74th ANNUAL REPORT

MOSQUITO CONTROL
FOR A SAFE AND QUALITY ENVIRONMENT

2020

February 18, 2021

Mr. Mark Stutler, Director
Toledo Area Sanitary District
5015 Stickney Avenue
Toledo, Ohio 43612

Mr. Stutler:

In compliance with Section 6115, paragraph 14 of the Ohio Revised Code, I hereby submit the Annual Report for 2020. This 74th Annual Report of the Toledo Area Sanitary District (TASD) contains a financial report for 2020 and a budget for 2021. It also summarizes the District's operations, field activities, and achievements over the past year.

2020 was a challenging year, due to the COVID-19 pandemic. Throughout the health crisis, the TASD was able to maintain its operations and continue to provide an efficient, economical, and environmentally conscious program for the residents of Lucas County.

The techniques, insecticides, and equipment used by the District are among the most widely recommended and accepted in the industry. As a result, the TASD has been influential in educating and recommending sound best management practices throughout the state of Ohio and into neighboring states.

The tremendous assistance and support we continue to receive from you and the Advisory Committee is greatly appreciated. Going forward, we will continue to do our best to fulfill our mission and provide the citizens of Lucas County with mosquito control for a safe and quality environment.

Respectfully submitted,

Paul R. Bauman
General Manager

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STAFF & ADVISORY COMMITTEE

EXECUTIVE COMMITTEE

Director . . . . . Mark A. Stutler
Secretary-Treasurer . . . . . Russell R. Miller
General Manager . . . . . Paul R. Bauman

FULL-TIME EMPLOYEES

Bradley Betz. . . . . Field Supervisor
Mike Bruce. . . . . Garage & Facilities Specialist
Myles Caryer . . . . . Larviciding Chief Supervisor
Lisa Diehl . . . . . Office Manager/Bookkeeper
Arianna Johansen . . . . . Office Clerk/Asst. Bookkeeper
Darnea Merrell . . . . . Larviciding Chief Supervisor
Doug Nabors . . . . . Field Supervisor
Mark Nye . . . . . Field Supervisor
Justin Rist. . . . . Water Management Chief Supervisor
Hunter Sanner. . . . . Field Supervisor
Bob Sattler . . . . . Operations/Substation Manager
Bob Schramm . . . . . Field Supervisor
Dr. Jennifer Shimola . . Education & Research Coordinator
Thomas Shultz. . . . . Field Supervisor
Jacob Sublett . . . . . Biologist & GIS Specialist
Cory Taylor . . . . . Field Supervisor
Ben White . . . . . Fogging Chief Supervisor
Shannon Wilson . . . . . Field Supervisor

2020 SEASONAL EMPLOYEES

Derek Frey . . . . . Night Fogging
Frank Fulkerson . . . . . Lab Technician
Kaitlin Plate . . . . . Lab Technician
Kurt Susdorf . . . . . Night Fogging
Johnny Uelmen, Ph. D . . . . . Research Assistant
Joshua White . . . . . Night Fogging
Casey Wilcher . . . . . Lab Technician

ADVISORY COMMITTEE & CONSULTANTS

Dr. Gary F. Bennett. . . . . Professor Emeritus of Biochemical Engineering, University of Toledo
Jennifer Gottschalk. . . . . Supervisor, Toledo-Lucas County Health Department
Michael K. Hart . . . . . Public Information - Consultant
David G. Huey. . . . . Retired Director, Toledo Area Sanitary District
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Jennie Lambert . . . . . Principal, Rehman
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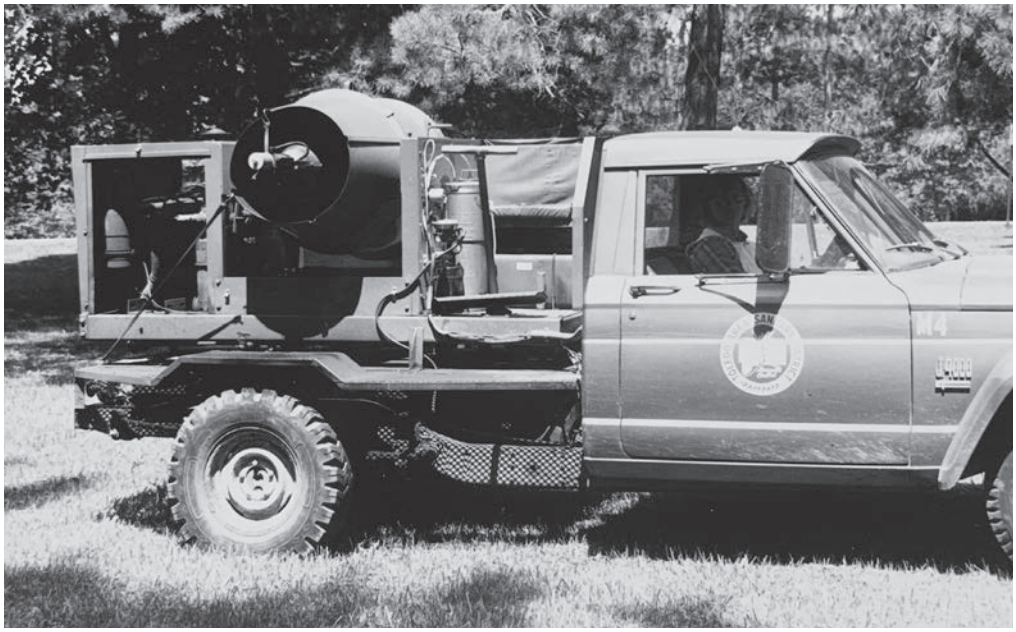
Amy K. Stone . . . . . Extension Educator, Ohio State University Extension - Lucas County
Konni Sutfield . . . . . Retired Supervisor, Toledo-Lucas County Health Department
Dr. R. Travis Taylor . . . . . Assistant Professor of Medical Microbiology & Immunology, UT College of Medicine

HISTORY, ORGANIZATION, & FUNDING



An early mister.

Under authority of the Sanitary District Act of Ohio, the Toledo Area Sanitary District (TASD) was established September 27, 1945, by the Common Pleas Court of Lucas County. Residents from the Village of Ottawa Hills petitioned to the Court for the establishment of the District for the abatement and control of mosquitoes. TASD was organized and formulated in 1946, with actual mosquito control operations beginning in 1947.

In accordance with the statute, responsibility for policy determination for the TASD resides with the Director, who is appointed by the Common Pleas Court. The Secretary-Treasurer and General Manager for the District are appointed by the Director. Although not required or provided for in the statutes, a volunteer citizen Advisory Committee is assembled by the TASD Executive Committee (Director, Secretary-Treasurer, and General Manager).

Funding for the TASD is provided through a special assessment levied upon property holders within Lucas County. For 2020, eligible properties were assessed at a rate of 0.34 mills, which equates to approximately $11.90 per $100,000.00 of taxable property value.

TASD employee spraying larvicide.

MOSQUITO BIOLOGY

EGGS are laid one at a time and can be attached together to form "rafts" which float on the surface of water. The female mosquito will seek out semi-permanent water sources to deposit these egg rafts, such as catch basins or water gardens. Other mosquitoes that do not make egg rafts will deposit their eggs on damp soil or inside artificial containers, waiting for rain to flood the area or fill the containers, exposing the eggs to water for hatching. Most eggs hatch into larvae within 48 hours; others might withstand subzero winters before hatching. Exposure to water is a necessary part of their habitat. The egg is the part of the mosquito lifecycle primarily responsible for survival through winter.

LARVAE live in water and come to the surface to breathe. Larvae shed (molt) their skins four times, growing larger after each molt. Most larvae have siphon tubes for breathing and hang upside down from the water surface. Some larvae do not have a siphon and lie parallel to the water surface to get a supply of oxygen through a breathing opening. A few other species of larvae attach to plants to obtain their air supply. The larvae feed on microorganisms and organic matter in the water. During the fourth molt, larvae change into pupae. Depending on environmental conditions, larvae can develop into pupae in as little as four days.

PUPAE are a resting, non-feeding, development stage; however, pupae are mobile and respond to light changes by moving (tumbling) with a flip of their tails (abdomen) towards the water bottom or protective areas. This is the stage when the mosquito changes into an adult. This process is similar to the metamorphosis seen in butterflies when the butterfly develops, while in the cocoon stage, from a caterpillar into a butterfly. In most mosquito species this takes about two days in the summer. When development is complete, the pupal skin splits and the adult mosquito will emerge. Pupae do not feed, but still must breathe air at the water's surface.

The newly emerged **ADULT** rests on the surface of the water for a short time to allow itself to dry and all its body parts to harden. The wings have to spread out and dry properly before it can fly. Blood feeding and mating do not occur for a couple of days after the adults emerge. Only females feed on blood and the primary food source for both males and females is sugar. Not all species of mosquito feed on people; some prefer other animals such as birds, amphibians, or reptiles. Flight ranges also vary greatly, from under one mile to 10-20 miles per day from a breeding location. The lifespan of a female adult mosquito can last several months. This is the lifecycle stage that is a pest to humans and can potentially spread disease.

MOSQUITO BREEDING HABITATS

Mosquitoes require water to complete their lifecycle and can breed in a variety of aquatic habitats. Listed below are some of the different types of breeding habitats the TASD routinely monitors and treats for developing mosquitoes.

PERMANENT WATER SOURCES
(wetlands, marshes, retention ponds, etc.)

Coquillettidia spp., *Anopheles* spp., and *Culex* spp. routinely breed and emerge from these types of habitats. These mosquitoes can be an extreme nuisance for humans, as well as potentially being involved in the transmission of diseases such as malaria, Eastern Equine Encephalitis (EEE), and West Nile Virus (WNV).

SEMI-PERMANENT & TEMPORARY WATER SOURCES
(ditches, floodwater, vernal pools, etc.)

