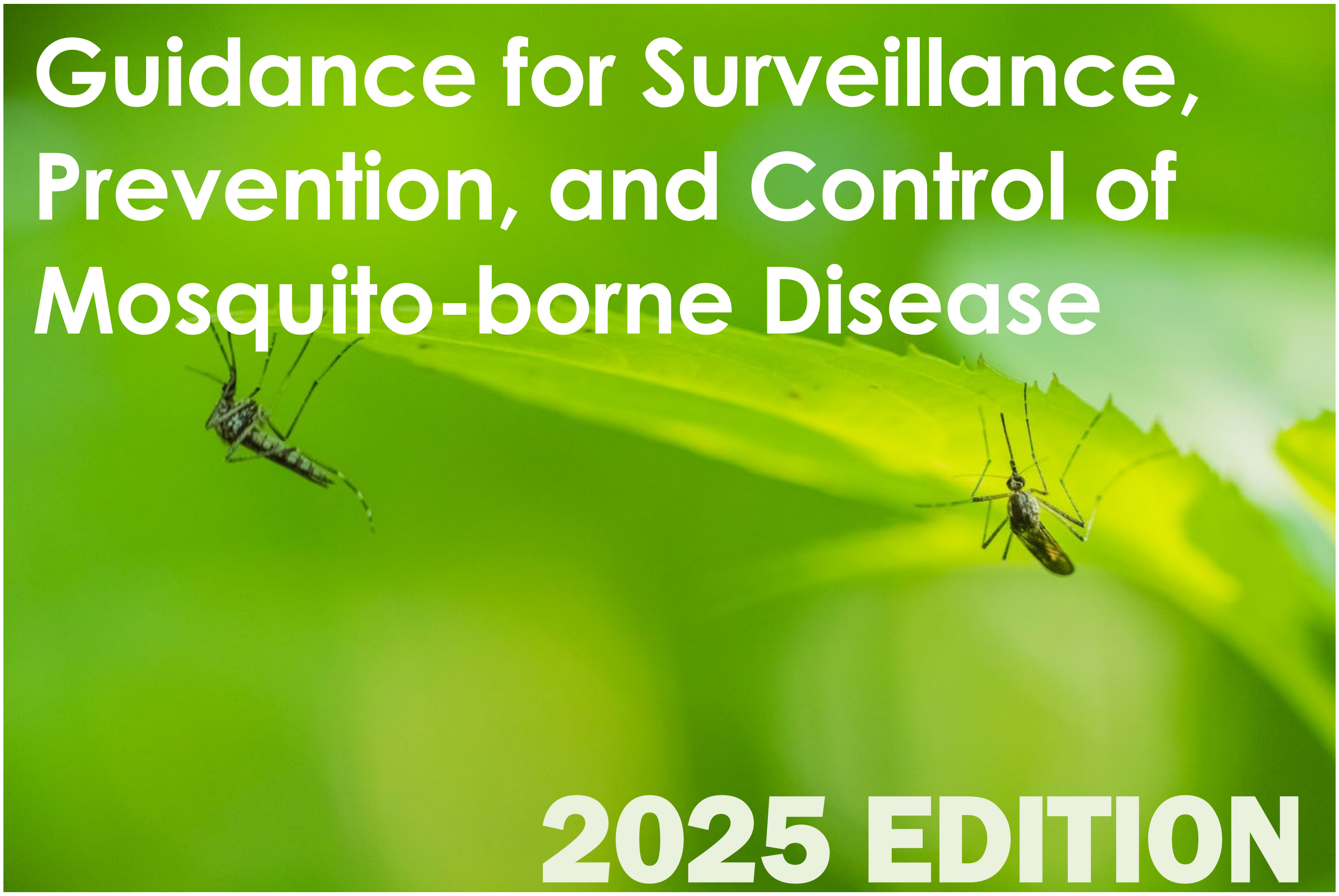
WASHINGTON STATE DEPARTMENT OF HEALTH

Guidance for Surveillance, Prevention, and Control of Mosquito-borne Disease



2025 EDITION

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DOH 333-149 2025

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Overview

Purpose

This document provides guidance for state and local agencies in Washington for surveillance, prevention, and control activities related to mosquito-borne viruses (arboviruses [**ar**thropod-**bo**rne **viruses**]). Detecting certain arboviruses in mosquito, animal or human populations requires prompt action to reduce risk of human and animal infection. This document is relevant for mosquito-borne arboviruses known to be endemic in Washington state (WA), with a focus on West Nile virus.

The appendices have detailed information on basic mosquito biology and habitat; surveillance techniques; mosquito control procedures; and arboviral infections in birds, equines, and humans.

Background

Arboviruses are maintained in nature through transmission among vertebrate hosts by blood-feeding arthropods (ticks, mosquitoes, psychodids, and ceratopogonids). Vertebrate infection occurs when an infected arthropod takes a blood meal. Arboviruses causing human disease are in four virus families: *Togaviridae* (genus *Alphavirus*), *Flaviviridae*, *Bunyaviridae, and Reoviridae*.

All arboviral encephalitides are zoonotic, maintained in life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. Some viruses are transmitted by more than one vector. Viruses may persist due to vertical transmission (from a female arthropod to her eggs). Humans and domestic animals may be infected by arboviruses but are usually "dead-end" hosts, not contributing to the transmission cycle.

Arboviral encephalitides occur globally with five main mosquito-borne diseases endemic in the United States (U.S.): eastern equine encephalitis (EEE), western equine encephalitis (WEE), St. Louis encephalitis (SLE), West Nile virus (WNV), and California encephalitis disease, which is caused by a group of related viruses (California serogroup viruses), including La Crosse virus. In WA, the most prominent mosquito-borne disease is WNV. Most, but not all, of these cases occur from June through September.

Most human arboviral infections are asymptomatic or manifest as a systemic febrile illness. Rarely, neuroinvasive disease occurs, including encephalitis or meningitis, which may cause permanent neurologic sequelae or death.

There are no effective antiviral drugs for arboviruses, so treatment is supportive. There are no commercial human vaccines for the U.S. arboviral diseases.

Western equine encephalitis (WEE) and Saint Louis encephalitis (SLE) both historically occurred in WA, with the earliest report of an encephalitis outbreak dating to 1923. These mosquito-borne disease outbreaks led to the creation of many of the current mosquito control districts (MCDs) in WA. Twenty mosquito control districts now operate in 14 counties, with 16 districts in eastern WA. These districts identify mosquito larval habitats, conduct larval and adult control, and educate the public on bite prevention and habitat reduction.

The geographic expansion of West Nile virus in the late 1990's and early 2000's resulted in surveillance activity increases. Washington State Department of Health (DOH) and its partners increased mosquito-borne disease surveillance in 2000. Under a cooperative agreement from the Centers for Disease Control and Prevention (CDC), DOH enhanced routine surveillance for human mosquito-borne diseases and established routine surveillance for infected mosquitoes and animals with local health jurisdictions, mosquito control districts, military installations, Washington Animal Disease Diagnostic Laboratory (WADDL), Washington Department of Agriculture (WSDA), and academic partners. A dead bird surveillance network was started to collect and test the most susceptible birds, primarily Corvids (crows, ravens, jays, magpies), and several MCDs maintained sentinel chicken flocks. Both sentinel flocks and dead bird surveillance programs were ended by 2019. Mosquito surveillance activities include mosquito pool identification and testing. Human mosquito-borne diseases surveillance includes passive surveillance through electronic laboratory reporting (ELR), active surveillance through syndromic surveillance data review, and occasional active surveillance conducted at the local level.

For current and historical WNV data see: https://www.doh.wa.gov/dataandstatisticalreports/diseasesandchronicconditions/westnilevirus.

Arboviral (arthropod-borne viral) diseases, including WNV infections, must be reported to local health jurisdictions in WA. For more information go to: https://doh.wa.gov/public-health-provider-resources/notifiable-conditions/arboviral-disease

Surveillance

Mosquito Surveillance

Mosquito surveillance is an essential component of a comprehensive mosquito-borne disease prevention and control program. The objective of such surveillance is to determine local species composition, geographic distribution, seasonal occurrence, and abundance of potential vectors of mosquito-borne pathogens to guide effective prevention and control.

