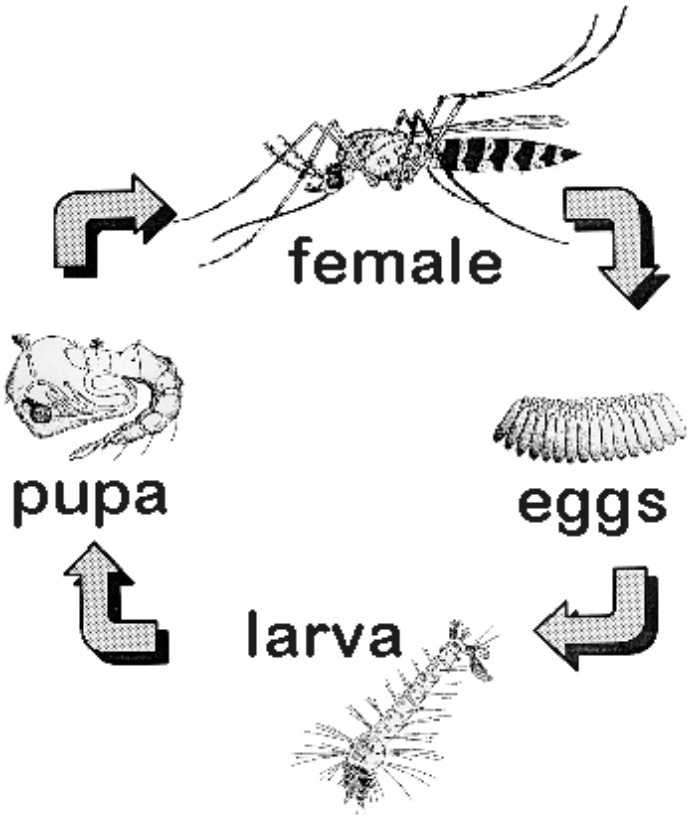
Mosquito Surveillance and Response Plan
City of Denton, Texas



Department of Environmental Services
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TABLE OF CONTENTS:

1.0 INTRODUCTION

Mosquitoes are insects that belong to the order Diptera, or True Flies. Female mosquitoes have modified mouthparts that form a long piercing-sucking proboscis, while male mosquitoes have mouthparts that are incapable of piercing skin. There are over 2,500 different species of mosquitoes that have been identified throughout the world, with approximately 150 species occurring in the United States. The Texas Department of Health estimates that there are approximately 82-84 mosquito species in the State of Texas, although only about 12 of these mosquito species have been implicated in the transmission of serious diseases.

Mosquitoes typically need still, stagnant water that is isolated from fish or other small predators to complete their metamorphosis from egg to adult. Larval habitats can range from marshes, freshwater wetlands, and tree holes to human-made structures like catchments, drains, gutters, and discarded tires. Not all species feed on humans and other mammals, and many species feed mostly on birds, amphibians, or reptiles. Only a small percentage of the known mosquito species are considered to be diseases vectors.

Although only a small percentage of mosquito species are capable of transmitting diseases, the effectiveness of mosquitoes as a vector for disease transmission makes control important, when necessary. Within the United States, the occurrences of mosquito-borne illnesses have been relatively rare in recent years. However, epidemics of mosquito-borne diseases were once common in the United States. Outbreaks of Yellow Fever have been recorded as far north as Philadelphia during the Colonial Period, and Dengue fever was prevalent along the Gulf Coast until the mid-1940s. At one time, malaria was well established in the continental United States, especially in the south. Other mosquito-borne illnesses like LaCrosse, St. Louis, and Eastern Equine Encephalitis are still threats in certain areas of the country. Although many of these historical mosquito-borne diseases have been eliminated or at least controlled, the subsequent rapid spread of West Nile Virus within the United States, and sustained local activity is a topic of current concern.

Mosquitoes may be controlled through a variety of different physical, chemical, and biological methods. Physical methods usually involve source reduction, which is simply the physical removal of the specific mosquito breeding habitats of the mosquito species of concern, namely small catchments of water around homes and in storm drain systems. Biological measures mainly center on the use of bacteria that kill mosquito larvae or the use of natural mosquito larvae predators. Chemical control typically involves the application of pesticides to rapidly reduce the adult mosquito population when the human population is at an elevated risk of acquiring a mosquito-borne disease.

Mosquito control pesticides are applied by various means, depending on the type and size of the area being treated. However, pesticides have the potential to impact non-target species, including humans, if not applied according to prescribed methods and quantities. Any consideration for the application of pesticide should be a careful weight of the known risks to the people in the area, potential ecological risks, and potential

environmental risks. Used in a targeted and brief manner, community ultra-low volume (ULV) pesticide application can and does reduce a community's risk from infection by West Nile virus with minimal to no risk to the human population and minimal risk to the environment (Peterson, 2006).

To target the most common mosquito-borne disease, West Nile virus, there are two main mosquito control pesticide groups used. The first group is larvicidal pesticides, such as bacillus thuringensis (BTi) that has targeted toxicity to mosquito larvae. This type of application is used frequently and is encouraged because of the low inherent risk and, when used widely, has a high level of success in mosquito population control.

The second mosquito control pesticide group targets adult mosquitoes. Pyrethrins and pyrethroids could be applied in a targeted manner using ULV spraying. These pesticides are typically applied using either backpacks for a small targeted area truck-mounted for broader applications, or aerial application to target a wide-spread outbreak of the disease. The relatively recent development of ULV with the addition of chemicals that increase targeted mosquito contact, along with operational changes to target the mosquito most likely spreading West Nile virus (Culex quinquesfasciatus), has vastly changed community pesticide application risks when compared to "fogging" of days past. That being said, there are still unknown risks or measures of risk to the environment and to ecological functions that are currently being studied and debated.