These types of habitats produce the most pestiferous and numerous mosquitoes in Lucas County. Spring *Aedes* spp. mosquitoes emerge from vernal pools and can live through the entire summer. Summer floodwaters produce large numbers of *Aedes vexans* mosquitoes that fly long distances and readily feed on people throughout the season.

NATURAL CONTAINERS
(tree holes, rock pools, gravel, etc.)

These small, cryptic, water-holding locations can be very difficult to locate and treat, but can produce numerous mosquitoes. *Aedes triseriatus*, the tree-hole mosquito and vector of La Crosse encephalitis, can commonly be found in these locations. *Aedes japonicus* is another mosquito that breeds in these natural locations.

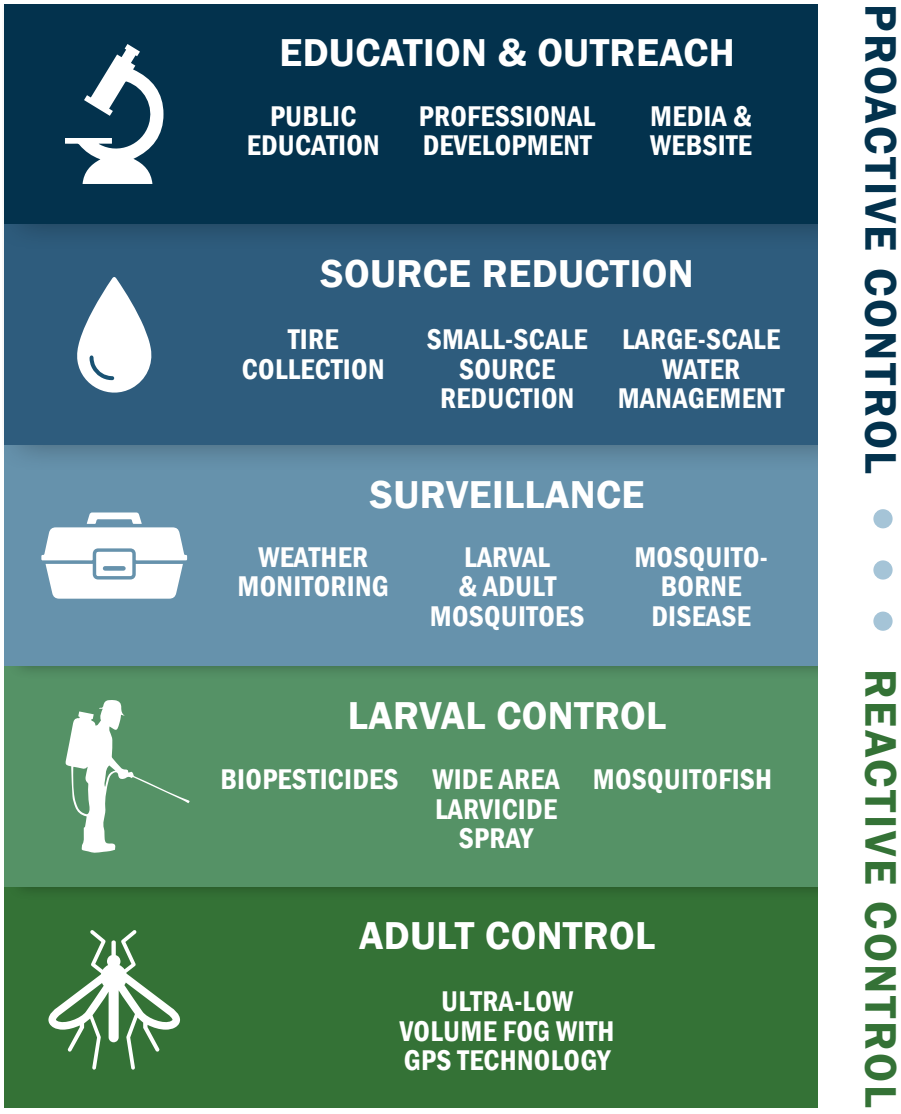
MAN-MADE CONTAINERS
(tires, swimming pools, ornamental water gardens, catch basins, etc.)

These types of man-made containers can be found throughout areas where people live. They provide a perfect habitat for numerous species of mosquitoes to develop. Many mosquitoes of concern for disease transmission breed in these types of habitats.

INTEGRATED MOSQUITO MANAGEMENT (IMM)

The TASD practices, promotes, and firmly believes in using *integrated mosquito management* (IMM) techniques for its operations. Using IMM philosophies means that the District approaches the task of mosquito control from a holistic perspective that is both proactive to prevent mosquito proliferation and reactive to reduce established populations when surveillance dictates the need.

The IMM approach employed by the TASD focuses on surveillance, mapping, breeding source reduction, larval mosquito control, adult mosquito control, and education/community outreach. No single phase of the IMM approach is more important than another. Each aspect of this approach is integral to reducing and controlling mosquito populations in the most efficient and environmentally conscious manner possible.



Educating the citizens of Lucas County on mosquito bite prevention, disease transmission, and source reduction is vital to the mission of the TASD. Unfortunately, the COVID-19 pandemic resulted in limited public educational events. The obvious impacts were event cancellations to accommodate for social distancing and mandatory quarantine. Additionally, the demand for unanticipated, online course development prevented the coordination of virtual events with teachers. For 2021, TASD is working on expanding its socially distant educational materials such as billboard advertisements and increasing its social media presence.

PUBLIC EDUCATION

A few educational events were offered in-person prior to quarantine and virtually post-quarantine. Information on mosquito breeding habitat and vector-borne disease was provided at the Imagination Station's annual Girl Power event aimed at young scientists. This activity was also provided as a take-home craft to a kindergarten classroom.

TASD presented on-site to the Ohio State University Extension's Master Gardeners. The Master Gardeners are volunteers which provide information to the public at various Lucas County events. Information on requesting TASD's various mosquito control services were emphasized. Programs such as Report a BITE! web-app and the email notification system were highlighted.

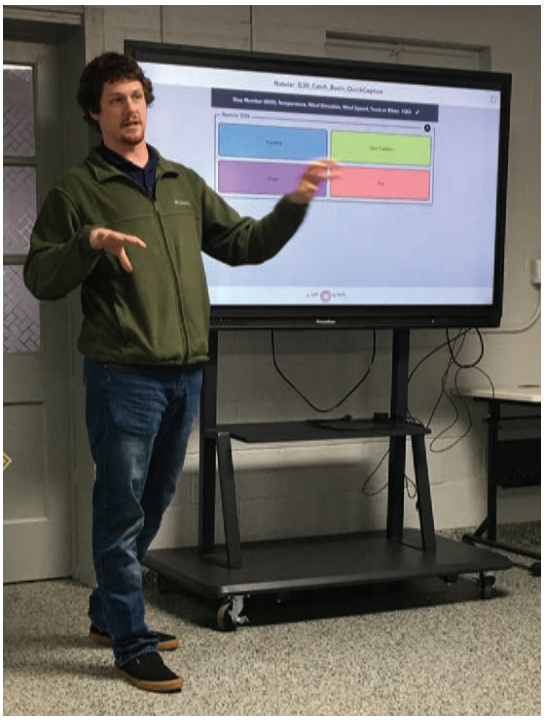
Finally, TASD provided a virtual program to BGSU's summer camp for high schoolers interested in veterinary medicine. The program emphasized integrated pest management and vector-borne disease relevant to veterinary medicine.

Dr. Jennifer Shimola, Education and Research Coordinator, teaches about mosquitoes at the Imagination Station's annual Girl Power event.

PROFESSIONAL DEVELOPMENT

All TASD employees attended 'School Day', an annual review of mosquito biology, mosquito control, and new technologies that are relevant to operations and conversations with the public.

TASD employees continued their education and promoted TASD's research by attending and presenting at the Michigan Mosquito Control Association's annual conference. The American Mosquito Control Association conference was cancelled in 2020.



Jacob Sublett, Biologist, gives a presentation in the District's education room.

MEDIA, SOCIAL MEDIA, AND WEBSITE

During 2020, TASD was the subject of five local news stories. The TASD Facebook page was used to inform citizens about TASD operations and services as well as current information on mosquito-borne diseases and personal protection, with an average reach of 246 people per post. The most engaging post in 2020 requested Report a BITE! submissions.

Paul Bauman, Biologist and General Manager, featured on 13 ABC News discussed mosquito testing during the pandemic.

IMM | WATER MANAGEMENT/SOURCE REDUCTION

The removal or modification of potential mosquito breeding habitats is a basic component of a good mosquito control program. TASD staff is routinely involved in small-scale mosquito breeding source reduction efforts on a daily basis. Activities such as emptying a bucket, dumping out a container, or removing a used scrap tire can make a big difference in reducing local mosquito populations.

Anything left to accumulate water can become a breeding ground for mosquitoes.

A unique component of the integrated TASD program is the large-scale water management projects conducted during the fall and winter. These projects can generally be described as cleaning ditches or removing blockages in local waterways and drain paths that are meant to keep water flowing properly and reduce spring-time flooding that creates mosquito breeding habitats. The TASD works with individual homeowners, land managers, and the Lucas County Engineer's office to identify areas in need. In the 2019/2020 water management season TASD completed three projects with a total of 3,298.4 linear feet of ditches being cleared. APPENDIX – Figure 1 depicts a map of the large-scale projects completed by the District in the 2019/2020 water management season.

TASD removes debris that was causing water to collect and breed mosquitoes.

Surveillance is the backbone of an integrated mosquito management program: determining the need to conduct control operations, providing the information necessary to prioritize control treatment plans, and providing the efficacy data for the evaluation of those control operations. The TASD routinely relies on citizen surveillance reports and data collected through a network of various surveillance traps to provide the information necessary for successful mosquito control operations.