An effective mosquito surveillance program includes identification of larval and adult habitats, data collection on mosquito population abundance and virus infection rates in those populations, and monitoring the effectiveness of vector control methods. Identification and mapping of larval mosquito habitats should be performed with ground-based and/or aerial methods. Surveillance locations should be established, and adult or larval mosquitoes identified to sex and species. Samples of adult female mosquitoes can be pooled by species and tested for the presence of mosquito-borne viruses, which helps determine potential enzootic and vector species in an area, as well as the vector index (VI). The VI is a measure of the intensity of virus transmission and provides a predictive index of human infection risk.

Mosquito surveillance in WA should typically begin in April or May and continue through September or early October, depending on location, weather conditions, and mosquito collection numbers. Collections should be made in a variety of habitats. Appendix A has information on basic mosquito biology and common habitats in WA. Appendix B has procedures for larval and adult surveillance. DOH's Public Health Entomologist is available to provide training on these topics.

Bird and Mammal Surveillance

Bird and mammal surveillance for mosquito-borne viruses may provide early or additional warning to allow for control actions to prevent human cases and reduce impacts on livestock, pets, and wildlife. Bird die-offs should be reported to Department of Fish and Wildlife (WDFW). WDFW determines whether collection and testing will be performed; positive results are returned to DOH and the affected jurisdiction. A comprehensive dead bird reporting system is not currently in use in WA. Appendix D has information on bird surveillance.

Several species of birds, both wild and domestic, have been used for mosquito-borne virus surveillance programs. Sentinel chicken flocks were historically used to monitor for mosquito-borne viruses but are not currently in use in WA.

Domestic mammal infections, especially equines (e.g., horses, donkeys) and camelids (e.g., llamas, alpacas), can also provide local information about mosquito-borne viruses. Unvaccinated horses have been found to be particularly susceptible to WNV. Veterinarians should consult WSDA about equine neurological disease of unknown origin to determine if the animal should be tested for mosquito-borne virus or for other neurological conditions such as rabies. Animals testing positive for WNV are reported from WSDA to DOH and then to the affected jurisdiction. Appendix D has more information on equine surveillance and vaccines.

Human Surveillance

Prevention and control of human disease is the primary goal of surveillance for mosquito-borne diseases. Due to the historical outbreaks of WEE and SLE in the Yakima Valley, surveillance for human arboviral infection has been long-standing in WA. The surveillance system relies on health care providers and laboratories for rapid reporting of suspected notifiable conditions, including arboviral infections. During months when mosquito activity is greatest, local health jurisdictions typically alert their health care community to be alert for potential WNV infections.

Guidelines for investigating and reporting WNV can be found at: https://doh.wa.gov/sites/default/files/legacy/Documents/5100/420-085-Guideline-WNV.pdf?uid=642f0973bdd5b

Guidelines for investigating and reporting suspected human arboviral infections other than WNV or yellow fever can be found at: https://doh.wa.gov/sites/default/files/legacy/Documents/5100/420-046-Guideline-Arbo.pdf

Prevention and Public Information

Enhanced public awareness, prevention education, and informing health care providers are important components of an effective mosquito-borne disease prevention program.

A public health education campaign about mosquitoes and mosquito-borne diseases should accomplish the following objectives:

- Encourage personal protection techniques, such as restricting outdoor activities when mosquitoes are active (dusk to dawn), as well as wearing long-sleeved shirts and long pants, treating clothing and gear with permethrin to kill or repel mosquitoes, using an effective mosquito repellent (contains an active ingredient that has been registered with the U.S. Environmental Protection Agency [EPA]), and using window and door screens to keep mosquitoes outside.
- Inform the public about how to reduce mosquito habitat by eliminating or covering stagnant water on privately owned property.
- Improve public and healthcare provider understanding of the mosquito-borne disease cycle and its sources and reservoirs in mosquitoes, birds, and mammals.
- Increase awareness among the public and health professionals of the potential risk for infection with mosquito-borne disease locally and when traveling to other areas.
- Improve knowledge among health care providers of the signs and symptoms of human arboviral disease, and encourage correct diagnosis and prompt reporting of notifiable human disease cases to public health.

Mosquito Control

Prevention and control of mosquito-borne disease is accomplished most effectively through a comprehensive, integrated pest management approach that minimizes public exposure to substances used for control. Programs are not intended to eliminate all mosquitoes, but rather reduce their numbers and thereby reduce the risk of disease transmission. Methods to reduce mosquito populations include reducing the available habitat for larval mosquito development and control of both mosquito larvae and adult mosquito populations.

Habitat reduction efforts focus on modifying or eliminating larval habitats by reducing flooding or minimizing standing water in irrigated areas. Other activities may involve management of impounded water or open marshes to reduce production and survival of the floodwater mosquitoes. Additional steps are maintaining or draining pools, tubs, water troughs, and birdbaths, cleaning roof gutters, and eliminating water-filled containers, such as buckets, plant saucers, cans, and tires. Pumps or fountains in landscape ponds can prevent water stagnation. Fish that eat mosquito larvae may be added to contained ponds, but selected fish species should not be those which damage native species. Contact the Washington Department of Fish and Wildlife (WDFW) and review applicable laws and regulations (Chapter 220-640 WAC) before introducing any fish into aquatic environments.

When habitat reduction or water management is not feasible, or these measures fail to adequately control mosquito populations, chemical or biological control may be required. Treatments may be directed at various life stages.

Larviciding— using chemicals to kill mosquito larvae or pupae in the water— is generally more effective and target-specific than applying chemicals to kill adult mosquitoes (adulticiding), but less permanent than habitat reduction. Selection of larvicide products must be appropriate for the habitat being treated, accurately applied, and based on surveillance data. Appendix C has detailed information on larval control compounds.

Adulticiding is usually the least efficient mosquito control technique and is the last line of defense in reducing mosquito populations. Insecticide selection and time of application should be based on the distribution and behavior of the target mosquito species. Appendix C has additional information and considerations for using adultices.

Roles and Activities

Local Health Jurisdictions

LHJs have the authority to take measures to control and eliminate mosquitoes to prevent and control diseases transmitted by mosquitoes (RCWs 70.05.060 and 70.05.070). Local health jurisdictions with available resources may support routine mosquito-borne disease surveillance, prevention, and education programs. Activities may include:

- Developing response plans for a mosquito-borne disease outbreak.
- Identification of departments within the local health jurisdiction or organizations external to the LHJ with capabilities to conduct larval and adult mosquito control.
- Seasonal larval surveillance, which may include finding, mapping, and characterizing mosquito habitats, collecting mosquito larvae from these habitats, and submitting samples for identification of species.
- Seasonal adult surveillance, which may include collection and submission of adult mosquitoes for identification of species and, if possible, for pooling of females to test for mosquito-borne virus.
- Recording of data collected from mosquito surveillance and testing and submission to WASurv.
- Facilitation and coordination of larvicide and adulticide use.
- Education of local governing bodies about mosquito control districts.
- Human and equine case surveillance in cooperation with physicians and WSDA, including active surveillance.
- Seasonal public information and education campaigns as appropriate for the level of mosquito and disease activity.

Counties and Municipalities

These governmental entities, under their broad powers to provide for the public health and safety, can generally undertake mosquito control measures on lands and bodies of water under their control, including larviciding and adulticiding when indicated, with proper licensing and permits (Washington Constitution Article XI, Section II; Titles 35, 35A, and 36 RCW).

Counties and municipalities must cooperate with state mosquito control plans (RCW 70.22.060).

Mosquito Control Districts

MCDs, funded through tax levies and operating under RCW Chapter 17.28 may take all necessary steps to exterminate mosquitoes and abate breeding places for mosquitoes. The county or city in which they exist has oversight. Mosquito control districts may provide larviciding and adulticiding and can enter without hindrance any land within the district to inspect to ascertain if there are mosquito breeding places. Mosquito control districts may act to assist local health jurisdictions with:

- Collecting and identifying mosquitoes, as well as testing for pathogens.
- Mapping mosquito habitat and location of disease vector species.
- Working with local health jurisdictions, cities, and counties to facilitate or provide mosquito control.
- Directing private property owners to control mosquitoes on their land, and under certain circumstances cause such control to occur at the owner's expense.