2.0 Objectives

The City of Denton Mosquito Surveillance and Response Plan was developed to meet several objectives. Specifically, the Plan:

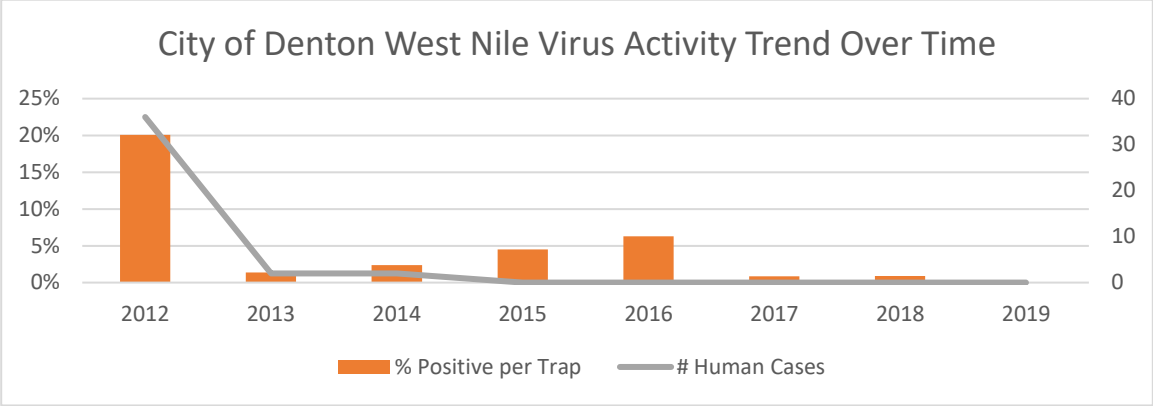
- Provides guidelines and information on mosquito populations, prevalence of diseases, and control strategies;
- Provides a systematic approach for using mosquito sampling and human disease data to establish Risk Levels;
- Establishes actions that will be undertaken for each Risk Level;
- Provides municipal staff and elected officials with a decision-support system;
- Outlines the roles and responsibilities of municipal staff and elected officials.

3.0 West Nile Virus (WNV) Concerns

West Nile Virus is a virus first identified in Africa in the 1960's and then first recorded in North American in August 1999.

In the following years the virus quickly spread across the United States and was first detected in Denton County in 2002 (Denton County West Nile FAQ's). Denton joined the North Texas region in experienced one of the country's most serious and deadly outbreaks of West Nile virus to record (Chung, et.al, 2013). Since 2012, there was

another cycle of activity in 2015 and 2016. Viral activity has been quiet in the last few years (2017 through 2019). The chart below depicts West Nile Virus activity trends over the last 8 years.



While still not fully understood, it is evident weather plays a major role in the risk of disease outbreak. Models using past data have shown stronger predictions for an outbreak when environmental conditions supported an increase in Culex species mosquitoes, a flux in naïve (not previously exposed to WNV) fledgling birds, and a lack of rainfall. The previous year of drought followed by a relatively warm winter and spring experienced in North Texas during 2011 to 2012 may have been a significant factor in the large amount of disease present during the 2012 mosquito season.

The relatively rapid spread of West Nile virus and the increase in disease incidence indicates that WNV is permanently established in the United States. It is likely that the virus survives the winter either within birds that remain in the area or within mosquitoes that survive the winter. When spring returns, the virus can amplify within birds and is readily passed to early season mosquitoes. As mosquito populations increase, mosquitoes begin to feed more frequently on birds, causing an increasing number of birds and mosquitoes that are infected. If environmental conditions are favorable for transmission, the virus will amplify to a theoretical point of spillover. At spillover, the virus can bridge out of the bird-mosquito cycle through mosquitoes that feed on birds, humans, and other animals. At the point of spillover, transmission to humans becomes more likely.

Currently, mosquito bite avoidance and mosquito control are the only practical method of protecting the human population from WNV infection. There are no known specific treatments or cures for the disease, and vaccines are currently not available for public use. The virus also kills a variety of native and non-native birds and may have impacts on other wildlife.

Understanding the types of mosquitoes in the area that transmit the disease is also a crucial consideration for directing control responses and public education activities. Since not all mosquitoes carry the virus, enacting mosquito control efforts that attempt to non-selectively reduce all mosquito populations will not necessarily reduce the risk of

WNV. In fact, based on 15 years of mosquito monitoring and disease analyses in the City of Denton, there appears to be only one mosquito that serves as a vector for this disease. Approximately 94 percent of the WNV infected mosquitoes captured in Denton's monitoring program over the last 15 years have been *Culex quinquefasciatus*, commonly known as the southern house mosquito. Approximately 99% of the mosquitoes that have tested positive for WNV during the last 15 years of monitoring have been some type of *Culex* species. Control efforts enacted by the City are therefore focused on *Culex* species, and are particularly focused on *Culex quinquefasciatus*.

The past experience of numerous mosquito control districts suggests that a mosquito control program should be based on the principals of Integrated Pest Management (IPM). The principals of IPM are:

- knowledge of mosquito biology and the epidemiology of the mosquito-borne diseases;
- surveillance and monitoring efforts for the detection and status assessment of mosquito populations and / or mosquito-borne diseases;
- a multifaceted prevention and control program comprised of a system of control tactics which are compatible with each other and which are proven effective;
- continue program evaluations and updates to ensure that the best methods are being used to meet the prevention and control objectives of the program; and
- continue education of the public to create awareness, understanding, and support.

These general guidelines have been used to develop the threshold-level responses of this surveillance and response plan.

4.0 The Role of Community Members

The role of residents, property owners, and business owners in reducing mosquitoes is crucial to an effective program. The City of Denton is committed to continuing to work with community members to increase the community's knowledge of West Nile Virus, the urban ecological cycle of breeding mosquitoes, and how this increases the risk of WNV outbreaks.