In 2020, from May 13th through September 28th, adult mosquito populations were monitored using 26 stationary New Jersey Light Traps, placed throughout Lucas County (APPENDIX – Figure 2) and sampled four or five nights each week. The mosquito collections were identified to species in the lab by trained personnel. The survey data was used to estimate relative population densities of individual mosquito species, suggesting which areas within Lucas County needed increased control efforts. The TASD laboratory staff identified 14,542 adult female mosquitoes from light traps, in 2020 (APPENDIX – Table 2).

West Nile Virus (WNV) prevalence in the mosquito population was monitored from over 50 different locations within the District, utilizing gravid mosquito traps. A combination of stationary locations and rotating gravid trap locations were used to collect female mosquitoes that could have potentially acquired WNV after taking a blood meal from a WNV infected bird. During the 2020 season, 16,913 gravid female mosquitoes were tested for WNV infection. Eighty-four of the mosquito pools submitted by TASD tested positive for WNV. These results were analyzed and mapped to determine areas of increased risk for human transmission of WNV: shaping control decisions designed to break the virus's transmission cycle.

A New Jersey Light Trap is used for mosquito surveillance.

West Nile Virus (WNV) testing results have been the preferred surveillance information for adult control applications at TASD in recent years. Without this surveillance data, control relies on mosquito population size and service requests. While it seems intuitive that more mosquitoes would result in higher disease risk, this is not a straightforward relationship. In fact, WNV positive pools tend to become more common as mosquito populations decline in late summer and early fall. Therefore, population-based control decisions are better suited to nuisance control rather than public health.

TASD has historically sent mosquitoes to the Ohio Department of Health (ODH) for no-cost West Nile Virus testing. However, this testing has been limited or unavailable in several years including both 2019 and 2020. To accommodate these changes, TASD contacted molecular laboratories that have previously provided fee-based testing for WNV, but quarantine restrictions at universities and supply chain limitations prevented these tests from coming to fruition.

Given the decline in no-cost testing and the importance of viral data to public health, TASD began developing its own molecular lab. In 2020, the lab space was renovated and most of the equipment was purchased. In 2021 the goal is to implement viral assays and to supplement ODH testing. Beyond 2021 all viral analyses will be performed at TASD's Vector-Borne Disease Detection Laboratory. Having an on-site lab guarantees that high-quality surveillance data will be available in future seasons. An on-site molecular lab will allow quicker turn-around times and more flexibility in testing.

Previously, viral testing results were received at least two weeks following sample collection. This created a lag between viral presence and mosquito control. On-site testing can provide results within a few days, promoting our public health mission.

On-site testing allows TASD to add surveillance locations as needed. ODH required that surveillance locations be registered for their records which constrained the addition of traps in-season. New traps are required when property owners change or if TASD needs to pinpoint viral hotspots. This flexibility will allow TASD to evaluate viral response to control at more locations.

WNV was first documented in 1937 but showed mild febrile illness and neurological effects until 1961. This shift in virulence is a potential for any virus. On-site testing allows TASD to obtain viral surveillance data for additional vector-borne diseases. La Crosse virus is routinely more abundant in Ohio than other states. Likewise, the Eastern Equine Encephalitis virus has become a regional concern following the 2019 Michigan outbreak. Neither La Crosse nor Eastern Equine Encephalitis testing is available through ODH. Pre-outbreak virus data promotes an informed outbreak response. Distribution of the virus, for instance, will identify high-risk areas.

Construction on TASD's Vector-Borne Disease Detection Laboratory.

Sejvar JJ. 2003. West Nile Virus: An Historical Overview. Ochsner Journal. 5(3):6-10.

IMM | LARVAL CONTROL (LARVICIDING)

Aside from removing a potential breeding source altogether, larval mosquito control (larviciding) is the most effective method of control used by the District. Thousands of potential mosquito breeding sites are routinely checked and treated by District personnel each season.

For the 2020 season, the first larvae of the year were collected on March 5th from a private residence near the Kitty Todd Nature Preserve. Larviciding control operations began on March 16th and continued throughout the season until October 16th. Due to the COVID-19 pandemic, a "work from home" approach was adopted for the field crews at the District, for early spring operations. Employees reported directly to the field each day and immediately began control applications. Supervisory employees serviced the crews out in the field to keep them stocked with the appropriate control products and supplies. This proved to be an extremely efficient model that will be utilized more in future years.

A jar of mosquito larvae

Throughout the season there was a large reliance upon the use of biological larviciding products. These products can be collectively referred to as "biopesticides" and are very specific and effective in their target and control of larval mosquitoes. In 2020, VectoMax® was the most heavily used larvicide product during control operations (13,119 pounds). With combined active ingredients of 4.5% *Bacillus thuringiensis israelensis* (Bti) and 2.7% *Bacillus sphaericus*, this biopesticide provides excellent residual larval control for up to 4 weeks. Other biopesticides utilized in 2020 included Aquabac 200G® (2.86% Bti) and Natular G30® (2.5% Spinosad). A complete listing of all the larval control products used during the 2020 season can be found in the APPENDIX - Table 1.

In 2020, TASD continued to expand its use of Wide Area Larvicide Spray (WALS) technology into its control strategies. Altosid Liquid Larvicide Mosquito Growth Regulator™ (5% (S)-methoprene) was trialed and the use pattern for VectoBac WDG™ was expanded. A new piece of WALS application machinery was manufactured by TASD, based off the design of the commercially available A-1 Mister. This machine was also trialed and characterized for field use. The results of the research and efficacy studies for the WALS applications are further discussed in the Research & Development portion of this report.

2020 also marked two major transitions for TASD larviciding operations. The final supplies of Abate products where exhausted when field crews used all of the remaining Tire Abate® for the treatment of auto tires. Additionally, electronic application and inventory record keeping trials were completed, allowing for paper record keeping to be permanently replaced by electronic records, moving forward.

IMM | ADULT CONTROL (ADULTICIDING)

The method of mosquito control most familiar to the public is ground adulticiding. Truck-mounted units treat during dusk or dawn as part of nighttime control efforts (fogging). Adulticiding is conducted when environmental conditions are favorable and when the target mosquitoes are most active. This important part of an Integrated Mosquito Management program is designed to kill adult mosquitoes in flight at the time of the application, with no residual control. TASD utilizes ultra-low volume (ULV) technology that disperses approximately one tablespoon of public health insecticide per acre in droplets that are approximately 20 microns in size. To further explain, this equates to 1.25 tablespoons of liquid applied to an area approximately the size of a football field in droplets that are small enough to fit 5 or 6 across the width of a human hair.

An adult mosquito feeding on a human.

A TASD fogging truck

The US Environmental Protection Agency (EPA) and the Centers for Disease Control (CDC) have asserted in a joint statement regarding mosquito control activities that the use of adult mosquito control products applied with ULV technology do not pose any unreasonable risk to humans or the environment.

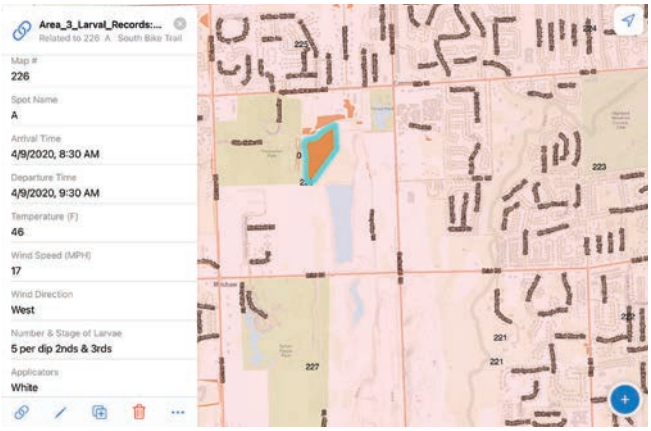
The first adult mosquitoes hatched in the field during 2020 were observed on May 13th. Adulticiding treatments began during the evening of June 4th, when New Jersey Light Trap counts exceeded 1,000 mosquitoes. Adulticide operations continued through the night of September 16th. For the season, almost 269,000 acres were treated during adulticiding operations.

To manage against insecticide resistance in the mosquitoes, control products were used just below mid-label application rate and rotated throughout the season.

A complete listing of all the adulticiding products used during the 2020 season can be found in the APPENDIX - Table 1.

Throughout 2020, the District has continued to create, use, and invest in ideas, technologies, and equipment to strengthen its various programs, including nighttime fogging, larval control, and citizen engagement.

Starting in the spring of 2020, all larval control personnel were equipped with GPS enabled tablets. These tablets, coupled with mobile GIS software, allowed technicians to track product inventory, monitor equipment/vehicle maintenance, create paperless daily product usage reports, record larval control treatments, document small scale source reduction, map new breeding locations, and update known breeding locations, as well as help technicians navigate to any area of concern with turn-by-turn directions. The goal for the 2020 season, was to act as a trial period, intended to allow staff members to gain familiarity with the technology and to test or fix any issues within these particular workflows. From this trial period, TASD has concluded the use of the aforementioned technology provides overwhelming benefit and any significant adjustments to the workflows have been made, thus the district will utilize these technologies for all larval control operations in the future.