United States Department of Agriculture (USDA)

USDA issues permits for the sale and distribution of veterinary biologics, including fully licensed WNV equine vaccines available through licensed veterinarians.

Washington State Department of Health

DOH has the authority to conduct studies to determine the effect of mosquitoes as a health hazard (RCW 70.22.020) including larval or adult mosquito control, if funds are available. DOH can provide assistance to:

- Train on surveillance and mosquito control potentially including on-site consultation.
- Identify and map mosquito breeding habitat and consult on locations for mosquito surveillance.
- Consult on techniques for adult and larval mosquito surveillance.
- Speciate mosquitoes.
- Conduct laboratory testing for arbovirus detection in mosquitoes.
- Support data management through WASurv.
- Share public information messages, news releases, and web pages.
- Provide statewide surveillance data on mosquitoes collected through local health jurisdictions and other partners.
- Develop plans for response to a mosquito-borne disease outbreak.
- DOH will facilitate coordination if outbreak conditions cross jurisdictions. During outbreaks, the Secretary of Health may request that the Governor declare a public health emergency (RCW 70.22.030).

Washington State Department of Ecology

The Department of Ecology is required by law to protect the waters of the state from actions that might pollute or harm them. Application of pesticides to waterways is allowed under the National Pollution Discharge Elimination System (NPDES) Permit and is administered by the Department of Ecology; an NPDES permit is required to apply pesticides for aquatic mosquito control.

Washington State Department of Agriculture

WSDA regulates labeling and registration of pesticides used in WA and has authority over the applicators of pesticides through licensing. Except for limited homeowner applications of some pesticides available at the retail level, an applicator of larvicides or adulticides must possess an applicator's license. WSDA also enforces animal disease reporting requirements for veterinarians, veterinary laboratories, and others

(Chapter 16-70 WAC). WSDA is the lead state agency for WNV response in equines but is required to immediately report cases to DOH (WAC 246-101-805).

Washington State Department of Fish and Wildlife

WDFW addresses concerns with potential impacts of WNV on bird populations and effects of mosquito control activities on wildlife populations including introduction of species (e.g., releasing fish that eat mosquito larvae).

Washington Parks and Recreation Commission

The Washington Parks and Recreation Commission protects the health and safety of park visitors and park employees. The agency may apply appropriate insect management controls.

Washington State Department of Transportation

The Department of Transportation has authority over larval control measures for vector mosquitoes located in Department of Transportation rights-of-way.

Guidelines for a Phased Response

The main goal of a phased response is to minimize the health impacts of mosquito-borne diseases in humans and animals, including livestock, pets, zoo and aquarium collections, and wildlife. Mosquito-borne diseases occur sporadically, so prevention and control measures, even when intensive, likely cannot avert all mosquito-borne infections in humans. However, surveillance results can provide risk estimates and help prevent human and animal cases of mosquito-borne disease with appropriate and timely response measures such as mosquito control and public education.

The following table provides guidelines for surveillance, education, and control strategies of WNV informed by risk modeling. Four surveillance factors are measured and analyzed within a defined spatial area (e.g., county or control district boundaries) to determine risk level for human infection with WNV, and thereby gauge the appropriate public health response level: environmental or climactic factors (temperature, rainfall), adult *Culex* vector abundance, virus infection rate in *Culex* vectors, and infections in humans and equines. Each factor is scored on an ordinal scale from 0 (lowest risk) to 4 (highest risk). The mean score calculated from these factors corresponds to a response level.

Depending on surveillance data, known mosquito habitat, population centers, availability of resources, prior experience with mosquito-borne diseases, and other factors, counties or areas within counties may choose to use different control responses and may step up public health responses at different points.

Specific and detailed recommendations will not fit all possible scenarios. Therefore, public health action should be flexible and rely on interpreting the best available surveillance data in an area. In addition, consider the following factors for developing a plan of action:

- Current weather and predicted climate anomalies.
- Quality, availability, and timeliness of surveillance data.
- Flexibility of the planned prevention and control activities, given existing budget, infrastructure and resources.
- Public acceptance of planned prevention and control strategies.

- Expected duration of WNV transmission (e.g., viral activity detected earlier in the transmission season will generally have greater significance).
- Other ongoing mosquito control activities, such as nuisance mosquito control or vector mosquito control.

WNV Phased Response Informed by Risk Modeling

Risk Levels for a Phased Response				
Risk Level 0: Remote/no risk of human outbreak	**Risk Level 1:** Low risk of human outbreak	**Risk Level 2:** Moderate risk of human outbreak	**Risk Level 3:** High risk of human outbreak	**Risk Level 4:** Epidemic conditions
Calculated risk score 0 – < 1 Contributing factors in the defined spatial area: • Off-season (no mosquito activity) • Climate unsuitable (average daily temperature in prior 2 weeks <56⁰F) • Adult vectors inactive • Vector abundance in the prior 2 weeks ≤ 50% of 5-year average for the same period. • No positive mosquito pools (MIR[1] = 0) • No human or animal cases	*Calculated risk score 1 – < 2* Contributing factors in the defined spatial area: • Average daily temperature in prior 2 weeks between 56⁰F and 65⁰F • Vector abundance in the prior 2 weeks below 5-year average for the same period (51-90% of average) • Fewer than one WNV-positive vector pool per 1,000 vector mosquitoes tested (MIR = 0.1-1.0)) • No human or animal cases	*Calculated risk score 2 – < 3* Contributing factors in the defined spatial area: • Average daily temperature in prior 2 weeks between 66ºF and 72ºF • Vector abundance in the prior 2 weeks at or below 5-year average for the same period (91-150% of average) • One or more WNV-positive vector pools detected per 1,000 vector mosquitoes tested (MIR = 1.1 – 2.0) • One locally-exposed human or equine case in a neighboring county or area	*Calculated risk score 3 – < 4* Contributing factors in the defined spatial area: • Average daily temperature in prior 2 weeks between 73ºF and 79ºF • Vector abundance in the prior 2 weeks above 5-year average for the same period (151-300% of average) • Multiple WNV-positive vector pools detected per 1,000 vector mosquitoes tested (MIR between 2.1 and 5) • One locally-exposed human or equine case in county or area • Multiple locally-exposed human or equine cases in neighboring counties or areas	*Calculated risk score ≥4.0* Contributing factors in the defined spatial area: • Average daily temperature in prior 2 weeks above 79ºF • Vector abundance in the prior 2 weeks above 5-year average for the same period (>300% of average) • High numbers of WNV-positive vector pools detected per 1,000 vector mosquitoes tested (MIR > 5) • Multiple locally-exposed human or animal cases in county or area

[1] Minimum infection rate, the number of positive pools divided by the number of mosquitoes tested; expressed as per 1,000 female mosquitoes tested.

Risk Level 0: Remote/no risk of human outbreak			
Surveillance Response	**Mosquito Control Response**	**Communications**	**Public Message**
LHJs, MCDs, and other local entities[1]: • Analyze environmental surveillance results from previous season. • Conduct ongoing surveillance and investigation of human mosquito-borne diseases. • Review and update mosquito surveillance plans for coming season. • Secure equipment, materials, funding and other resources. **DOH:** • Coordinate the statewide WNV surveillance program. Secure resources and plan for laboratory testing of mosquitoes. • Clean statewide surveillance data in WASurv. • Produce annual statewide and jurisdiction-specific surveillance reports. • Submit all final data to CDC ArboNet. • Update statewide protocols and training materials for mosquito surveillance. • Provide training, technical assistance, consultation, and coordination as needed.	**LHJs, MCDs, and other local entities:** • Secure resources necessary to enable appropriate control response. • Obtain necessary licenses and permits required for mosquito control. • Establish mosquito control contracts with private organizations as needed. **DOH:** • Assist LHJs and MCDs with securing control resources.	**LHJs, MCDs, and other local entities:** • Evaluate effectiveness of previous educational materials, review and update local communications plans for the coming season. • Facilitate planning and coordination among local partners, including municipalities, MCDs, and other local and regional organizations. • Develop partnerships with media and work with community leaders, local partners, and organizations on education for the general public through targeted prevention messages. • Alert DOH to gaps in local surveillance, education, and control plans. **DOH:** • Review and update statewide communications plans for the coming season. • Develop updated educational materials. • Maintain a website with current information on environmental and human surveillance in Washington. • Provide technical assistance, consultation, and coordination, as needed, for the development of local plans. • Hotwash/feedback to surveillance partners.	• Prevent mosquito bites during travel.
[1] Includes municipalities, mosquito control districts, and other local and regional agencies and organizations.			