Community members can play an important role in reducing the number of adult mosquitoes by eliminating standing water that may support the development of mosquito larva and pupa. For example, residents can properly dispose of discarded tires, cans, buckets, maintain pools correctly, unclog blocked gutters and drains, dump water from bird baths and pet dishes at least every 2-3 days, ensure that air conditioning condensate is not pooling for several days, control irrigation so that standing water is not produced, irrigate so that runoff is not produced, and perform similar activities around homes and businesses. Water that cannot be eliminated should be treated with a biological

mosquito larvicide such as *Bacillus thuringiensis israelensis* (Bti) in accordance with manufacturer's recommendations.

Culex quinquefasciatus (Southern House Mosquito), the target mosquito for control, tends to prefer to lay its eggs in "artificial" sources of water such as those listed above, as opposed to laying eggs in wetland areas, streams, and ponds. Generally, this mosquito cannot fly long distances, so emerging adult mosquitoes often remain near the habitat they lived in as larva and pupa. Adults will rest during the daytime in vegetation, particularly in areas where humidity is high. Irrigated urban and suburban landscapes can offer excellent habitat, especially if there is standing water present. Underground storm drains that receive small amounts of runoff from irrigation are also good habitat for these mosquitoes. As a result, *Culex quinquefasciatus* tends to become more associated with urban and suburban areas during the summer months. Often these same areas will also have birth baths, bird feeders, trees, and other vegetation that serve to attract birds, especially during the drier times of the year when food and water become scarce. As a result, the opportunities for WNV disease amplification in urban and suburban areas can become more pronounced during summer months.

5.0 Denton's Plan for Mosquito Surveillance

The risk of mosquito-borne diseases depends on the size of mosquito populations and the incidence rate of disease, as well as the likelihood of the mosquito population changing in response to climate factors. Although mosquito abundance can be estimated through collection of either immature or adult mosquitoes, adult mosquito abundance is a key factor contributing to the risk of virus transmission. For this reason, the City of Denton monitoring program primarily focuses on collecting adult mosquito populations for targeting control measures and gauging the potential for disease outbreak. The current mosquito surveillance program is a partnership between the City of Denton and the University of North Texas. This surveillance program collects adult mosquitoes using both CDC light traps and gravid traps. Captured mosquitoes are sent to the Texas Department of State Health Services for testing. Each sample (sometime referred to as a "pool") consists of female mosquitoes that are collected at a specific collection site, in one of the two types of trap. The information obtained from these surveillance efforts is used to map mosquito populations, provide public information, and to determine the incidence of WNV or other arbovirus (CDC, 2013)

The mosquito surveillance program allows analysts to map potential mosquito breeding grounds and areas of persistent disease. Using this information, more targeted efforts towards habitat disruption, source reduction, larviciding operations, and other control mechanisms are possible. An effective, broadly applied surveillance program can allow analysts to detect the presence of WNV of other mosquito-borne viruses during the amplification phase. If targeted mosquito controls are implemented at the amplification stage, the likelihood of bridging can be minimized, thus reducing the risk of human transmission. Depending on weather patterns and monitoring results, trapping can be expanded or contracted and the trapping season may be lengthened or shortened. If

control measures are applied, trapping data may also be of some use for evaluating the effectiveness of control measures.

The overall goal of the mosquito surveillance program is to use data on mosquito populations and mosquito virus infections rates to:

- assess the threat of human disease;
- determine the geographical areas of highest risk;
- determine the need for intervention events, and the timing of these events;
- identify larval habitats that are in need of targeted control;
- monitor the effectiveness of control measures; and
- develop a better understanding of transmission cycles and potential vector species.

Adult surveillance methods should:

- Use both fixed and flexible trap locations if possible
    - Fixed positions allow for the development of a database so year to year comparisons are possible;
    - Flexible sites allow for responses to epidemiological and natural events.
- Use more than one trapping method (CDC light traps, gravid traps, etc...)
    - Testing data collected in the City of Denton's monitoring program suggests that if resource limitations require a choice between CDC light traps or gravid traps, gravid traps are preferred. These traps have been more effective in collecting *Culex quinquefasciatus*, and more effective for establishing the prevalence of WNV.
- Account for different influencing factors, including:
    - Habitat size and diversity;
    - Resource availability;
    - Proximity to human population centers and / or recreational areas; and
    - Flight ranges of target mosquito vector(s).

Advantages of using adult mosquito surveys include:

- The ability to provide early evidence of viral activity in an area;
- Helpful for determining if viral activity is local and / or restricted to a few areas;
- Providing information on potential mosquito vector species
- Providing estimates of vector species abundance and temporal prevalence;
- Providing information on virus infection rates for different mosquito species;
- Providing information on potential risks to humans and animals;
- Providing baseline data that can be used to guide emergency controls.

Disadvantages of using adult mosquito surveys include:

- The amount of labor required, and associated expenses;

- The need for substantial expertise to ensure proper collection and handling of mosquitoes;
- The delays associated with receiving mosquito arbovirus screening results;
- The fact that collectors may be at risk from mosquito bites (although using personal protection methods can minimize risks).

5.1 Adult mosquito collection

The adult mosquito surveys implemented by the City of Denton in conjunction with the University of North Texas are designed to determine the relative abundance of various species present during the sampling period as well as the incidence of arthropod-borne virus/diseases within the captured specimens. Using this information, City of Denton personnel determines the need for various control measures, and can conduct more effective searches for larval breeding places, assess the extent of the problem, and potentially gauge the effectiveness of control measures. Reports concerning the incidence rates of arthropod-borne virus/diseases and the relative risks to citizens are also produced. Currently, collections are made using both CDC light traps and gravid traps deployed simultaneously.

6.0 Mosquito Control Strategies

Human activities can greatly affect the ecology of mosquito populations. Large concentrations of people or animals, for example, can increase exposure rates and the probability of disease outbreak. The use of irrigation, development of drainage networks, elimination of mosquito predators, prevalence of improperly maintained birdbaths and other water holding containers can increase the numbers of certain types of mosquitoes. Expanding international trade and travel has increased the chance of introducing new mosquito species into our areas, as has happened with the Asian tiger mosquito (*Aedes albopictus*). The introduction of new diseases is also a concern, as has been seen recently with both Chikungunya and Zika viruses.