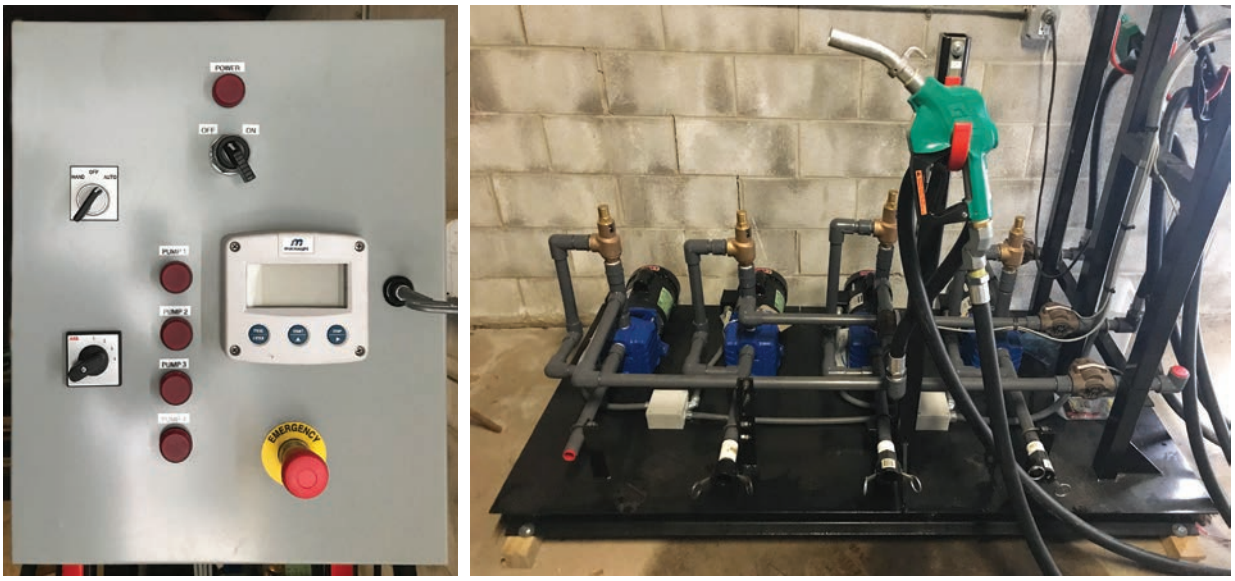


Mobile GIS Software.

Justin Rist, Field Supervisor for TASD, using new GPS enabled tablet.

While the greatest advancements in GIS applications were made in larval control operations, there were further advancements in the nighttime adult mosquito control program through updates to the Windows ULV software. These advancements include "User Defined Fields", which allows the District to insert customized data fields that may be important to record keeping. Additionally, the software now enables customized audible warnings for different area types, such as no treatment areas or long driveways. These different warnings signal technicians of an approaching point of interest and offer them enough time to take appropriate action. Furthermore, adult control staff now have the ability to use turn-by-turn directions to navigate to treatment areas, saving time. Finally, several enhancements have been made to the Office ULV software,

such as enabling a print map feature, allowing users to print a screenshot of their current view; spatial bookmarks, allowing for more expedient map viewing; and a "replay" feature that shows exactly how a treatment session was conducted. All of these new features have granted office employees the ability to view and consume data more rapidly and efficiently. Moreover, while many new developments were made within the ULV software, TASD upgraded the way in which adult control products are transported from storage containers to vessels on the control trucks by acquiring a new "pumping station". With this new piece of equipment, staff members can choose one of up to four different product options, preselect a precise amount of product to dispense, and distribute into a truck mounted vessel with many new safeguards in place.



TASD's new adulticide pumping station.

EMAIL NOTIFICATION SYSTEM

While many advancements were made within District operations, TASD also created new avenues to further engage with its citizens. Starting in the 2020 adult mosquito control season TASD began utilizing an automated email notification system. This system allows for Lucas County residents to sign up to receive important information about adult mosquitoes. Specifically, the system is primarily used to inform people of upcoming treatment events in their area, but can also be utilized to inform subscribers of an increase in disease risk in their area or other useful mosquito-related information.

CURRENT AFFAIRS & MOSQUITO-BORNE DISEASE

Since the onset of the COVID-19 pandemic research has focused on how the virus can be spread. This work has encompassed blood-feeding arthropods and their potential to spread the virus. As a result of this research, there is currently nothing that suggests mosquitoes are capable of carrying or transmitting the COVID-19 virus to humans.

West Nile Virus continues to be the mosquito-borne disease of primary concern to citizens of Lucas County. A total of 2 human cases of West Nile Virus (WNV) were reported from Ohio in 2020, with no cases diagnosed in Lucas County residents. Targeted night fogging applications, conducted by TASD, after the identification of WNV-positive mosquito pools were very successful at reducing mosquito populations and protecting citizens from infection. The TASD WNV mosquito testing was conducted by Michigan State University and the Center for Disease Control (CDC) through the Ohio Department of Health.

Nationwide, in 2020, forty-four states reported a cumulative total of 557 human cases of WNV, including 38 fatalities. Leading states for WNV cases included: California (184 cases), Texas (69 cases), and Florida (49 cases).

Although overshadowed by West Nile Virus, other arboviruses also occur in Ohio: St. Louis Encephalitis Virus (SLE), Eastern Equine Encephalitis Virus (EEE), Jamestown Canyon Virus (JCV), and La Crosse Virus (LAC) have all been found in Ohio in the past. From 2010-2019, Ohio had 222 of the 683 cases of LAC diagnosed throughout the nation. In 2020, LAC activity was high in Ohio again, but there were no human cases diagnosed in Lucas County residents.

TASD maintains an active surveillance and control program for arboviruses and their primary mosquito vector species. Mosquitoes are routinely tested for the presence of a virus. *Aedes triseriatus*, the vector of LAC, is controlled through nighttime fogging applications and the

Shannon Wilson, Field Supervisor for TASD, uses a bicycle to treat catch basins in response to West Nile Virus activity.

elimination and treatment of breeding tree-holes and man-made containers. Traditional breeding locations for *Culex pipiens*, the primary vector of WNV to humans, are routinely monitored and treated when standing water is present. In 2020, TASD continued the use of bicycles to treat residential catch basins, traditional *Culex spp.* breeding locations. This strategy continues to be very successful in increasing the number of catch basins treated by District employees: reducing exposure of Lucas County citizens to potential disease-carrying mosquitoes.

As in 2019, Michigan reported an outbreak of Eastern Equine Encephalitis (EEE) again in 2020. Although the total number of EEE cases was much smaller than WNV as well as EEE cases in 2019, the implications of contracting the disease are cause for concern and action. According to the CDC, approximately one-third of all people with EEE die from the disease. Death usually occurs 2 to 10 days after the onset of symptoms but can occur much later. Of those who recover, many are left with debilitating and progressive mental and physical ailments, which can range from minimal brain dysfunction to severe intellectual impairment, personality disorders, seizures, paralysis, and cranial nerve dysfunction. Many patients with these severe lasting impacts die within a few years. With this in mind, the Michigan Department of Health & Human Services conducted aerial spray treatments for adult female mosquitoes in 17 counties that were deemed "high risk".

2020 MOSQUITO-BORNE DISEASE STATISTICS, AS OF DEC. 2020

	NATIONAL	OHIO
Chikungunya	22 cases (imported)	none
Dengue	332 (imported); 80 (local)	2 cases (imported)
Malaria	avg. 1500-2000 cases/yr. (imported)	17 cases (imported)
LaCrosse Encephalitis	69 cases	30 cases
St. Louis Encephalitis	13 cases	none
Eastern Equine Encephalitis	10 cases (3 in MI)	none
Zika Virus	1 cases (imported)	none

TASD's 2020 research endeavors focused on product efficacy and the response of non-target organisms to mosquito control.

Due to changing product availability, pricing, and rotations, TASD is continuously modifying its mosquito control tools. While these products have been well studied by the EPA and by the manufacturer prior to TASD's use, product performance needs to be evaluated under the unique characteristics of Lucas County. Mosquito species composition, water quality, environmental factors, and breeding source could alter product longevity. Furthermore, TASD strives to prevent the development of pesticide resistance in larval and adult mosquitoes. Experimentation and survey data ensure that treatments are effective and do not promote pesticide resistance.

TASD aims to minimize its impact on non-target organisms. The shift of adulticide treatments to night-only applications and emphasis of larval control are two ways TASD has acted to reduce its impact. One current endeavor is a collaborative project monitoring non-target insect diversity in urban prairies near treated roadways.

RESIDUAL LARVAL CONTROL IN FLOODWATER

In 2019, the District evaluated VectoMax® as a residual control treatment to replace a discontinued product in floodwater sites. The results in 2019 suggested that residual control was not required. However, the longevity of floodwater and, thus, the probability of rebreeding vary from year to year. Therefore, VectoMax® evaluations continued in 2020 and its performance was compared to a short-term larval control product, AquaBac®. Both the residual and short-term larvicides provided at least three weeks of larval reduction (APPENDIX – Figure 4). After week three, larval abundance in the experimental control declined while low larval abundance was maintained in treated sites. Only one site was retreated during the 2020 study and this occurred in week seven at an AquaBac® site. Given the success of both products in spring floodwater at the study location, future research should expand to additional locations.

Spring floodwater produces mosquitoes without larval control treatments. Some of the mosquito species from spring floodwater emerge in large numbers once per year.

LARVAL CONTROL IN CATCH BASINS

Granular larvicide efficacy in catch basins was evaluated for Spinosad, BTI, BS, and BTI+BS during the 2020 field season. Catch basins were monitored for mosquito larvae prior to treatment and for six weeks following treatment. Product efficacy was also evaluated under controlled laboratory conditions by exposing lab-reared larvae to catch basin water that was collected each week. Each product met the manufacturer's claimed longevity in the field during at least one experiment (APPENDIX – Table 3). As claimed, FourStar Bti CRG®, VectoMax®, and Natular G30® provided the longest control in the field. While Censor® provided the briefest period of control, its performance met the claimed expectations. VectoLex® was variable in its success, performing poorly in the first experiment and well in the second experiment. FourStar Bti CRG® performed poorly in laboratory assays which could be due to experimental design as poor performance contradicts field results. As such, bioassays in 2021 will be modified to determine how to sample FourStar Bti CRG®-treated water in the field.

A TASD employee samples catch basin water to determine if granular treatments were effective.