Risk Level 1: Low risk of human outbreak			
Surveillance Response	**Mosquito Control Response**	**Communications**	**Public Message**
LHJs, MCDs, and other local entities: • Initiate or wind down mosquito surveillance and record & report results to WASurv. Report positive detections to DOH in real time. • Identify mosquito species and test for disease or submit to PHL for identification and testing. • Ongoing surveillance and investigation of human mosquito-borne diseases **DOH:** • Coordinate with local partners, laboratories, and other contracted services for statewide mosquito collection, identification, and testing. • Coordinate mosquito data collection and reporting to CDC. • Provide information to health care providers and veterinarians on recognition, diagnosis, laboratory testing, and reporting of mosquito-borne diseases. • Provide training, technical assistance, consultation, and coordination as needed. • Track occurrence of human or animal cases.	**LHJs, MCDs, and other local entities:** • Promote removal of mosquito larval habitat where possible. • Follow local response plans that include guidelines for conducting mosquito control using integrated pest management principles. • Consider promoting the use of mosquito larvicides at specific locations identified as having potential amplifying and bridge vectors species present and where larval counts meet or exceed an established level. **DOH:** • Provide training, technical assistance, consultation, and coordination as needed.	**LHJs, MCDs, and other local entities:** • Alert DOH to gaps in local surveillance, education, and control plans under changing conditions. • Conduct community outreach and public education emphasizing source reduction • Identify high risk populations (+60 years old, immune compromised, significant outdoor exposure) and locations (outdoor venues used in the evening hours) for targeted messaging. **DOH:** • Provide technical assistance and coordination, as needed, for development and implementation of local plans. • Alert local health to existing, updated, and new educational materials available for statewide use.	• Promote Source reduction • Encourage use of insect repellent and protective clothing (long sleeved shirts, long pants, tall socks)

Risk Level 2: Moderate risk of human outbreak			
Surveillance Response	**Mosquito Control Response**	**Communications**	**Public Message**
LHJs, MCDs, and other local entities: • Continue surveillance activities described in Alert Level 1. • Enhance mosquito surveillance as necessary – increase larval surveillance, expand surveillance in areas of positive findings and in adjacent areas, and test more vector mosquito pools. • Inventory and map surveillance findings and new mosquito habitats in areas with positive findings and in adjacent areas to identify water body sources where mosquitoes develop. **DOH:** • Continue coordination of the statewide WNV monitoring system and other activities, as described above. • Provide training, technical assistance, consultation, and coordination as needed. • Support expansion of targeted surveillance in locations with positive mosquito or human detections.	**LHJs, MCDs, and other local entities:** • Continue control activities described in Alert Level 1. • Continue larval control efforts. Promote expanded larval control and source reduction, including in areas adjacent to those with mosquito-borne disease activity. • Consider implementing adult control[1]. • Focus control efforts where surveillance indicates potential for human risk to increase. **DOH:** • Provide training, technical assistance, consultation, and coordination as needed.	**LHJs, MCDs, and other local entities:** • Continue communications activities described in Alert Level 1. • Consider expanding public information using TV, radio, and newspaper media. • Engage local leaders and organizations to inform their communities about mosquito-borne diseases. • Ensure culturally and linguistically appropriate materials for target populations **DOH:** • Continue communications activities described in Alert Level 1. • Assist with development/distribution of culturally and linguistically appropriate materials through appropriate organizations.	• Emphasize personal protection/bite prevention, particularly for persons over 60 years of age, the immunocompromised, and people with significant outdoor exposure. • Emphasize source reduction. • If spraying insecticide that targets adult mosquitoes (adulticiding) becomes necessary, provide information for the public and those who might be impacted (include information about products being used, their safety, and environmental concerns).

1 In general, detection of a positive mosquito pool is not evidence of an imminent threat to human health. Consider adulticiding only after taking into account multiple factors, including: documentation of the presence of mosquito-borne viruses in the area, abundance and species of the mosquito populations, mosquito minimum infection rate (MIR), density and proximity of human populations, time of year and weather conditions, accessibility to the area where the mosquito vector is located, rapidity of the response required as determined by the seriousness of the public health threat, potential impact on people and the environment.

Risk Level 3: High risk of human outbreak			
Surveillance Response	**Mosquito Control Response**	**Communications**	**Public Message**
LHJs, MCDs, and other local entities: • Continue surveillance activities described in Alert Level 2. • Consider active surveillance for persons hospitalized with mosquito-borne infections. **DOH:** • Continue coordination of the statewide WNV monitoring system, as described above. • Continue other surveillance activities described in Alert Level 2. • Provide training, technical assistance, consultation, and coordination as needed. • Consider expanded use of syndromic surveillance data to detect additional arboviral disease cases.	**LHJs, MCDs, and other local entities:** • Continue control activities described in Alert Level 2. • Continue larval control efforts. • Implementation of adult mosquito control, targeted at areas of potential human risk. • If feasible, monitor the effectiveness of spraying on target mosquito populations if adulticides are used. **DOH:** • Provide training, technical assistance, consultation, and coordination as needed.	**LHJs, MCDs, and other local entities:** • Continue communications activities as in Alert Level 2. • Increase visibility of public messages, official press release (or at first human detection). • Consider door to door messaging in areas where high MIR or human cases detected. • Communicate with employers of high-risk workers, ensuring occupational precautions. • Maximize visibility of public education through mass media and use of local leaders and organizations to target information for identified high risk groups and areas. **DOH:** • Continue communications activities as in Alert Level 2. • Publish press release if 1) outcome of case is death or 2) first case of the season and LHJ does not plan a press release. • Assist LHJs and MCDs at request.	• Promote clear messages, i.e. Take precautions now, the risk is high! • Emphasize that mosquito populations are peaking. • If spraying insecticide that targets adult mosquitoes (adulticiding) becomes necessary, provide information for the public and those who might be impacted (include information about products being used, their safety, and environmental concerns)

Risk Level 4: Epidemic conditions			
Surveillance Response	**Mosquito Control Response**	**Communications**	**Public Message**
LHJs, MCDs, and other local entities: • Continue surveillance activities described in Alert Level 3. • Broaden geographic area of mosquito surveillance. • Active surveillance for persons hospitalized with mosquito-borne infections. **DOH:** • Continue coordination of the statewide WNV monitoring system, as described above. • Continue other surveillance activities described in Alert Level 3. • Plan coordinated response with state and local emergency response teams	**LHJs, MCDs, and other local entities:** • Continue control activities described in Alert Level 3. • Consider intensifying adult mosquito control program by widespread application of low-volume adulticides and repeat adulticide applications in areas of high risk or human cases. • Monitor efficacy of spraying on target mosquito populations. • If outbreak is widespread and covers multiple jurisdictions, consider a coordinated, widespread aerial adulticide application. **DOH:** • Provide training, technical assistance, consultation, and coordination as needed.	**LHJs, MCDs, and other local entities:** • Continue communications activities described in Alert Level 3. • Emphasize urgency of personal protection through community leaders and media. • Emphasize use of repellents at visible public events. **DOH:** • Continue communications activities described in Alert Level 3. • Issue provider health alerts • ZD Program alerts internal DOH partners that one or more LHJs are experiencing an outbreak in progress.	• Promote clear messages, i.e.: Take precautions now, the risk is very high! • Emphasize that mosquito populations are at their peak. • If spraying insecticide that targets adult mosquitoes (adulticiding) becomes necessary, provide information for the public and those who might be impacted (include information about products being used, their safety, and environmental concerns)

Appendix A: Mosquito Biology

Basic Mosquito Information

Basic Mosquito Biology

Mosquitoes are insects in the order Diptera, the "true flies". Their mouthparts form a long, piercing-sucking proboscis. Only female mosquitoes take a blood meal, to nourish their eggs. Male mouthparts are not able to pierce skin.

