their employees are well trained. It is to the benefit of MMCD to assist, as when a private company has an impact, positive or negative, it will reflect on all of us. While many of the Minnesota private companies are diligent, however, diligence does not always occur elsewhere. CW – regarding the requirements, if an applicator is paid, they must be licensed and use licensed products. Some of the turf/ornamental companies are expanding into mosquito control which appears to be related to an increase in complaints. Many complaints are regarding human exposure over the property boundaries. One state wrote a white paper on what equipment these companies are using and posed questions to the Environmental Protection Agency (EPA) about the labels and the equipment used, trying to come to an understanding about methods and rates and whether the products are being used correctly and with the correct equipment.
SK – the services came about with Solo and Stihl coming up with an air blast sprayer. What has been developed is using an air blast to apply this material. Labels allowed permethrin application to foliage. Normal liquid sprayers were not easy to use, and the new air blast sprayer made it much easier. Lawn companies could treat for weeds and grubs and add on mosquitoes. This seems to be based on what the consumer wants for their property, more so than what MMCD is (or is not) doing.
CS – follow up – since you have technical expertise and work with the Minnesota Department of Agriculture (MDA), is there an opportunity to look at a regulatory piece, e.g. for rusty patched

bumble bee, which requires there be no spraying? Most of the District is within the RPBB area. MnDOT has trouble with that for applying herbicides. Is some of that technical expertise being shared with private companies? MS – one of the reasons we wanted to invite private companies to the regional conference mosquito control agency training was to get a sense of where these private companies work vs where we work and to try to avoid double treatments. Private companies do not easily share treatment records, so it is difficult to get that information.

Mosquito-borne disease 2022 season
– Kirk Johnson, MMCD Vector Ecologist

Kirk Johnson presented an update on mosquito-borne diseases in the District, including impacts from the drought. We are in the endemic area for La Crosse encephalitis and much of our work is preventative via reduction of the vector species habitat (tires, tree holes, containers). The mosquitoes and virus tend to stay in an area and the virus can be transmitted transovarially. *Aedes triseriatus* numbers were low most of the summer as containers dried out but there were two peaks related to rainfall. We were notified about one LAC case late in 2022 and will be following up on inspecting that area in a few months.

We have been working on understanding Jamestown Canyon virus. There were eight human cases in the US, including one in a District resident that we suspect was exposed elsewhere. We did find JCV in an *Ae. provocans* larval sample, indicating transovarial transmission of this virus in our mosquito populations. The virus is endemic, and transovarial transmission may be partially responsible for increasing case numbers.

EEE was not detected in MN this year and cases were relatively low elsewhere in the US. There were extremely low populations of the vector, *Cs melanura*, consistent with very dry conditions in the bogs where they develop.
SP – how widespread is use of the EEE vaccine in horses? KJ – seems like since WNV the vaccine use in equines has increased and for other diseases as well. ES – here, some people do not realize they need to revaccinate every year and in FL they have to vaccinate more than once per year.

Kirk reported that there were 19 WNV cases in Minnesota with one fatality. Two of the 19 cases were District residents, but there is some question as to their exposure locations. Animal cases included a reindeer in Como Zoo.
SP – was the Hennepin case near where you have found WNV + mosquitoes in the past? KJ – yes, it was from an area where many WNV + mosquitoes have been collected.
AG – some WNV tests are not yet completed so the 19 WNV case total is preliminary.

Cx tarsalis numbers were low in 2022 which is probably drought related. However, *Cx restuans* and *Cx. pipiens* numbers were normal, as they use stormwater sites that hold water during dry periods. The summer was warm enough that *Cx pipiens* populations expanded later in the season, which sometimes correlates with expanded WNV transmission, as the heat also increases WNV replication in the vectors. This year had the fourth highest rate of infection for mosquitoes tested, but the low numbers of *Cx tarsalis* seem to have minimized transmission to humans and horses.

Kirk also reported on improvements in our data management system for catch basin treatments that are applied to control *Cx pipiens* and *restuans*. The new system allows for easy digital tracking of treatments by individual catch basin (CB) and helps employees share real-time information on which basins have been treated and plan treatments more efficiently.

JM – how do you add new CBs? Via development, hundreds of new CBs are being created in the western side of Maple Grove. KJ – CB maps are updated 3-4 times per year in the field and can be done in real time. We also get CB updates from cities. CS – we build a lot of stormwater infrastructure. Are there some types that cause more problems? Have you gotten that information out to people? KJ – yes to all – stormwater structures that hold water for seven days are a problem. We work with many cities, and some cities even do the CB treatments as well. KJ and CS will communicate further on this issue after this meeting. NR – the Minnesota Stormwater Structure guidance document has a section on mosquitoes that the MNDOT can examine.
CS – you mentioned tree-hole filling? Can you describe? KJ – there are many kinds of tree holes. If they do not hold water, we are not concerned. If they are holding water, they are typically not used as habitat by wildlife. We usually use on-site dirt to fill. These filled tree holes may become wildlife habitat. CS – have you tried drilling holes? KJ – yes, we have. Unfortunately, the water-holding tree holes usually occur in living tissue and so post-drilling, the holes tend to close over time.