LIQUID LARVICIDE EFFICACY

The District continued to trial liquid larvicide treatments in 2020. Both floodwater and catch basin efficacy was evaluated through the collection of field data and laboratory bioassays. Spring floodwater data showed mixed results in parks with liquid BTI performance tending to be less effective than granular larvicide. However, a spring liquid BTI treatment was extremely effective at the canal in both the field and the bioassays.

When applied to catch basins, liquid BTI showed increased mortality in treated samples during the bioassay. Field data supporting the efficacy of liquid BTI in catch basins was limited, but tended towards lower larval abundance after treatment.

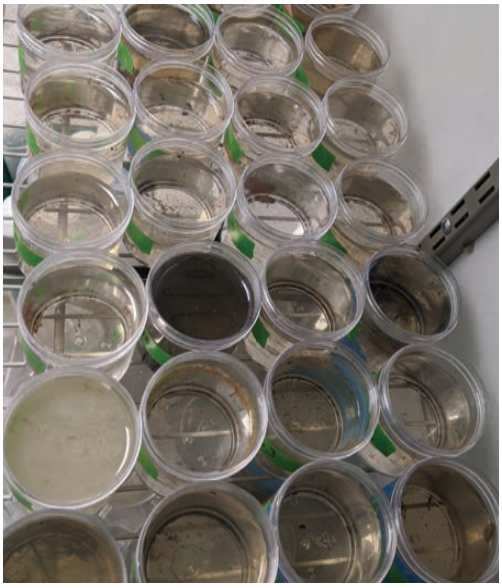
TASD trialed an insect growth regulator, Altosid Liquid Larvicide Mosquito Growth Regulator®, in 2020 as a liquid application in urban environments. Results were not favorable and the application method requires modification.

PESTICIDE RESISTANCE TESTING

Pesticide resistance testing was evaluated throughout the 2020 field season. In total, six CDC bottle bioassays were performed with the active ingredient permethrin and five assays were completed with the active ingredient etofenprox.

Permethrin performed well in most cases, but did demonstrate potential resistance in two assays (APPENDIX – Table 4). However, the repetition of each assay indicated that resistance was not a concern.

Etofenprox, on the other hand, did not perform well (APPENDIX – Table 5). All of the resistance tests with etofenprox indicated a resistance concern, despite experimental modifications such as solution age. Etofenprox is a newer active ingredient at TASD and has been used with very limited frequency throughout the county. The probability of resistance developing with such infrequent use is low and we hope to evaluate etofenprox more thoroughly during the 2021 field season.



Above is a bioassay in TASD's insectary. This bioassay is an experimental exposure of mosquito larvae to treated catch basin water. Larval survival is monitored for at least 48 hours to evaluate product efficacy.

ADULT CONTROL EFFICACY

Adulticide efficacy was monitored during the field season to determine if equipment or treatments required adjustment to improve control. Droplet size for adult control products is critical to effective mosquito control. Droplet characterization was performed whenever efficacy indicated a particular machine was performing poorly.

In-depth analyses of adulticide efficacy are ongoing, but currently 66% of the monitored applications experienced a reduction of gravid mosquitoes compared to control sites. It should be noted that gravid mosquitoes are more resistant to pesticides than host-seeking mosquitoes[1]. As such, the reduction TASD observed is lower than the percent reduction of the entire mosquito populations.

Six products were evaluated in 2020, but only three (PCT 3-15 ULV®, Pursuit 4-4®, and Zenivex E4 RTU®) have data available for more than ten trials (APPENDIX – Figure 5). Of these products, PCT 3-15® (active ingredient permethrin) performed the best with 85% of treatments reducing gravid mosquitoes. Zenivex E4 RTU® (active ingredient etofenprox) had poor field efficacy in 2020 with only 55% of treatments reducing gravid mosquitoes. Given the poor results of this product in the field we will be evaluating Zenivex E4 RTU® in controlled experiments during 2021.

NON-TARGET ORGANISMS

Urban prairies provide habitat for insects and can improve water quality. Here a dragonfly is perched on a Black-Eyed Susan in TASD's on-site prairie.

The variety of land use in Lucas County results in a unique environment for mosquito control. Urban prairies, installed and maintained by the Toledo Zoo, are one of the county's more unusual environments. Urban prairies provide habitat for wildlife (especially pollinators) and can improve water quality. However, urban prairies are closer to roads than most natural habitats. As such, the exposure to roadside adult mosquito control is greater. Yet, mosquito control in these urban areas is essential as West Nile virus risk is high in urban and suburban areas.

TASD continued its partnership with the Toledo Zoo's local conservation effort, Wild Toledo, as a means of promoting both public and environmental health. This collaborative study evaluates non-target insect diversity in urban prairies near treated and untreated roads. Each prairie was sampled for one day prior to adulticide application and five days following application. Untreated sites were monitored simultaneously to account for temporal and environmental fluctuations in insect diversity. Insects are currently being identified from the samples collected in 2020.

[1] Clifton ME, Xamplas CP, Nasci RS, & Harbison J. 2019. Gravid Culex pipiens exhibit a reduced susceptibility to ultra-low volume adult control treatments under field conditions. Journal of the American Mosquito Control Association, 35(4):267-278.

ENVIRONMENTAL SUSTAINABILITY

Everyone recognizes that mosquitoes are a nuisance, but few realize the magnitude of the health threat and economic impact they present. Mosquito eradication is not possible. Nevertheless, much can be done to control these pests without harming humans, wildlife, or the environment. All of the products utilized by the TASD have been approved for mosquito control use by the United States Environmental Protection Agency (USEPA) and the Ohio Department of Agriculture (ODA), posing little to no risk to human health, other organisms, or the environment.

The public health insecticides used during mosquito control operations are readily biodegradable and do not accumulate in the food chain or leave harmful residues on plants or other surfaces. These products have not been implicated in the contamination of well water or public waterways. TASD operations are covered by the general NPDES permit for Ohio, under the Clean Water Act. As an individual partner, under the auspices of the American Mosquito Control Association, in the Environmental Protection Agency's Pesticide Environmental Stewardship Program, the District is committed to embracing sound environmental stewardship practices in its operations, whenever possible.

"Green" initiatives continued at the District. The on-site native pollinator habitat continued to thrive. Plans have been made to expand this important initiative to provide much needed additional urban habitat for our important pollinators. The District's on-site honeybee colony will contribute to the health of the prairie and provide the opportunity to promote pollinator protection and health to the public through various educational efforts.

Continued capital improvements to the District office were made with energy efficiency in mind and this will continue to be a focus as more capital improvements are planned for 2021.

In 2020, the TASD expanded the scrap tire recycling program that was started in 2017. Through this program, TASD employees collected and removed 8,231 (over 90 tons) discarded scrap tires from the environment. This was the largest number of tires recycled in the history of the program. This program provides lasting mosquito control by removing a known breeding source. It also has direct environmental benefits that come along with the removal of these illegally dumped tires. Employees actively search for these scrap tires throughout the county, collect them, remove any water and breeding mosquitoes, and stack them for proper recycling.

TASD's on-site prairie continues to develop.

2020 FINANCIAL REPORT & 2021 BUDGET

	2020 FINANCIAL REPORT	2021 BUDGET
FUNDS ON HAND		
Petty Cash	$ 100.00	$ 100.00
Cash Book Balance	1,314,498.59	1,795,861.82
TOTAL FUNDS ON HAND	$ 1,314,598.59	$ 1,795,961.82
RECEIPTS		
Maintenance Assessments (Gross)	$ 2,923,665.42	$ 2,700,000.00
Grants	1,030.00	0.00
Interest Earned on Investments	1,207.52	1,000.00
Sale of Equipment & Supplies	0.00	0.00
Sale of Scrap	97.94	0.00
Adjustments & Refunds	79,929.11	0.00
TOTAL	$ 3,005,929.99	$ 2,701,000.00
TOTAL RECEIPTS & BALANCES	$ 4,320,528.58	$ 4,496,961.82
EXPENDITURES		
OFFICE & ADMINISTRATION		
Wages - Permanent	$ 369,352.89	$ 405,000.00
Wages - Temporary	24,766.52	40,000.00
Equipment	360.47	11,000.00
Utilities & Communications	21,414.07	40,000.00
Professional Services	70,761.60	300,000.00
Pension & Employee Insurance	484,709.27	750,000.00
General Insurance	119,224.50	130,000.00
Travel & Conference	(781.38)	20,000.00
Supplies	5,276.22	15,000.00
Education & Research	4,015.63	45,000.00
R.E. Improv., Maint. & Rental	35,107.16	420,000.00
Assessment Roll & Taxes	13,530.23	115,000.00
Workers' Comp. & State Auditor	7,700.55	50,000.00
Adjustments	0.00	0.00
TOTAL	$ 1,155,437.73	$ 2,341,000.00
FIELD PROGRAM		
Wages - Permanent	$ 807,386.95	$ 820,000.00
Wages - Temporary	9,097.50	70,000.00
Vehicles & Equipment	158,094.53	220,000.00
Larvicides & Insecticides	195,718.00	375,000.00
Fuel & Lubricants	27,204.19	45,000.00
Equipment Maintenance & Shop	19,112.35	30,000.00
Field Supplies & Hand Tools	125,514.92	47,000.00
Miscellaneous & Contingencies	400.00	2,000.00
Drainage Equipment Maintenance	12,090.09	15,000.00
Special Projects	0.00	0.00
Vehicle & Equipment Rental	0.00	0.00
Environmental Sustainability	14,510.00	17,000.00
TOTAL	$ 1,369,129.03	$ 1,641,000.00
TOTAL EXPENDITURES	$ 2,524,566.76	$ 3,982,000.00
BALANCE	$ 1,795,961.82	$ 514,961.82

LISA DIEHL
OFFICE MANAGER/BOOKKEEPER

APPENDIX

Table 1. TASD Product Use Summary (2020)

Product	Use Pattern	Amount Used
Anvil 2+2®	Night fogging applications	14 gals.
BioMist 3+15®	Night fogging applications	67 gals.
Duet®	Night fogging: disease response	15 gals.
PCT 3-15®	Night fogging applications	283 gals.
Pursuit 4-4®	Night fogging applications	1,275 gals.
ULV Mosquito Master 412®	Night fogging: product rotation and resistance management	50 gals.
Zenivex E4®	Night fogging applications	364 gals.
Abate 5% Tire Treatment®	Tire larval control	513 lbs.
Altosid Liquid Larvicide®	Urban WALS *Culex* control and disease management	5.75 gals.
Aquabac 200G®	Temporary floodwater treatment	4,370 lbs.
BVA 2®	Pupal and late fourth instar larval control	343 gals.
Censor Larvicide Granule®	Temporary floodwater treatment	992 lbs.
FourStar Bti CRG®	Catch basin treatments and containers	344 lbs.
Natular G30®	Catch basin treatments and containers	491 lbs.
Vectobac WDG®	Urban WALS *Culex* control and disease management	348 lbs.
VectoLex FG®	Catch basin treatments and semi-permanent floodwater	706 lbs.
VectoMax FG®	Spring floodwater applications	13,119 lbs.