The mosquito has four distinct life cycle stages: egg, larva, pupa, and adult. Stages lasts 7 days to a month or longer. All stages but pupae can over-winter. Adults hibernate in basements, culverts, mines, or other protected areas. Larvae over-winter in permanent pools or containers of water. Eggs in soil near rivers or in flood plains hatch when flooded, even several years later.

Of the over 3,000 species of mosquitoes globally, 174 species and subspecies occur in North America; about 50 species have been identified in Washington with genera including *Aedes, Culex, Culiseta, Anopheles*, *Coquillettidia*, and *Orthopodomyia.*

Egg

Eggs are laid singly (*Anopheles*), in rafts on the water surface (*Coquillettidia*, *Culex, Culiseta*), or singly on damp soil subject to flooding (*Aedes*). Eggs may be laid in tree holes (*Orthopodomyia*), old tires, wading pools, or clogged gutters. Most eggs hatch into larvae within 48 hours, but eggs laid on soil need to be flooded.

Larva

Larvae, or "wigglers," live in water, eating aquatic microorganisms and organic matter. They molt skin four times, growing larger each time; between molts they are termed instars. The larval stage usually lasts 7-14 days. Larvae of most species hang from the surface by with an air tube.

Pupa

Pupae, also called "tumblers," do not feed. After one to four days, the pupal case splits and the adult mosquito emerges.

Adult

The average life span of an adult mosquito is one to two months. Flight range is usually up to two miles but can be up to 20 miles. Both female and male adults feed on nectar. Females must also seek a blood meal to produce eggs. Mating usually takes place before the blood meal.