Mosquito control strategies have changed dramatically over the last few decades. Diesel oil, inorganic poisons, and source reduction using ditching operations were the basic tools of early mosquito control programs. Chlorinated hydrocarbons, organophosphates, pyrethroids, monomolecular oils, bacteria, and natural predators are more recent additions to mosquito control efforts. With the growth of ecological consciousness and environmental science, people began to realize the environmental damage that accompanied the use of broad-spectrum chemical control agents, particularly those that did not readily break down in nature. Concerns were also raised because many mosquito populations also appeared to develop resistance to the more commonly used chemical control agents.

Over the past few years, major advances have been made in the areas of biological mosquito control. Biological control strategies may include using natural predators like *Gambusia affinis* (Mosquito fish), fungi, protozoans, round worms, flat worms, and

bacterial agents such as *Bacillus thuringiensis israelensis* (Bti). Each biological control agent has certain benefits and restrictions. In order to use a biological control agent successfully, the applicator must have a basic knowledge of biology associated with the control agent. Some biological control mechanisms, for example, are limited by salinity, temperature, or organic pollution and some mosquito species are much more susceptible to specific types of biological control agents. All of these factors must be considered when choosing and applying biological control agents.

The perfect pesticide is one that is easily applied, reasonably inexpensive, not toxic to non-target organisms, and that eliminates the pest quickly before it becomes a threat. Although no single pesticide can combine all of these factors, certain types of *Bacillus* bacteria have been developed into pesticides that are very close to the perfect pesticide model. *Bacillus thuringiensis israelensis* (Bti), for example, is a naturally occurring soil bacterium that produces a poison capable of killing mosquito larvae. Bti is considered ideal for mosquito management because of its specificity for mosquito larvae and because of the minimal to no toxicity to non-target organisms. These bacteria form reproductive cells, called endospores, which enable them to survive in adverse conditions. The endospores of Bti also contain crystals of an insecticidal protein toxin called delta endotoxin. Once ingested by a mosquito, the alkaline conditions of the stomach dissolve the crystal and release the delta-endotoxin. The toxin has an affinity for the stomach wall lining causing the cells to first swell then rupture. When enough stomach cells burst, the mosquito larvae is unable to effectively digest food. Once affected, larvae stop eating and rapidly die. Currently, Bti is commercially available in powder, liquid, granular, capsule, and “briquette” formulations.

BTi is a registered pesticide. Agencies applying pesticides directly to waters of the United States, or where deposition may enter waters of the United States, are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit from the Texas Commission on Environmental Quality (TCEQ). This permit is titled “General Permit to Authorize Point Source Discharge of Biological Pesticides and Chemical Pesticides That Leave a Residue in Water”. Agencies must comply with all applicable provisions of this permit (see TCEQ General Permit TXG87000). The City of Denton complies with all requirements necessary to maintain the City’s permit under TXG87000.

6.1 Larviciding vs. Adulticiding

In the past, many mosquito control programs have relied heavily upon adult mosquito controls using chemical agents. In certain areas, routine mosquito spraying has been an integral component of control strategies. However, even near-continuous exposures to pesticides may not kill all mosquitoes. Those mosquitoes genetically able to resist higher pesticide concentrations may survive and pass on this resistance to future generations. Eventually, the pesticide becomes less effective as resistance increases in the mosquito populations.

Resistance can be minimized through the "Management by Moderation" approach. Management by moderation is an attempt to prevent the onset of resistance by:

- using doses that are no lower than the lowest recommended application rate to avoid genetic selection of resistance genes;
- using less frequent applications;
- using chemicals of short environmental persistence;
- avoiding the use of slow release formulations;
- avoiding using the same class of pesticides to control both adults and immature stages;
- applying pesticides to only hot spots. Area-wide treatments should only be considered during imminent public health threats;
- leaving certain generations, populations, or population segments untreated; and
- establishing action thresholds that accentuate control mechanisms other than chemical control of adult mosquitoes.

Although management by moderation is a viable means of minimizing resistance, there are other environmental and human health concerns associated with the application of pesticides for adult mosquito control. Routine mosquito spraying, for example, has the potential to expose the public to pesticides. Depending upon the pesticide used, effects on humans are possible and may be more likely for people who already suffer from asthma or other respiratory problems. If proper safety precautions are not followed, applicator personnel may also be in danger of overexposure. Managers must therefore decide whether mosquito populations and the related threat of disease transmission or the chemicals used to control mosquitoes represent the bigger threat to humans.

All mosquitoes begin their lives in water. Prime breeding sites include discarded tires left outdoors, poorly maintained bird baths, clogged rain gutters, unused swimming pools and plastic wading pools, pet dishes, or any other container capable of holding water for more than a few days. Mosquito breeding can therefore be prevented by either eliminating the source of water (source reduction) or by killing larvae (larviciding). Larviciding programs use a combination of source reduction, biological, and possibly chemical measures to control mosquito larvae before they develop into biting adults. If properly implemented, this strategy can be the most effective, economical and safest method for mosquito control because mosquito larvae are minimized, thus reducing the need for adult mosquito control and subsequently reducing the impacts of control measures on non-target organisms. Larviciding programs also offer the opportunity to use biological controls, which minimizes the impacts of the control program on non-target organisms and lessens the risk of chemical exposures to the public. Using biological controls also minimizes the chance of pesticide resistance in the mosquito populations. Experience suggests that the most effective and economical way to reduce mosquito populations is by larval source reduction through a locally funded abatement program. The goal of this program should be to monitor mosquito populations and initiate controls before diseases are transmitted to humans or domestic animals (CDC, 2001).

When larval control is not possible or when more immediate control measures are needed, adult mosquito control may be required to diminish populations of infected mosquitoes and interrupt viral transmission. Adult mosquito control products may be

applied using ground-based equipment, fixed wing aircraft, or helicopters. In all cases, products should be applied in ultralow volume (ULV) formulations and doses, and should be comprised of pyrethrins or pyrethroids.