APPENDIX

Table 2. New Jersey Light Trap Collections (2020)

	MAY				JUNE				JULY				AUGUST					SEPTEMBER									
WEEKS:	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	**TOTALS**						
MOSQUITO SPECIES																						May	June	July	Aug.	Sept.	**TOTALS**
Ae. aurifer	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	**1**
Ae. canadensis	1	0	9	2	5	4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	24	12	11	0	1	0	**24**
Ae. cinereus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	**1**
Ae. grossbecki	0	2	0	12	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	22	14	8	0	0	0	**22**
Ae. japonicus	0	1	10	17	8	9	5	8	1	14	12	7	4	13	2	4	0	5	1	0	121	28	30	34	23	6	**121**
Ae. sollicitans	0	0	0	42	5	3	0	28	28	3	0	2	0	1	0	3	0	0	0	0	115	42	36	33	4	0	**115**
Ae. sticticus	0	0	10	195	164	99	107	70	87	20	15	3	0	4	0	2	0	0	0	0	776	205	440	125	6	0	**776**
Ae. stimulans	1	0	2	10	6	10	0	2	2	0	0	1	0	0	2	2	0	0	0	0	38	13	18	3	4	0	**38**
Ae. triseriatus	0	0	0	1	0	0	0	1	0	0	2	2	0	5	1	1	0	0	0	0	13	1	1	4	7	0	**13**
Ae. trivittatus	0	0	0	243	28	12	15	3	0	2	1	1	0	0	0	1	0	0	0	0	306	243	58	4	1	0	**306**
Ae. vexans	0	4	43	2935	1228	608	535	379	542	196	270	212	109	118	20	150	18	95	44	2	7508	2982	2750	1220	415	141	**7508**
An. barberi	0	0	0	1	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	1	3	0	1	0	**5**
An. perplexans	0	1	5	4	0	0	1	1	6	1	3	3	0	0	1	1	0	1	0	0	28	10	2	13	2	1	**28**
An. punctipennis	0	1	5	7	3	5	12	15	11	5	12	15	7	29	3	16	1	3	0	0	150	13	35	43	56	3	**150**
An. quadrimaculatis	0	1	0	3	1	4	9	14	92	59	119	111	91	406	307	663	43	51	31	0	2005	4	28	381	1510	82	**2005**
An. walkeri	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	11	0	18	1	0	0	6	11	**18**
Cq. perturbans	0	0	0	1	0	20	12	33	256	30	88	15	10	46	32	140	1	0	0	0	684	1	65	389	229	0	**684**
Cx. erraticus	0	0	1	4	0	0	1	0	0	0	0	0	0	0	104	318	11	5	0	0	444	5	1	0	433	5	**444**
Cx. pipiens	0	27	26	55	18	15	30	24	17	9	8	7	10	8	20	85	7	14	47	1	428	108	87	41	130	62	**428**
Cx. restuans	24	40	45	69	26	34	34	14	31	11	14	27	20	47	14	61	1	16	17	0	545	178	108	83	143	33	**545**
Cx. pipiens/Cx. restuans	0	0	23	30	11	29	38	14	55	68	94	121	134	99	38	35	3	71	0	0	863	53	92	338	309	71	**863**
Cx. tarsalis	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	1	0	0	0	**4**
Cx. territans	2	9	2	19	10	34	12	11	3	13	0	5	0	12	21	16	0	2	0	0	171	32	67	21	49	2	**171**
Cs. inornata	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2	0	0	0	1	**3**
Cs. melanura	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	**1**
Cs. minnesotae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	**1**
Or. signifera	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	**2**
Ur. sapphirina	0	0	1	0	3	1	3	2	14	17	19	12	3	13	61	94	0	22	0	0	265	1	9	62	171	22	**265**
TOTAL FEMALE	**29**	**89**	**182**	**3654**	**1524**	**889**	**817**	**620**	**1147**	**448**	**657**	**545**	**388**	**801**	**628**	**1596**	**87**	**286**	**152**	**3**	**14542**	**3954**	**3850**	**2797**	**3500**	**441**	**14542**
TOTAL MALE	**2**	**15**	**37**	**2340**	**1493**	**447**	**288**	**230**	**327**	**451**	**277**	**325**	**146**	**333**	**266**	**693**	**25**	**563**	**77**	**2**	**8337**	**2394**	**2458**	**1380**	**1463**	**642**	**8337**

APPENDIX

Table 3. A summary of longevity claimed versus longevity observed by catch basin control product. Observed longevity was defined as the time from initial control until the last successful week occurring before the second failed week[1]. Claimed longevity information was obtained from the product labels provided by the distributor.

PRODUCT	LONGEVITY CLAIMED (DAYS)	OBSERVED LONGEVITY (DAYS)		
		PASS/FAIL	LARVAL ABUNDANCE	24-HOUR BIOASSAY[2]
CENSOR	Up to 7	7-28	7[4]	7[4]
Natular G30	30	28-35	7-35	14-21[4]
FourStar Bti CRG	Up to 40	35	35-42	7[4]
VectoLex FG	Up to 28	28[3]-42	0-42	7-35[4]
VectoMax FG	Up to 28	28-42	28-42	7-42[4]

[1] Observed longevity equals 21 if a product passes in week 1 and 3, but fails in 2 and 4; observed longevity equals 7 if a product passes in week 1 and 4, but fails in 2 and 3.

[2] Bioassay data at 48-hours excluded due to high control mortality.

[3] Effective control persisted for 28 days after a three-week delay.

[4] Effective control persisted for 7 days after a one-week delay in experiment one or two.

APPENDIX

Table 4. Summary of permethrin resistance testing in 2020. Results of concern are highlighted in red.

DATE	SERVICE MAP	SOLUTION DATE	SUSCEPTIBILITY AT CDC DIAGNOSTIC TIME[1] (%)	NON-KDR (%)	CONTROL MORTALITY[2] (%)
7/6/2020	121	2019	**78.57**	-	0
7/29/2020	121	2019	100	100	0
9/17/2020	121	9/9/2020	97.5	97.5	0
9/10/2020	199	9/9/2020	99	98	**54.5, 95 (30, 120 minutes)**
9/11/2020	199	9/9/2020	**96.7**	**87.9**	**15, 65 (30, 120 minutes)**
9/16/2020	199	9/9/2020	99	**91.8**	0

[1] Un-corrected susceptibility as this value is not calculated when control mortality exceeds ten percent.

[2] Control mortality calculated from (total dead – initial dead)/total mosquitoes per bottle.

APPENDIX

Table 5. Summary of etofenprox resistance testing in 2020. Results of concern are highlighted in red.

DATE	SERVICE MAP	SOLUTION DATE	SUSCEPTIBILITY AT CDC DIAGNOSTIC TIME[1] (%)	MINUTES TO 97+% MORTALITY	NON-KDR (%)	CONTROL MORTALITY[2] (%)
7/24/2020	98	2019	**75.2**	**Did not reach >97%**	-	**15.8, 21 (15, 120 minutes)**
9/22/2020	199	2019	**14.4**	**120**	**65**	**4.7, 9.5 (15, 120 minutes)**
10/1/2020	199	9/30/2020	**69.1**	**45**	**71.8**	**0, 42.9 (15, 120 minutes)**
10/6/2020	199	9/30/2020	**23.6**	**75**	**81.8**	0
10/9/2020	71	9/30/2020	**12.1**	**90**	**59.3**	0

[1] Un-corrected susceptibility as this value is not calculated when control mortality exceeds ten percent.

[2] Control mortality calculated from (total dead – initial dead)/total mosquitoes per bottle.

Figure 1.