Mosquito Life Cycle

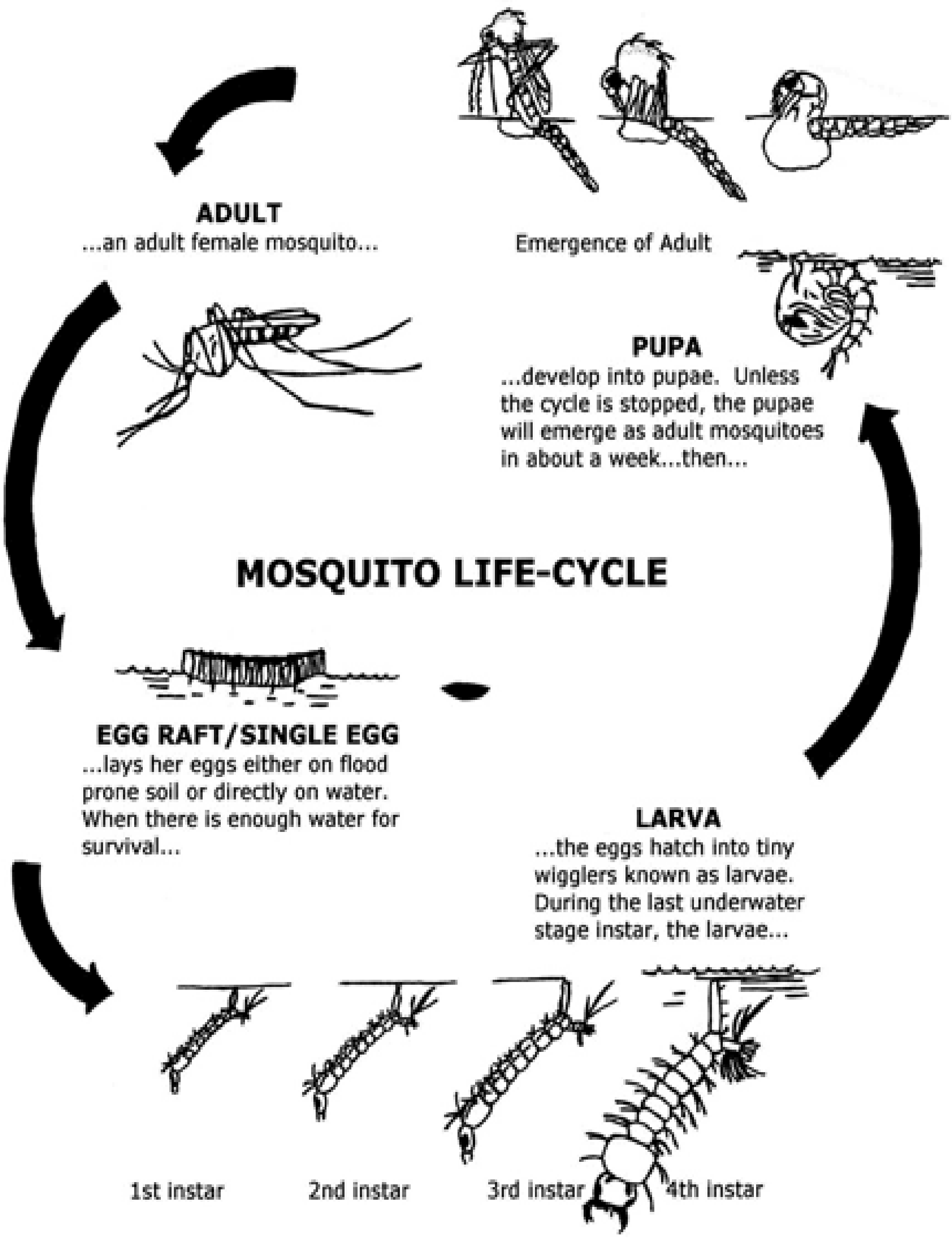

Image Credit: West Umatilla Vector Control District

Principles for Identifying Mosquitoes

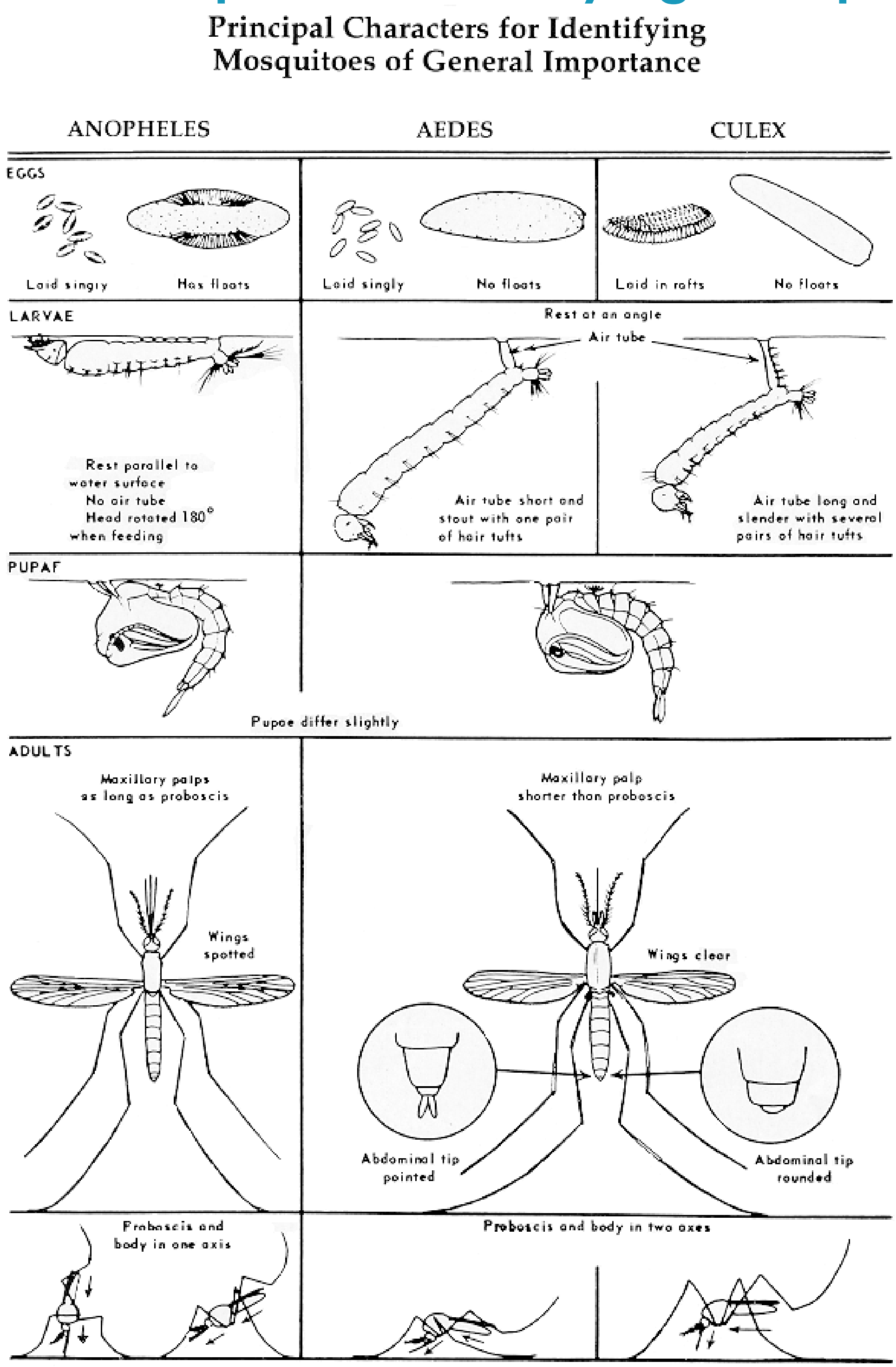

Image Credit: Kent S. Littig, Chester J. Stojanovich; Characteristics of Anophelines and Culicines

Mosquito Habitats in Washington

Mosquitoes that breed in permanent or semi-permanent pools will usually be found in most localities. In some areas mosquitoes occur due to floodwater, irrigation, or ponds and artificial containers.

Floodwater

Aedes vexans and *Ae. sticticus* develop in large numbers along the flood plains of the Columbia River and other rivers. Larvae hatch in the spring or early summer when streams flood lowlands where eggs were laid. When temperatures are below 45°-50°F the eggs of these species are dormant so only some of the eggs hatch after a spring flood.

Successive river rises may occur. The first hatch may produce females laying eggs that hatch in later rises of the river along with previously laid eggs. Eggs not flooded may remain viable for up to four years until flooded.

Aedes vexans and *Ae. sticticus* breeding areas have been partly managed by controlling water levels above the Bonneville Dam. Dikes prevent flooding in other areas. Clearing brush may have value. However, control of floodwater habitats may require insecticides targeting larvae or adult mosquitoes.

Irrigation Water

Mosquito numbers can be high with uncontrolled irrigation and flooded pasture lands that provides breeding places. *Aedes dorsalis*, *Ae. melanimon, Ae. nigromaculis*, and *Ae. vexans* are the most important species that may develop if water stands 7 to 10 days. Other species such as *Culex tarsalis*, *Culiseta inornata*, and *Anopheles freeborni* occur if water stands for longer periods. Insecticide applications to control larvae or adults do not replace proper irrigation water management. Insecticides may be needed for larval habitats that cannot be drained.

Tidal Waters

Aedes dorsalis is the only species in the Northwest that readily breeds in both fresh and brackish water. In some coastal areas the larvae develop in potholes filled by higher tides or where sea-level create permanent or semi-permanent seawater pools. Leveling, drainage, and similar practices prevent mosquito breeding, but treated areas must be properly maintained. Insecticide control of the larvae or adults may be necessary if these methods are ineffective. *Aedes togoi* has been found in coastal San Juan, Island, Skagit, and Whatcom counties. This species prefers rock holes just above the high tide line.

Snow Water

In many high mountain meadows, and also at lower levels, mosquitoes breed in pools caused by snow melt. *Aedes communis, Ae. cinereus, Ae. hexodontus, Ae. aboriginis, Ae. fitchii,* and *Ae. increpitus* are the most common species in these locations. Development may require several weeks at high elevations. Usually there is only one generation a year, but the large numbers produced are a severe annoyance to those working or seeking recreation in these areas.

Elimination of breeding areas by drainage or maintenance of constant water levels is practical in some situations. Insecticide applications may need to be made on foot or by plane in some areas because of inaccessibility for heavy ground equipment.

Ponds and Artificial Containers

Mosquitoes that lay their eggs on the water are usually found where water is present continuously for at least several days during the breeding season. Such locations include natural permanent ponds, log ponds, semi-permanent ponds of various types, and artificial containers. *Culex tarsalis*, *Cx. pipiens*, *Cx. stigmatasoma*, *An. freeborni*, *An. punctipennis*, *Cs. incidens*, and *Cs. inornata* are commonly found in such places. *Culex tarsalis* and *Cx. pipiens* develop in large numbers in log ponds. *Cx. pipiens* also develops in large numbers in sewer drains, catch basins, and water left in artificial containers. *Coquillettidia perturbans* is found in permanent water in swamps and marshes that have emergent or floating vegetation.

Insecticides are often effective in controlling most of these species, except for those breeding in artificial containers. Water standing in barrels, cans, old tires, and other receptacles should be emptied. Larvae of *Coquillettidia perturbans* are difficult to control because they attach to the roots of plants. Eliminating host plants, if possible, or using slow release insecticide briquets are methods that have shown to be effective in controlling this species.

Select Mosquito Species in Washington

The following mosquitoes are commonly found in Washington. West Nile virus has been isolated and/or WNV ribonucleic acid (RNA) has been detected in several of these species. The results only indicate that the species has come into contact with the West Nile transmission cycle, but not that it is a competent vector. Mosquitoes may help amplify the virus or be competent vectors able to transmit disease to animals other than birds. Based on information from Washington and other parts of the country, of the species below, Cx. *pipiens* and Cx. *tarsalis* are considered our state's most efficient WNV vector species.

Select Mosquito Species Found in Washington

Species	Habitat	Behavior	Additional Information
Aedes cinereus	• Occurs in a wide range of larval habitats, most frequently in woodland and open meadow pools and in cattail swamps. • In some mountain areas it is the predominant species.	• Does not travel far from larval habitat. • Will bite at any time of day. • Known as an "ankle biter" because it focuses on lower extremities. • May hatch later in the season in colder climates or at higher altitudes.	
Aedes vexans	• One of the most common floodwater mosquitoes, particularly along the bottom lands of the Columbia River. • Occurs in irrigated and inland floodwater areas.	• Bites humans and domestic mammals, more commonly at dusk and dawn but also during the day. • Flight range >20 miles • Eggs are laid in mud and hatch when flooded in spring or early summer.	• **Competent vector for WNV**

Select Mosquito Species Found in Washington			
Species	**Habitat**	**Behavior**	**Additional Information**
		• Several hatches may occur in a season if water levels fluctuate but eggs remain viable for several years if not flooded.	
Aedes canadensis	• Found in woodland pools filled by melting snow or rain.	• Adults live for several months and feed on a broad range of animals including large and small mammals, birds and reptiles. • One of the first species to emerge in the spring.	• Can be a serious pest in shaded areas near its breeding site.
Aedes dorsalis	• Larvae are found in brackish and saline waters along the edges of marshes, bays, lakes, and flooded pastures.	• Females prefer to feed on large mammals like cattle and horses, but readily bite humans. • Bite throughout the day, particularly towards dusk, and are so aggressive and persistent that livestock tend to avoid infested areas. • Flight range is 20 miles or more.	• Maintenance vector for WEE in nature.
Aedes fitchii	• Larvae occur in large, grassy pools, pools created by spring snow melts, and cranberry bogs. • Widely distributed in WA.	• Eggs overwinter and there may be two generations a year. • Readily bite humans.	