6.2 Rationale for different treatment methods

Chemical usage should not be viewed as a long-term control strategy, and should be only implemented when there are occasional episodes of heavy uncontrolled breeding concurrent with a high degree of public health risk. This strategy is most appropriate because prolonged use might lead to the development of resistance in mosquito populations, thereby limiting overall management options (Tabashnik, 1990). The most efficient and effective program is one in which mosquito larvae are prevented from becoming biting adults through the use of biological control agents. The bacterium Bti or the related bacterium *Bacillus sphaericus* (Bs.) are considered to be the among the most environmentally acceptable commercially available biological control agents because of their relative specificity for mosquitoes and negligible toxicity for vertebrates (Rishikesh et al., 1983). Larvivorous fish can also be a valuable component of an integrated control program, either alone or together with chemical control agents (Walton et al., 1990; Walton and Mulla, 1991; Reed et al., 1995). For these reasons, the City of Denton relies heavily on source reduction and larviciding for mosquito control.

6.3 Integrated Pest Management

Integrated pest management dictates that control efforts should be dependent on threshold levels. This means simply that a certain defined risk needs to exist before particular control measures are recommended. Levels of risk are based on knowledge of mosquito biology, the epidemiology of the mosquito-borne diseases, and monitoring efforts for the status assessment of mosquitoes and / or mosquito-borne diseases. Risks levels are then used to design multi-tactic prevention and control program that are comprised of a system of tactics which are compatible with each other and which are proven for their effectiveness. Continual program evaluations and updates ensure that the best methods are being used to meet the prevention and control objectives of the program, and continued public education is used to create awareness, understanding, and support. Frequent mosquito population assessments allow analysts to map potential mosquito breeding grounds and determine overall disease transmission risks. Using this information, more targeted efforts towards habitat disruption, source reduction, larviciding operations, and other control mechanisms are possible.

7.0 Denton's Plan for Mosquito Control

The primary objective of mosquito control is to decrease the risk of mosquito-borne human diseases. This objective should be accomplished by:

- Stressing source reduction as a viable means of control, both by residents and on municipal properties, including enforcement actions for stagnant water located on private property;
- Aggressively larviciding where such activities are feasible, practical, and likely to be effective. This includes providing limited supplies of larvicides to citizens for use on private property.
- Promoting the use of personal mosquito protection measures, especially for the elderly and those individuals with compromised immune systems, through public education and outreach.
- Providing public information so that citizens are informed about the current Risk Level, areas of the City where WNV has been located, current municipal control measures, and what can be done by the public to help reduce risks.
- If warranted, implement adult mosquito control measures through targeted ULV pesticide applications (adulticiding).

7.1 Adulticiding

Adulticiding should and will be considered a supplemental control measure. The decision to spray shall be based on the conditions listed (in no particular order) below.

7.1.1 Triggers for adulticides: Adulticiding shall be considered only when there is evidence of WNV activity at a level suggesting a high probability of human infection. In general, finding an isolated WNV-positive mosquito pool does not by itself constitute evidence of an imminent threat to human health and does not warrant adulticiding.

Physicians and laboratories are required by Title 25 of the Texas Administrative Code (Pt. 1, Ch. 97, Subch A, §97.3) to report cases of WNV infection or positive test results in humans to the State and County Health Departments. Positive human WNV cases are investigated by Health Department officials. During an investigation, the Health Department collects demographic and clinical information from the patient and attempts to determine date of onset, whether the infection was acquired locally or from a region outside of the patient's residence, and whether the infection may have been acquired by a non-mosquito route of transmission such as a blood transfusion or organ transplant. To help aid control measures, the Health Department provides some of this information to municipal officials within the municipality where the patient resides. Human case information is used by municipal officials as one of the trigger conditions for the risk levels outlined in this plan

7.1.2 When to use adulticides: The goal of spraying is to reduce the risk of human diseases by decreasing the number of target adult mosquitoes as much as possible. However, today's pesticides tend to only be effective when physically contacting the mosquito, which is most likely to happen when mosquitoes are actively flying. This typically will mean that spraying should be conducted between dusk and dawn. Since the target mosquito, *Culex quinquefasciatus*, is thought to be most active soon after dusk, spraying should be timed to strike the best balance between impacting the target mosquito during its most active time and minimizing impacts on non-target organisms.

It is also important to realize that weather conditions, including air temperature and wind speed, have a large influence on the effectiveness of adulticides. Spray events should be cancelled and rescheduled if conditions are not conducive for effective spraying.

7.1.3 Where to use adulticides: The terrain of the proposed spraying area has a major impact on the pesticide effectiveness. Because pesticide application is typically conducted from a vehicle, if there is substantial vegetation, dense shrubbery, trees, hedges, or tall buildings, the density of the droplets from the ULV machine are substantially reduced over distance and pesticide applicationeffectiveness is reduced. Applications should be made so that the maximum penetration into these types of obstructions is achieved. In some cases, a mild breeze may be able to help distribute the pesticide. Application strategies should consider the meteorological conditions at the time of application, and use these conditions to help improve application effectiveness if possible.

7.1.4 Human population density considerations: The human population density in an area where there is evidence of intense epizootic activity should also be considered. If the area in question is rural and does not contain many people, the cost and potential risk associated with spraying may not justify its use. If the area in question is densely populated, adult mosquito control may be more justified as long as adequate precautionary measures are taken.

7.1.5 Mosquito population considerations: Information from mosquito surveillance can be helpful in determining when to conduct mosquito control and to assess the effectiveness of control measures. It is also important to know the numbers and species of the vector populations in specific localities. The best way to obtain this information is through mosquito trapping efforts. The City of Denton formed a partnership with the University of North Texas to provide the specially trained staff needed for systematic mosquito trapping efforts.