Ten-minute break

MMCD Black Fly Control Program
– Carey LaMere, MMCD, Black Fly Specialist

Carey gave a quick overview of the black fly program. Black flies develop in running water and treatments are determined through a permit process with the MnDNR. Small stream treatments are based on grab samples and whether larval counts are over thresholds. We recently added another species (*Simulium tuberosum*) for spring treatments based on reports of human impacts and our investigations that followed. Large river sampling is performed using mylar samplers and has a different threshold. In 2022, there was a cool start that delayed spring treatments but we were able to complete them. This included treating more than once for *S. tuberosum*. In the large rivers, the Mississippi River levels were normal due to outstate rain amounts, and we used average amounts of treatments (*Bti* liquid). The South Fork Crow River level was very low and required very few treatments. Our overall adult numbers were again reduced to a tolerable level for most locations of the District for most of the year. In 2021, we had a record number of black fly complaint calls, mostly due to *S. tuberosum*, but in 2022 there were much fewer calls, probably due to both treatment and drought. We continued the nontarget impact monitoring which is in place to detect any changes in the macroinvertebrate community. This work had to be cancelled in 2021 due to low water levels.

DC – why do you think *S tuberosum* is on the increase? CL – stream restoration may be contributing.

MMCD Tick Vector Services and Tick Surveillance
– Janet Jarnefeld, MMCD, Tick Specialist

Janet Jarnefeld presented data on MMCD's tick work. MMCD conducts tick surveillance because of a legislative mandate in 1989. Janet gave some background on our 2022 tick distribution study. Results of the study showed *Ixodes scapularis* numbers collected from hosts reached a record high (2.11 ticks removed per mammal). The number of positive sites was about average at 59 / 100. Looking at the ticks/mammal over time, the numbers started increasing in 2000. In 2022, the highest weekly number of ticks were collected in a week just after a rainfall, when the ticks were probably more active. Only one *Amblyomma americanum* (lone star tick) was reported within the MMCD's service area in 2022 and zero *Haemaphysalis longicornis* (longhorned tick) were known to have been found in Minnesota in 2022 or previously. No extra cooperative research projects are planned for 2023.

Janet reported that work is progressing on the article submitted for publication to the Journal of Medical Entomology which covers 30 years of tick surveillance conducted by MMCD. She thanked Dr. Scott Larson for statistical analysis and editorial support, and Dr Nancy Read for the creation of and for updating a map of wooded habitat relative to tick collection sites as well as her additional editorial suggestions. The majority of ticks collected has been *Dermacentor variabilis,* but she expects that to eventually change. Early in the study, we collected mostly *D. variabilis,* but we now collect mostly *I. scapularis,* which have increased in both number and area covered. Janet shared maps showing dramatic changes in the distribution of both tick species. The study also found that ticks tend to be found earlier in the season. The movement of ticks seemed to be sporadic before becoming established. The number of ticks collected shows a similar pattern to human cases reported statewide, with the human case increase about two years later than the tick increase.

Drone review
– Scott Larson, MMCD, Assistant Entomologist

Scott described the current UAS (drone) fleet in use by MMCD, including three photo and now two application drones. We have just purchased a DJI Agras T10 to test in 2023. The photo drones are used for updating air photos, especially in new construction areas. They can also be used to scout difficult sites or take other useful photos. Larviciding is done with drones particularly for sites of 1-3 acres in size, especially if they are sites considered to be difficult to reach or treacherous. Treatment control materials include primarily Altosid® P35 and VectoLex® FG. We calibrate the drones using the same collectors as are used for helicopters. To calibrate, we fly over a set of collection funnels, estimate the current swath width, and modify application settings to get the dose desired. The drone software allows us to enter the area that is to be treated. We also have a trailer for managing the drone and the generator for charging the drone's batteries. There are many requirements to become a drone pilot, including licensing both for Category L (mosquito) and Category B (aerial applicator), plus Part 107 UAS requirements and MNDOT and FAA registration. We also hold a COA (certificate of authorization) that allows us to operate drones for treatment as a governmental agency. In 2022, we hired two seasonal technicians specifically to apply drone treatments. This doubled the number of sites and acres treated compared with 2021. We did some comparison of treating with drone vs hand/backpack, and it appears we can treat about three times faster with drones. Replacing briquet treatments with drone treatments using alternate product formulations can also reduce costs.