Select Mosquito Species Found in Washington			
Species	**Habitat**	**Behavior**	**Additional Information**
Aedes japonicus	• Larvae are found primarily in artificial containers, water-filled depressions, tires, birdbaths and coastal rock pools.	• Daytime biter.	• **Competent vector for WNV.** • Found in western WA, where WNV is less common.
Aedes melanimon	• Found in irrigated pastures, fields and saline pools.	• Adults bite humans and domestic animals. • Flying range has been reported to be ten miles.	• Similar to, and may be associated with, *Ae. dorsalis.*
Aedes nigromaculis	• Irrigated or flooded meadows.	• Strong flyer with a 20-mile flight range.	• Often associated with *Ae. dorsalis* and other species found in irrigated or flooded meadows. • Major pest for large mammals and humans.
Aedes sticticus	• Breeds in large numbers along the brushy flood plains of the Columbia River and other similar locations.	• Adults may disperse up to 20 miles.	• Eggs remain viable for several years on inactive flood plains.
Aedes sierrensis	• Found primarily in Western Washington. • Breeds in water-filled holes or depressions in trees.	• Peak feeding occurs at dusk. • Feed predominantly on small mammals, but will feed on large mammals and humans when available.	• Also known as the western treehole mosquito. • Vector of the dog heartworm, *Dirofilaria immitis.*
Coquillettidia perturbans	• Found in marshes, ponds and lakes with a thick growth of	• Adults bite birds, mammals, and humans.	• This species has been implicated in the maintenance cycle of eastern equine

Select Mosquito Species Found in Washington			
Species	**Habitat**	**Behavior**	**Additional Information**
	cattails or other aquatic vegetation. • They have also been found in storm water ponds where aquatic vegetation is allowed to grow.	• This species enters houses and is active primarily in the evening, but will bite during the day in shady places. • Larvae attach to the stalks of vegetation with a modified air tube and do not need to breathe at the surface, making control difficult. Generally overwinter as larvae.	encephalitis (EEE) in the eastern United States. • Most common nuisance mosquito species in western WA.
Culex pipiens	• Populations reach their greatest numbers in urban and suburban areas, but also occur in rural areas. • Common larval habitats include catch basins, storm water ponds, clean and polluted ground pools, ditches, animal waste lagoons, log ponds, and other waters rich in organic matter. • This species also deposits eggs in artificial containers that hold water, such as tin cans, tires, and birdbaths.	• Widespread in Washington and readily enters houses on warm summer nights. • Primarily feeds on birds, but also on mammals, including humans and dogs. • Flight range is about one mile. • Larvae may be present from spring through fall.	• Commonly called the northern house mosquito. • **This species plays a significant role in the amplification and transmission of WNV and is a competent vector.**

Select Mosquito Species Found in Washington			
Species	**Habitat**	**Behavior**	**Additional Information**
Culex stigmatasoma	• Larvae are occasionally found in clean water, but primarily in stagnant or polluted water in storm catch basins, around farms, sewage plants and sometimes in artificial containers. • Reported primarily from southwest Washington and western Oregon.	• Females rarely feed on humans.	• Referred to as *Culex peus* in older literature. • Western equine encephalitis (WEE) virus has been isolated from wild caught specimens in California.
Culex tarsalis	• Widespread species found in every county in the state • Most commonly found in seepage areas and surface pools associated with irrigated pastures or flooded meadows. • Larvae colonize new sunlit pools surrounded by grasses and annual plants.	• Prefers to feed on birds, domestic animals, and humans, primarily as an evening and early morning biter. • Flight range is >10 miles. • Mated females hibernate over winter.	• **A key vector of WEE and SLE and a primary amplifying species and vector of WNV in Washington.**
Culiseta impatiens	• Favors woodland and timbered habitats. • Found along logging roads, ditches and other small pools.	• Early season biter. • The females overwinter with one generation per year.	

Select Mosquito Species Found in Washington			
Species	**Habitat**	**Behavior**	**Additional Information**
Culiseta inornata	• Mainly breeds in woodland pools or in slow moving or stagnant water, but seldom in containers. • Wide distribution in irrigated areas. • Occurs at elevations up to 6,000 feet in very cold water.	• Long breeding season.	• Competent vector of WEE and is often found with *An. freeborni* or *Cx. tarsalis.* • Serious pest of livestock.
Culiseta morsitans	• Inhabit semi-permanent woodland swamps and bogs containing grasses and cattails.	• The species is suspected of over-wintering in the egg and larval stages and occasionally as adults. • Birds are their preferred hosts. • Larvae are produced in early spring.	

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Appendix B: Mosquito Surveillance

Establishing a Mosquito Surveillance Program

Mosquito surveillance programs are valuable both for enhancing control efforts where mosquito control is available, and for providing early warning of disease risk in areas where control is unavailable. Effective mosquito control begins with sustained, consistent surveillance that focuses on pest and vector species, identifies and maps egg and larval habitats by season, and documents the need for control. Programs can use the records to determine the effectiveness of control operations, whether preventing mosquito-borne diseases or reducing mosquito populations to levels allowing outdoor activities without undue discomfort. Similarly, mosquito surveillance supports health education to populations at risk when identification and testing results are available to the public in a timely manner.

Surveillance is a critical component of an integrated pest management and control program. Knowing when and where to treat mosquito populations reduces the use of pesticides and allows for targeted pesticide application. All components of an integrated management program must be monitored for efficacy using best practices and standard indices of effectiveness. Comprehensive mosquito surveillance includes larva and adult sampling, mapping/record keeping components, and data analysis components. A surveillance program ideally should be sustained and maintained as a consistent effort over several seasons. Advantages of mosquito-based surveillance include:

- May provide the earliest evidence of disease activity or transmission.
- Helps establish information on potential mosquito vector species.
- Provides an estimate of vector species abundance.
- Provides baseline data to guide emergency control operations.
- Allows evaluation of control methods.
- Yields quantifiable information on virus infection rates in different mosquito species.
- Gives quantifiable information on potential risk to humans or animals.

Sampling

Surveys are essential for the planning, operation and evaluation of an effective mosquito-control program. Initial surveys identify the species of mosquitoes present and provide general information on locations, densities and disease potential. With this knowledge it may be possible to determine life cycles and feeding preferences; predict larval habitats, adult resting places and flight ranges; and perhaps even make preliminary recommendations for control programs.

Surveillance activities address larval and adult population density and species composition, rainfall and sometimes tide monitoring, and breeding site locations. Such surveillance does not determine the absolute population of mosquitoes, but it can show fluctuations in relative mosquito abundance and diversity over time in the various habitats visited.

Larval surveillance involves sampling a wide range of aquatic habitats for the presence of pest and vector species during their developmental stages. Trained inspectors should collect larval specimens on a regular basis from known larval habitats and perform systematic surveillance for new sources. Properly trained mosquito identification specialists can identify nuisance and vector mosquito species. Responsible control programs target vector and nuisance populations for control and avoid managing habitats that support benign species.

Adult mosquito surveillance is used to monitor species presence and relative abundance of adult mosquitoes in an area. Information derived from adult mosquito surveillance programs using standardized and consistent surveillance efforts provide information essential to monitoring potential vector activity, setting action thresholds, and evaluating control efforts. Adult surveillance testing can provide information on pathogens such as West Nile, St. Louis, and western equine encephalitis viruses, which may be circulating within a mosquito population.

The detection and measurement of pest mosquito populations has often proved easier by routine light trap and human bait collections of adults than by larval sampling. However, treating larval habitats has, in general, remained a more effective method of reducing mosquito populations than the application of adulticide sprays. Larval surveys have consequently continued to be important in assessing population size and the impact of control measures.

Additional specialized surveillance may be conducted to detect arboviral presence in birds and mosquito populations. This information not only provides justification for habitat reduction and insecticide applications, but also serves as an ongoing indicator of the effectiveness of these activities and continually adds to the database of knowledge concerning mosquitoes in the area.

Mapping

Maps provide information for field surveys, control activities, program evaluation, and reporting and budgeting purposes. Maps are used to locate larval breeding places and plot sampling stations. For a large area, a master map may be needed to indicate treatment areas, the possible flight range of mosquitoes from breeding sites, the potential degree of penetration into populated areas, and larval and adult sampling stations (indicated by symbols and numbers). Counts made at the stations every one to two weeks provide data to evaluate the current mosquito problem and areas of high priority for treatment by indicating the abundance of mosquitoes, species involved, flight range and habitat, and disease potential.

Record Keeping

Surveillance should be consistent both in method and location. Keeping clear, accurate records is as important as gathering data. Surveillance records are managed in a manner so that subsequent inspections can be done in a similar manner by others less familiar with the area. In addition to the data collected, records usually include the inspector's name, date of inspection, and exact location. Data-recording forms and devices promote uniformity, which makes records easier to read, interpret and summarize, and remind the inspector to include all pertinent information. Without data recorders, standardized formats lead to more consistently accurate transcription of the data into the permanent records.