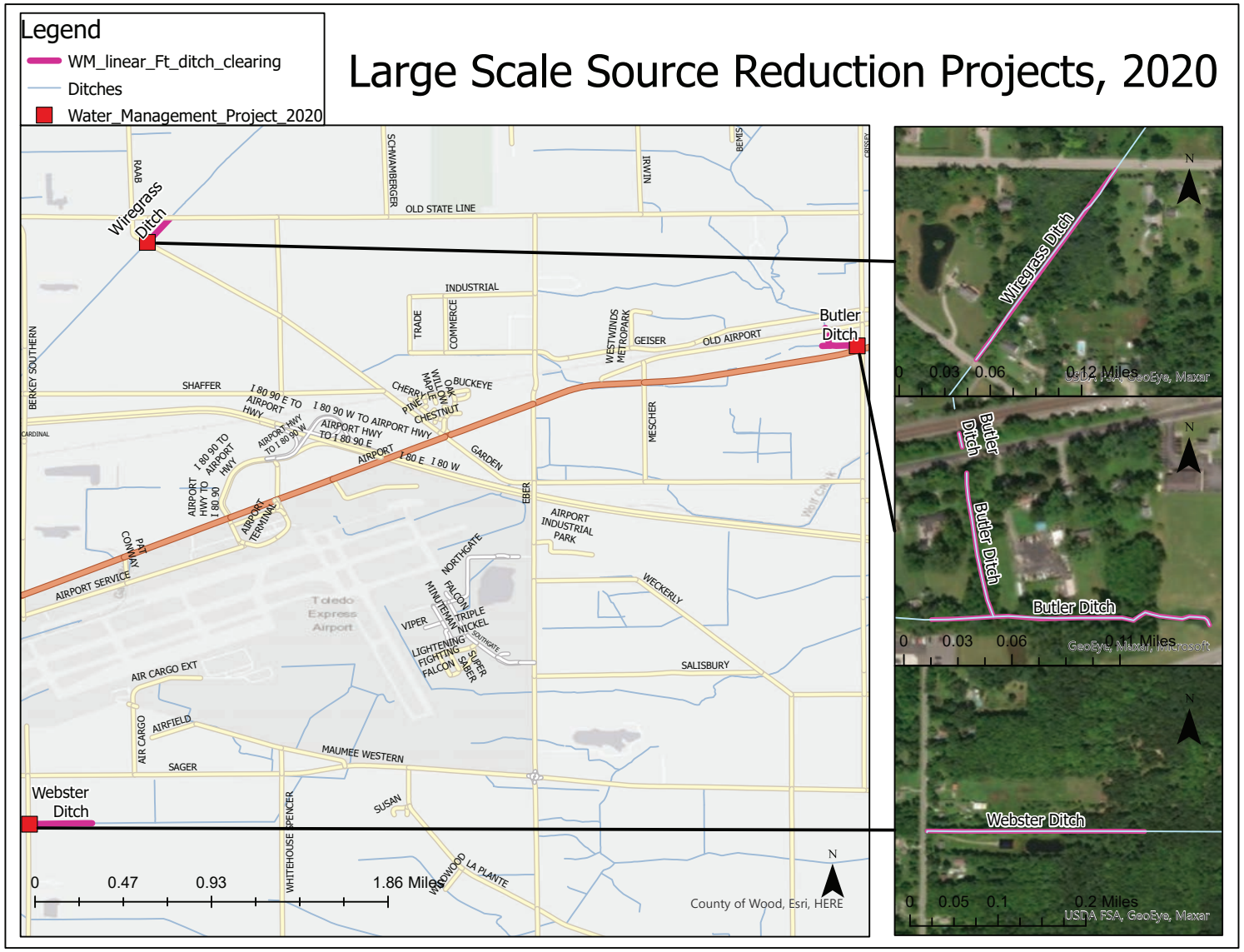
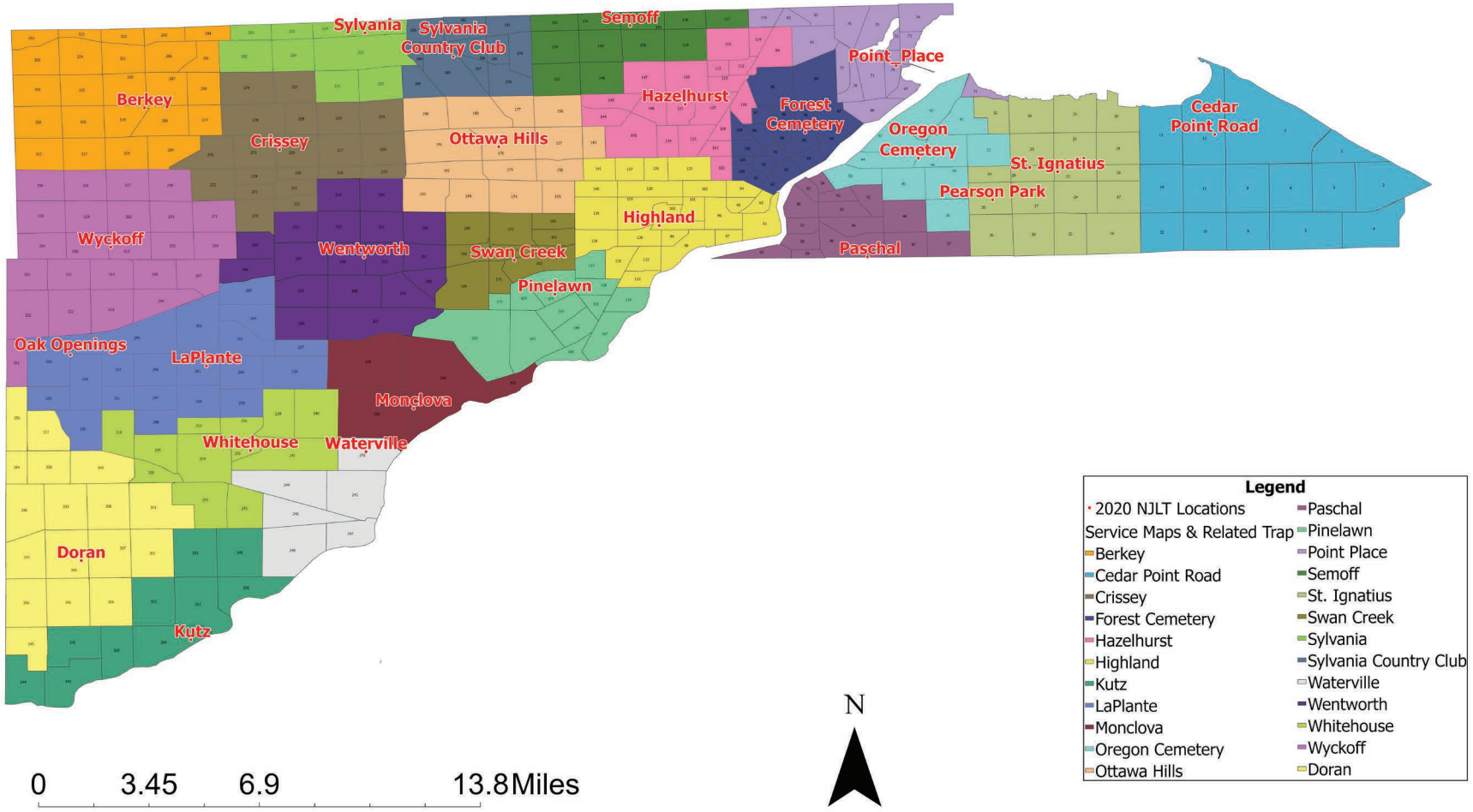
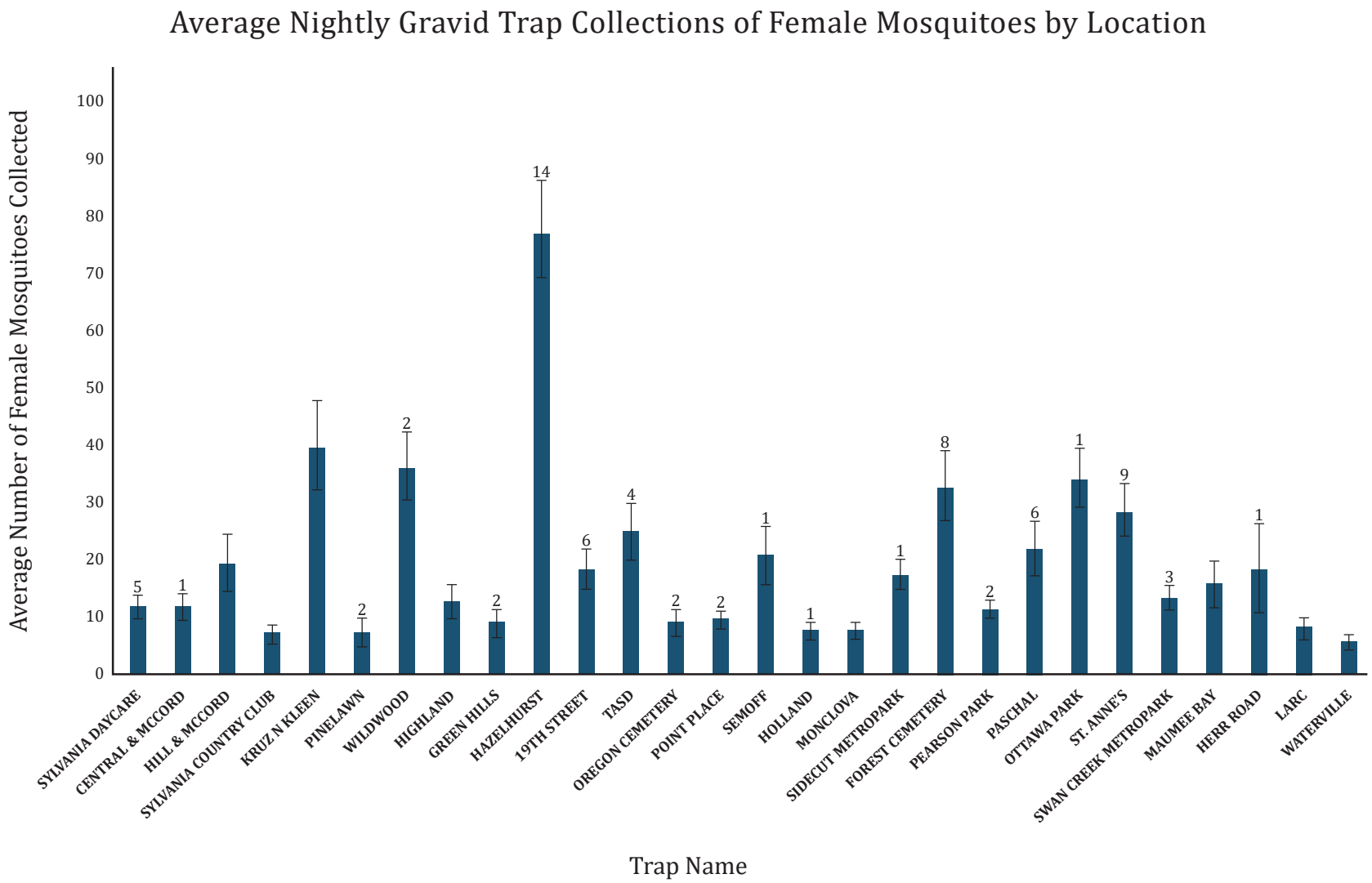