JM – have you thought about increasing the size of wetlands you use drones on? SL – so far, we have plenty of smaller ones to get to. We could do larger sites, but the drone capacity is currently small and we would need to refuel and reload more often.

Review of 2022 TAB resolutions
– Mark Smith, MMCD, Technical Services Manager
Mark quickly reviewed the resolutions from last year and actions taken. Resolution #2 last year stated "The TAB appreciates MMCD's ongoing efforts to reduce how District operations might affect nontarget species and recommends MMCD staff reinitiate conversations with USFWS Ecological Services Field Office on species of concern such as the rusty-patched bumble bee (RPBB) and monarch butterfly." Scott Larson has started looking at northern long-eared bat, doing an informal consultation with USFWS, using a similar approach as MMCD's recently retired Director Stephen Manweiler had done with RPBB.

TAB members requested input
Mark Smith had sent the following questions to TAB members prior to the meeting and asked for their input. Given the time remaining Mark proposed getting these responses through email.

Question #1
As MMCD continually reviews our operations in respect to new species being listed as endangered, threatened, or species of special concern, we would like to understand how different agencies approach this issue. Examples of species may include the Northern long-eared bat, monarch butterfly, and rusty patched bumblebee.
How do endangered species or species of concern affect your organization's daily operations? How is this information communicated to your field staff? How does your agency measure the impact of your operations on that species?

Question #2
As MMCD looks at our operations, we often use past public survey information and focus group research in our decisions. Some of that information is becoming dated and MMCD is reviewing methods for updating our citizen's views on many aspects of our program. Examples may include vector borne disease, annoyance, mosquito and vector control, ticks, black flies, drone use, etc.
How does your agency gather relevant information from the public? How do you use public opinion in your work? How often are citizen opinions updated in your organization?

Question #3
MMCD is having multiple conversations on topics that employees brought up during our facility meetings. One of these workgroups is focusing on our control of adult mosquitoes. They are reviewing how adulticides are used in our IPM plans, when and how they are used, how is this information conveyed to the public, is our use decision-making process consistent in all our facilities, etc.
As MMCD is reviewing our practices in controlling adult mosquitoes, do you have any specific concerns or comments that you would like to see considered in these adulticiding workgroups?

Impact of fire on mosquitoes and ticks
Chris Smith had sent in a question regarding some proposals he had seen on reducing tick and mosquito populations through controlled burns in grasslands or woodlots. JM – we love working on recent prairie burns because the tick numbers are low. Forest burns for harborage reduction would be difficult to do especially in populated areas. Cattails burn with a lot of smoke so those impacts might be worse than the control materials. CS – just wondering about reviewing the literature. SL – The first question would be to determine whether the MMCD has the legal authority to conduct burns. I reviewed the literature on the effect of burns on ticks. Fire has an immediate knock down, but ticks seem to return within a year. Burns done repeatedly and frequently may alter the habitat into something more open and drier that makes it a less ideal habitat for ticks. We could do some measurements. JM, CS – we do a lot of burns if you want to come out. CS – typically woodlands treated with prescribed burns are retreated repeatedly. JM – burns are often done for invasive species control in woodlands, may depend on what moves in after burn. JJ – difficult using burns for tick control especially in private lands. Have seen *Ix. scapularis* at Camp Ripley within a week of prescribed burns there.

Discussion and Resolutions
Discussion:
CW asked if there were ways to get more information on horse vaccination, especially for EEE. SK said the UMN horse extension specialists would love to have more information on the need for vaccination.

Resolutions were proposed by TAB members and are as follows:

Resolution #1 – The TAB supports the program presented in the 2022 Review and 2023 Plan and acknowledges and appreciates the efforts of the MMCD staff in its presentation.
- Motion by JM. Second by CS. Motion approved unanimously.

Resolution #2 – The TAB encourages the MMCD Commissioners to keep a requirement that the Director has an entomological or biological background, so science continues to drive MMCD decisions.
- Motion by JM, second by SK. Motion approved unanimously.

Resolution #3 – The TAB thanks the MMCD for developing a strong Integrated Vector and Pest Management program based on prevention and reducing the need for reactive techniques for pest management such as adulticides. The TAB urges the Commission to continue this emphasis, including ensuring that the budget must be based on preventative measures.
- Motion by SK, Second by CW. Motion approved unanimously

Resolution #4 - The TAB supports the District's intent to explore collection of updated public input to inform its practices.
- Motion by SP, second by ES. Motion approved unanimously.

Mark thanked members for their time and asked for them to send responses to him by email for the questions posed in the agenda.

The Chair called for a vote on adjournment and the meeting adjourned at 3:50 PM.

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The following people wrote or reviewed major portions of this document:
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First Draft January 23, 2023
Second Draft April 17, 2023
Final July 27, 2023

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