While trapping efforts are crucial for assessing mosquito populations and the prevalence of disease, it is important to realize that surveillance specimens requires some processing time after collection. In the time between the collection date and the date of test results, circumstances may have occurred which would alter a decision to spray. For example, weather conditions may have adversely affected mosquito populations, local mosquito habitats may have been altered, or larviciding efforts may have reduced the number of newly emerged adults. All of these occurrences may result in a reduced need to spray, and should be taken into consideration during control efforts.

Surveillance information should also be evaluated through time to determine the progress of diseases and the relative risk of disease transmission. Surveillance information may also be of some use in gauging the effectiveness of control measures, although establishing control effectiveness is difficult using only surveillance information. In all cases, the available surveillance information should be evaluated as a part of the decision making process for enacting adulticidal activities.

7.1.6 Local perspectives on spraying: Different communities have different perspectives on the benefits and risks associated with adulticiding activities. While these perspectives are valid and should be considered, individuals are likely to have strong opinions on either side of the issue. The City of Denton has incorporated a rationale framework within the mosquito control program that is designed to be protective of both human health and the environment. The decision to spray, however, is a complex issue that will likely be faced without complete information. Thus, there will be citizens that do not believe that the City of Denton has done a good job with regards to reducing public health and environmental risks, regardless of the decision. The mosquito control program should therefore remain flexible and should attempt to address citizen concerns through public education and dialogue.

7.1.7 Denton's plan for mosquito adulticiding operations

Once arbovirus activity is detected and the decision is made to implement mosquito control using adulticides, the size of the area to treat must be determined. Unfortunately, there is no simple formula for determining how large of an area to treat, nor is there adequate information to guide decisions about the degree of vector population suppression that must be attained, or for how long this suppression must be maintained to reduce the risk of disease. The CDC (2001) suggests considering the following factors where deciding the scope of the adulticiding effort:

- the general ecology of the area;
- the flight range of vectors that are known or are believed to be of importance in the area;
- the population density of the vectors;
- the length of time since virus-positive mosquito pools were collected;
- the potential risk to the human population (including the age demographics of the area) as well as the community perception of the relative risk of pesticides versus the risk of arbovirus infection; and
- the season of the year - how much time the transmission risk can be expected to persist until the vectors enter diapause;

It is very likely that some of these factors will be unknown or poorly known, and practical experience in conducting a mosquito control program is needed to refine control recommendations. If adulticiding operations are conducted, the following parameters should be monitored:

- Weather conditions during the application (temperature, wind speed, wind direction, etc.);
- Flow rate of Ultra-Low Volume applications; and
- Overall amount of pesticide applied.

If the application of adulticides is deemed necessary, the public must be informed. The following actions / activities will take place prior to adulticide applications:

- Information, including a map of the proposed spray area, will be released 24 hours in advance through the media and through the city of Denton web site. Under certain conditions in Public Park areas, applications may take place in less than 24 hours notice. For these cases, the facility will be closed to the public during, and a few hours after, application.
- Press releases should be prepared and shared with the appropriate media
- CodeRed, Reverse Utility automated calling systems, and available forms of social media should be used to inform citizens of spray events. CodeRed will make an automated phone call with a message to all individuals that have signed up for the service. The Reverse Utility automated calling system will make an automated phone call with a message to all individuals within an area designed by the spray map. For both systems, it is possible that some residents outside of the spray area will receive one of these calls. However, these systems are the most rapid and accurate means of notifying the public of upcoming spray events.
- If practical, street signs indicating that spraying will occur in the neighborhood should be placed at major roadways entering and exiting the targeted area.

7.2 Plan for Public Education Concerning Mosquitoes

Public education is a key component of a successful mosquito control program. Since the appearance of the West Nile Virus in the United States, the City of Denton has produced and aired many public service announcements, given numerous presentations, and provides information on the City web page concerning this disease. Depending somewhat on Risk level, the following key information will be conveyed to the public:

- The location of WNV positive mosquito trap locations and current risk level;
- Comprehensive prevention strategies and activities used by the City of Denton to address the threat of West Nile Virus;
- The public will be advised to eliminate standing water sites by removing all materials that can hold water for longer than 2-3 days; and
- The public will be informed about the symptoms of West Nile Virus (headache, high fever, muscle pain, weakness, and disorientation).

Techniques used to disseminate information may include any or all of the following:

- Televised public service announcements using Denton's local cable channel;
- Radio announcements;
- Brochures for public use placed in municipal buildings;
- Postings describing the current risk level placed in municipal buildings;
- Brochures and / or fact sheets to be distributed to community-based organizations, community boards, elected officials, schools, nursing homes, libraries, outdoor activity sites, etc.;

- Presentations to elected officials and / or community groups concerning the current risk level, mosquito population and disease status, and mosquito control activities; and
- Press releases describing West Nile virus response activities.

7.3 City of Denton Response Plan

The purpose of this response plan is to:

1. Minimize human illness through public education and targeted vector control.
2. Provide an assessment of virus transmission risk to humans that can be used to plan and adjust control activities.
3. Map the density of mosquitoes and the incidence of the virus within the City of Denton.
4. Identify areas where the incidence of disease is high and provide appropriate warnings to the citizens of Denton.
5. Identify the key vector species that carry diseases within Denton.

The prevention of West Nile virus, as with many diseases, is most efficiently accomplished by ensuring that prompt, accurate information reaches the public. If the appropriate information reaches the public in a timely manner, personal protective measures may be implemented, and control strategies can be enacted efficiently.

The City of Denton will provide continuous information on the city web page concerning West Nile virus, including a frequently asked questions (FAQs) section, disease symptoms, personal preventative measures, and sources of additional information. If a sampled mosquito pool tests positive for arthropod-borne virus/diseases, information describing the location of the sampling event, the date, and other pertinent information will be provided.

This response plan is partially based on Texas Department of Health recommendations. The plan is divided into 5 levels based on the risk of human disease. Each risk level is described below, along with specific recommended responses. In accordance with the principals of Integrated Pest Management Control measures are recommended for each level.