Legend
WM_linear_Ft_ditch_clearing
Ditches
Water_Management_Project_2020
Large Scale Source Reduction Projects, 2020
Wiregrass Ditch
Butler Ditch
Webster Ditch
OLD STATE LINE
INDUSTRIAL
SHAFFER
AIRPORT HWY
AIRPORT
GARDEN
EBER
AIRPORT INDUSTRIAL PARK
WECKERLY
SALISBURY
AIR CARGO EXT
AIRFIELD
MAUMEE WESTERN
SAGER
SUSAN
LA PLANTE
AIRPORT SERVICE
Toledo Express Airport
0 0.47 0.93 1.86 Miles
County of Wood, Esri, HERE
0 0.03 0.06 0.12 Miles
0 0.03 0.06 0.11 Miles
0 0.05 0.1 0.2 Miles
USDA FSA, GeoEye, Maxar

Figure 2. New Jersey Light Trap Locations and Associated TASD Service Maps (2020)



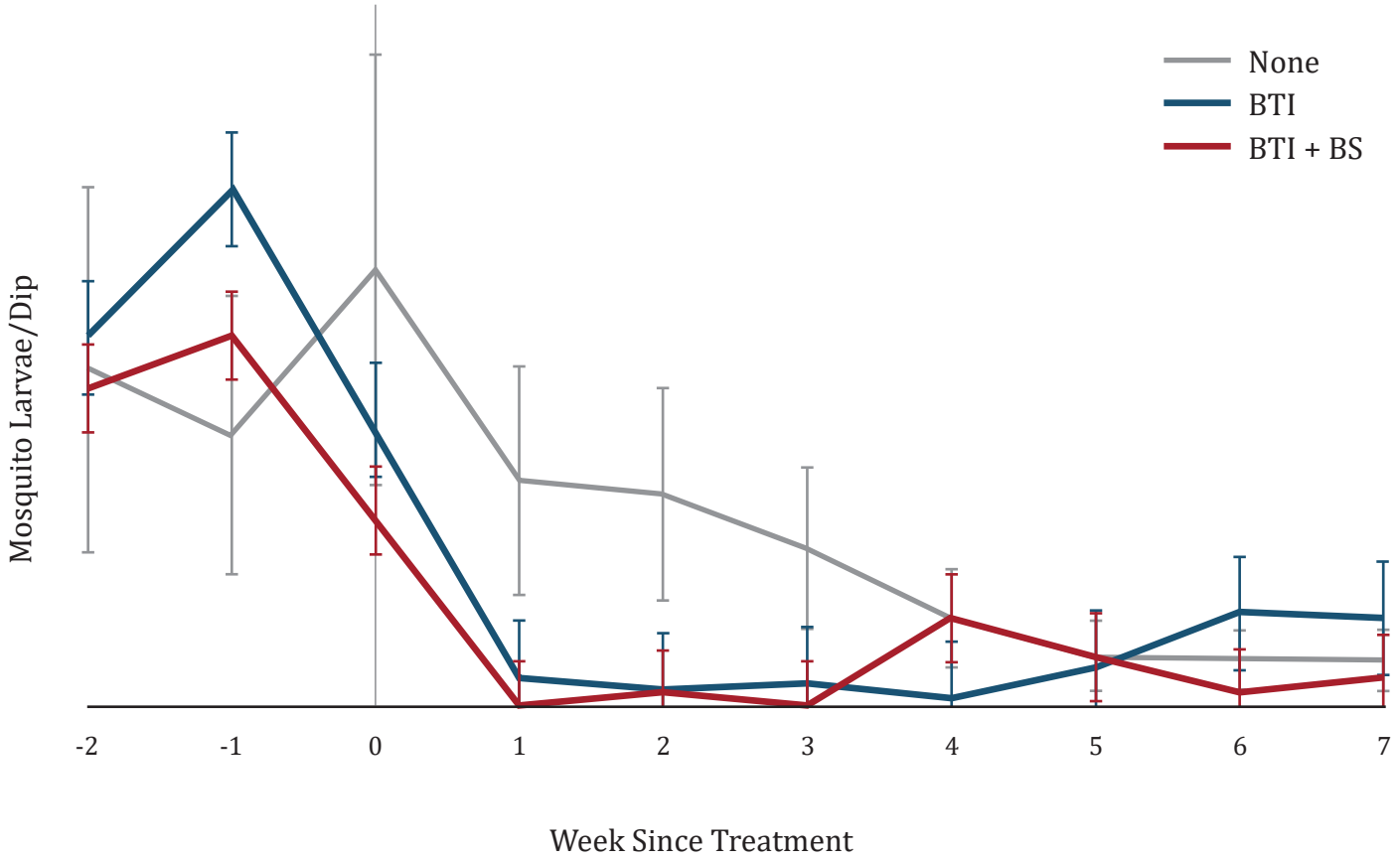
APPENDIX

Figure 3. Values above the bars are the total number of positive West Nile Virus mosquito pools obtained from the site in 2020.



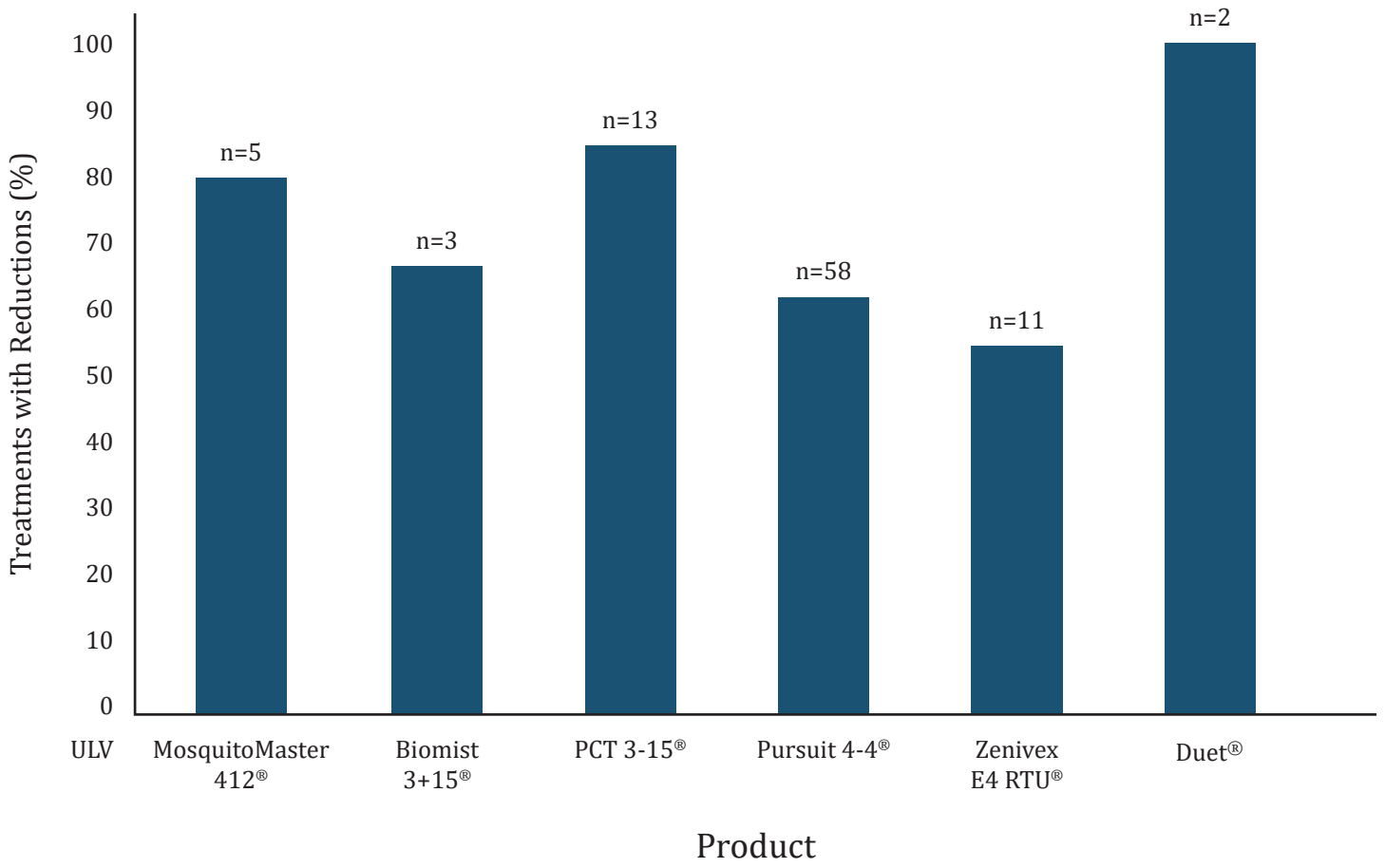
APPENDIX

Figure 4. Larvae were significantly less likely to occur in treated sites in weeks one through three post-treatment compared to control sites. No difference in treatment and control sites was observed before treatment or after four-weeks post-treatment. Reapplication was not made after three weeks as larval abundance was still significantly lower than the start of the season. One BTI-only site was retreated on week seven (May 27) due to higher larval counts. Multiple comparisons were only made within each week, not between weeks.



APPENDIX

Figure 5. Adult control products varied in the number of successful treatments. The percentage of efficacy evaluations with declining gravid mosquito abundance after application is shown by product. Values above the bars are the total number of efficacy evaluations available for each product.



NOTES