Generally, there are 4 surveillance / observational factors that are evaluated to determine if the trigger condition has been met for a particular risk level. These factors are:

1. Environmental / climatic conditions (mainly temperature, rainfall, and season)
2. Adult *Culex quinquefasciatus* abundance
3. Virus infection rates in *Culex quinquefasciatus* and other mosquito vectors
4 Confirmed infections in humans, including epidemiological information.

7.3.1 Risk level 1 - Normal Response

Condition: Probability of human outbreak is none or remote
Trigger: Normal mosquito activity with no evidence of arthropod-borne virus/disease detected during the past 3 years in vectors, humans, or other hosts.

Recommended Response:

Surveillance:
Surveillance is optional. Under the normal response, mosquitoes are considered to be only a nuisance without significant influences on public health. Complaint calls and informal surveys of larva and adults will be used to direct mosquito control efforts.

Public Information / Education:
Publicize methods for mosquito reduction and personal protection prior to the main season for mosquito activity and outdoor human activities.

Control Measures
Use public information to promote source reduction and personal protection. Conduct standard larviciding approaches using *Bacillus thuringiensis israelensis* (Bti) .

Rationale:
Larviciding and source reduction / elimination are considered to be the most effective long-term solutions for mosquito control. The control measures are designed to accomplish mosquito control by preventing larval mosquitoes from becoming biting adults.

7.3.2 Risk Level 2 - Enhanced Response

Condition: Probability of human outbreak is low
Trigger: Normal mosquito activity with <u>little or no</u> evidence of arthropod-borne virus/disease. Enhanced response level is due to recent historical presence of arthropod-borne virus/disease in vectors, humans, or other hosts within the vicinity of Denton (approximately 100 miles).

Recommended Response:

Surveillance:
Surveillance is optional, but strongly encouraged. If possible, conduct routine surveillance of adult mosquito populations using light traps baited with CO2 and gravid

traps (at minimum). Collected mosquito species should be identified to species level and mosquito pools should be screened for the presence of arboviruses. If positive tests are obtained during arthropod-borne virus/disease screening, additional tests should be performed to determine what type of arbovirus is present.

Public Information / Education:
Implement all steps for public information established by the Public Communication Office for this Risk Level. Generally, this will reflect routine public information concerning methods for mosquito reduction and the importance of personal protection measures. This information should be disseminated at the beginning of the mosquito season.

Control Measures
Use public information to promote source reduction and personal protection. Conduct standard larviciding approaches using *Bacillus thuringiensis israelensis* (Bti).

Rationale:
Larviciding and source reduction / elimination are considered to be the most effective long-term solutions for mosquito control. The control measures are designed to accomplish mosquito control by preventing larval mosquitoes from becoming biting adults.

7.3.3 Risk Level 3 - Public Health Concern

Condition: Probability of human outbreak is low to moderate
Trigger: Arthropod-borne virus/disease isolated from mosquitoes collected during trapping activities at a single monitoring site.

Recommended Response:

Surveillance:
Continue to conduct routine surveillance of mosquito populations. If resources allow, increase surveillance in the area where the positive sample was collected. Use geographic information systems to plot the location of the positive sample and provide this information to the public via the City of Denton web page.

Public Information / Education:

Implement all steps for public information established by the Public Communication Office for this Risk Level, which includes public notification, press releases, and City of Denton web page updates with a map of the positive trap location. Notify medical professionals, veterinarians, and all those registered with the City of Denton's various public notification options of the presence of the disease.

Control Measures

Use public information to promote source reduction and personal protection. Conduct enhanced larviciding using *Bacillus thuringiensis israelensis* (Bti). Increase efforts in areas where positive mosquito pools were detected. Control measures will be implemented based on the following IPM criteria: time of year, the extent of previous mosquito control activities, the current level of mosquito activity, weather conditions, and surveillance results.

Prepare for ground level spraying activities using ULV applications of pyrethriods. Ensure adequate funding and personnel are in place for conducting ULV applications.

Rationale:
Larviciding and source reduction / elimination are considered to be the most effective long-term solution for mosquito control. Increasing these measures in areas where positive mosquito pools are detected offers an additional degree of risk reduction.

7.3.4 Risk Level 4 - Public Health Warning

Condition: Probability of human outbreak is moderate to high
Trigger: Multiple mosquito pools collected at different times and locations test positive for arthropod-borne virus/diseases.
Single human case confirmed with laboratory testing

Recommended Response:

Surveillance:
Continue to conduct routine surveillance of mosquito populations. Increase surveillance in areas where WNV positive samples have been collected if resources are available. Use geographic information systems to plot the location of positive mosquito samples and provide this information to the public via the City of Denton web page.

Public Information / Education:

- Implement all steps for public information established by the Public Communication Office for this Risk Level, which includes public notification, press releases, and City of Denton web page updates with a map of the WNV positive trap location(s).
- Update web page map for all subsequent WNV positive trap locations
- Notify medical professionals, veterinarians, public health officials, and all those registered with the City of Denton's various public notification options of the presence of the disease.

Control Measures
Use public information to promote source reduction and personal protection. Intensify enhanced larviciding efforts using Bti in targeted areas. Consider using Spinosad products in areas where positive mosquito pools were detected, if applicable. Control

measures will be implemented based on the following IPM criteria: time of year, the extent of previous mosquito control activities, the current level of mosquito activity, weather conditions, and surveillance results.

Finalize all actions needed for implementing ground level spraying activities using ULV applications of pyrethroids

Rationale:
Larviciding and source reduction / elimination are considered to be the most effective long-term solutions for mosquito control. Increasing these measures in areas where positive mosquito pools are detected offers an additional degree of risk reduction.

7.3.5 Risk Level 5 - Public Health Alert

Condition: Human outbreak is confirmed
Trigger: Multiple human cases. Cases must be confirmed by laboratory testing.

Recommended Response:
Surveillance:
Continue to conduct routine surveillance of mosquito populations. If resources allow, increase surveillance in areas were arthropod-borne virus/disease positive samples were collected. Use geographic information systems to plot the location of WNV positive mosquito samples, and provide this information to the public.

Public Information/Education:

- Implement all steps for public information established by the Public Communication Office for this Risk Level, which includes public notification, press releases, and City of Denton web page updates with a map of the WNV positive trap location(s).
- Update web page map for all subsequent WNV positive trap locations
- Notify medical professionals, veterinarians, public health officials, and all those registered with the City of Denton's various public notification options of the presence of the disease.
- Increase public education, emphasizing source reduction, personal protection, and disease symptoms.

Control Measures:
Use public information to promote source reduction and personal protection. Intensify larviciding efforts using Bti in targeted areas. Additional larvicides containing IGRs or pesticides such as Spinosad may be applied at this time. Intensely treat standing water in

City Parks. If the threat to human health is considered imminent, consider targeted adulticide applications using ground-based Ultra-Low Volume (ULV) equipment. The decision to spray will be made by a Resolution of the City Council of Denton prior to the first application, for each mosquito season. Based on information available at the time of the Council decision, the Resolution may include specific requirements in addition those outlined in this plan. ULV applications should be implemented in the vicinity (approximately one mile) of areas where positive human cases were detected When ULV applications are initiated, notification will be provided to the public as outlined in Section 7.1. For further protecting non-targeted organisms and pollinators the option of excluding undeveloped properties and protected habitats from spraying would be considered if the efficacy of treatment is not compromised.

During 2020, the City of Denton utilized Merus 3.0®, an organic pyrethrin product not containing petroleum distillates. Natural pyrethrins are a botanical insecticide produced primarily by flowers from the chrysanthemum family. Merus 3.0® is Organic Review Materials Institute (OMRI) listed and meets National Organic Program (NOP) standards for adult mosquito control. The use of Merus 3.0®, or any organic-certified pesticides that may become available, would continue to be used as the preferred option for adulticiding operations in accordance with integrated pest management.

Control measures will be implemented based on the following IPM criteria: time of year, the extent of previous mosquito control activities, the current level of mosquito activity, weather conditions, the species of mosquitoes that test positive for disease, the number of local mosquito pools which test positively for disease, the likely time until a killing frost, the density of roads or other access to mosquito breeding grounds, and the density of human populations. Epidemiological data associated with reported human cases of WNV will also be considered. In general, if an area has been sprayed, that area will not be sprayed again in response to an additional human case unless the date of onset of the new case indicates exposure occurred after the previous spraying event. Areas will also not be sprayed in response to a reported human case if epidemiological information clearly indicates that exposure did not occur in the City of Denton. If public health emergencies are declared at the county or state level, the recommended responses associated with the declaration will take precedence over the control plan of the City of Denton.

Rationale:
Larviciding and source reduction/elimination are considered to be the most effective long-term solutions for mosquito control. Increasing these measures in areas where positive mosquito pools are detected offers an additional degree of risk reduction. However, at this Risk Level, applications of adulticides may be needed to rapidly reduce mosquito populations and halt disease transmission. The objective is to kill a high enough proportion of older adult mosquitoes to break the disease transmission cycle. If adult mosquito controls are implemented, the approaches for adulticiding outlined in this plan are effective and are designed to minimize adverse effects to the environment and non-target organisms.

8.0 Emerging Diseases

In recent years, mosquito-borne viruses from other areas of the world have caused outbreaks in the Western Hemisphere. In addition, mosquito-borne viruses that have been restricted to the tropics for the last several decades are beginning to move northwards, and could cause concerns for outbreaks in the southern portions of the United States.

8.1 Chikungunya, Zika, Dengue and California Seropositive viruses

Chikungunya virus, for example, has become firmly established in the Caribbean; two cases of locally-transmitted Chikungunya virus were observed in Florida in 2014 and one in Texas in 2015. Chikungunya virus disease became a nationally notifiable condition in 2015. Cases are reported to CDC by state and local health departments.
Dengue is a serious arboviral disease of the Americas, Asia and Africa that has become more common in south Texas and the Florida Keys in recent years.

Zika virus has been responsible for outbreaks in tropical areas throughout the world, and was found in 2015 for the first time in the Western Hemisphere. The rapid spread of this disease and the possibility of transmission from human to human without mosquito vectors is particularly troubling. To date, local transmission of Zika virus in Texas has only been documented in Brownsville. However, the City of Denton has experienced human cases of Zika virus, and has developed a response protocol in coordination with the Denton County Public Health Department to ensure that appropriate measures are taken to minimize the likelihood of transmission of the virus from the infected person to local mosquito populations.
The City of Denton also documented two cases of California Seropositive viruses (a group of viruses, some of which can cause human disease) in mosquito samples collected in 2016. These samples were later confirmed to be trivittatus virus. While all mammals including humans are capable of contracting trivittatus virus from the bite of an infected mosquito, this disease is predominately found in wildlife, and human cases are extremely rare. It is important to note that both Zika and trivitattus virus are spread by only a few species of mosquito, and control measures must be specifically targeted to these species. In response to these emerging concerns, City of Denton staff continues to work with local and State public health personnel to assess the risk of disease and coordinate responses.

Currently, emerging disease responses are documented within Standard Operating Procedures (SOPs) that are reviewed with local health officials and mosquito control experts on a regular basis. Modifications to the SOPs are possible more research is conducted on control strategies and risk minimization measures. As more information is collected and evaluated, it is likely that the City of Denton Mosquito Surveillance and Response Plan will be modified in the future to add information specific to these emerging diseases.

8.2 Corona Virus Disease 2019 (COVID-19)

Mosquitoes typically transmit blood borne illnesses. COVID-19 is part of the corona virus family and other members of this family are not transmitted through mosquitoes. COVID-19 is a respiratory virus primarily transmitted through sneezing and coughing, in addition to touching contaminated surfaces and then touching the face. Ongoing research is being conducted to determine if mosquitoes can infect humans with the virus.

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