WASurv can also be used as a standardized central repository for mosquito surveillance data, including trap locations, date of collection, mosquito species, sex, number of specimens tested, agent tested, test type, and result of test. It can also be used for data visualization, including displaying on a map the locations where tested and positive mosquito pools were collected. WASurv does not store human or mammal data. Data import templates and additional information on WASurv can be found on the VectorSurv website. To request a WASurv account, please contact zd@doh.wa.gov.

Adult Mosquito Collection Methods

The objectives of adult sampling are to determine species composition, population age structure, currently active species, locations of the greatest numbers and, if doing pathogen surveillance, what species are carrying what agents. Surveys also provide data on seasonal and spatial distribution of adults. Depending on the type of information desired, different collection methods and equipment may be required.

Repeatedly sampling adult resting populations gives a cross-section of the overall population. Sampling resting populations is usually time consuming, especially for natural resting sites. The number of specimens collected per unit of effort may be low compared to other collection methods. Sampling active adult populations indicates what species are currently seeking a host and can also provide information on the locations as well as the times when various species are most actively seeking a blood meal.

Resting Populations

Adults of many mosquito species rest during the day in dark, humid, cool sites. Most species shelter in response to changes in light intensity and humidity near dawn, and usually shelter until dusk. Different species or different adult stages may use different types of resting sites. An index of population density is given by counting the number of adults found resting. Sites are also sources of specimens to test for mosquito-borne viruses. A resting adult collection usually gives a representative population sample, including teneral and post-teneral unfed, blood-fed, and gravid females, as well as males. Resting adults are most easily collected with an aspirator but can be taken with a sweep net or drop nets, useful in grass or low vegetation.

“Natural” Resting Sites: These include any site not specifically built to shelter mosquitoes, such as storm sewers and culverts, bridges, houses, porches, barns, stables, chicken coops, privies, burrows, tree holes and vegetation. With experience, the suitability of shelters as resting sites is easily evaluated. Collections must be standardized for accurate comparison of results.

“Artificial” Resting Sites: These sites are built to attract mosquitoes if suitable natural resting sites are unavailable. Sites include red boxes or cloth shelters and privy-type shelters. The shelters should be in shaded, humid locations near suspected breeding places or in other known gathering places. Shelter boxes, one cubic foot in size with one side open and painted red inside, have been used successfully including to capture *C. tarsalis* and other species.

Types of Traps

Baited traps, light traps, oviposition traps, and BG sentinel traps are the most common traps used for mosquito surveillance. In Washington State, the primary traps used for WNV surveillance are CO_2-baited traps and Reiter Gravid traps.

Baited traps and attractants: Animal-baited or CO_2-baited traps disproportionately attract host-seeking females, the stage of most interest for mosquito-borne virus surveillance. The types of bait vary significantly in attractiveness, affecting trap performance. Other considerations are the collection duration and time of day (most important for species with a narrow host-seeking window). A final consideration is whether to let mosquitoes feed (important if specimens are to be used for blood meal identification). Specimens can be removed from the trap periodically with a hand-held aspirator. CO_2-baited traps rely on the dissipation of dry ice or bottled CO_2 as the attractant, imitating CO_2 release by a host. Another material, 1-octen-3-ol (octenol) has been used, either alone or with CO_2, as a bait attractant. Octenol is a derivative of gases produced in the rumen of cows and has been shown to be an effective attractant to some species (such as *Ae. japonicus*). Other types of baited traps include drop nets, tent traps, and small animal bait traps.

Light traps: Adults of many mosquito species are attracted to light, allowing sampling between dusk and dawn. Attraction to light can vary with the source, wavelength and intensity. Competing light sources (such as moonlight, road lights, and "urban glow"), fan size and speed, and presence or absence of screens also affect trap performance. Some species are not attracted to light or are repelled. In addition, species inhabiting wooded areas are less attracted to light traps than those preferring open areas. Only flying populations are sampled. Light traps do not reflect the number or presence of species that are not attracted to light or are only active during the day so should be combined with other sampling methods.

Light traps have two primary functions in mosquito surveillance programs. One function is to record mosquito abundance and species presence in an area. Historical data show fluctuations on a year-to-year basis as well as over one season, which can indicate the impact of mosquito control activities or justify more control efforts in an area. Light trap records are especially useful for program budgeting and for acquiring pesticide use or water management permits. Another function is to give information rapidly on mosquito abundance and species composition for planning and directing day-to-day mosquito control activities.

Light trap captures are greatly improved by adding dry ice (or CO_2 gas from a cannister) as a CO_2 attractant. However, CO_2-baited traps without added light are typically preferred, as light traps will attract many non-target insects like moths, midges, and beetles. These additional species can damage the mosquito specimen and increase the time spent sorting and speciating mosquitoes.

Common types of light traps include the Encephalitis Vector Survey (EVS) Traps and CDC Miniature Light Traps.

Oviposition traps: Oviposition traps sample populations of mosquito females looking for a suitable location to lay their eggs (also called gravid females). Since the gravid population has fed on blood at least one time, these individuals are more likely to be infected. This reduces the work involved in processing mosquito pools for virus isolation. Minimum infection rates (MIRs) will, on average, be higher than those obtained from light trap catches. Traps can be separated on the basis of whether or not they retain the ovipositing (egg-laying) females or allow them to escape.

The Reiter gravid trap samples female *Culex* mosquitoes as they come to lay their eggs. It is selective for females that have already taken at least one blood meal. If mosquitoes are being collected for virus isolation, there is a higher probability of collecting infected mosquitoes. Gravid trap counts might also have a higher correlation with disease transmission. See Guidelines for Using Gravid Traps.

BG sentinel traps: BG sentinel traps use attractants (e.g., octenol lure, human scent lure, carbon dioxide) to lure more female mosquitoes, similar to baited traps. Unlike baited traps, the body of a BG sentinel trap is flexible and designed to mimic convection patterns emitted by human skin. The type of lure used can greatly affect the efficacy of the trap. This trap works best to target *Ae. aegypti* and *Ae. albopictus*.

Larval Mosquito Collection Methods

Different mosquito species prefer different habitats for egg laying, ranging from large expanses such as swamps or flooded meadows to small collections of water, like those in snail shells, fallen leaves, or tires. Washington has many types of mosquito habitats, such as flooded areas, irrigation sites, tidal ponds, marshes, containers, tree holes, and storm water retention ponds.

Larval surveillance is an essential component of an effective mosquito surveillance and control program. Larval surveys have many functions. They are used to determine the locations and seasons that mosquitoes use specific aquatic habitats. When specimens are identified and counted, the information can provide species composition and population densities which can be used to determine optimal times for application of larval control measures, including chemicals, biologicals, draining or impounding. Larval surveillance can also help forecast the need for adult mosquito control and assess the effectiveness of both chemical and biological control measures.

Routine larval surveillance data can be useful in interpreting adult mosquito surveillance data. For example, if larval surveys indicate 95-100% control by larvicides but the number of adults does not decline, one can suspect, in the absence of reinfestation, that an important larval concentration was missed.

Larval surveillance should be conducted at each chosen site one to two times per week during the mosquito season. However, inspectors should always be on the lookout for potential new larval habitats. Data should include site identification, weather at time of collection, number of larvae collected per dip and instar stage, number of dips taken, average number of larvae per dip, and species collected. Larvae can be identified in their larval form, stored in vials of alcohol for later identification, or reared to adults for identification. Representative specimens can be transferred with an eye dropper as needed.

Sampling Methods

Dipping: The most commonly used larval collection method is the "standard dipper," usually a plastic, white pint to quart-sized scoop-on-a-handle. It is possible to get a rough idea of the breeding activity of most species by computing the average number of larvae of each species per dip. The number of dips needed depends on the size of the area and relative larval density, but for convenience is often a multiple of ten. Inspect at weekly or biweekly intervals during the mosquito breeding season, as areas entirely negative at one time may rapidly become heavily infested.

When surveying for mosquito larvae, approach the habitat cautiously. Footstep vibrations, casting a shadow or moving vegetation that touches the water may cause larvae to dive to the bottom. Try to approach the water quietly and slowly while facing the sun, moving vegetation only as necessary.

The species of mosquitoes of interest and the type of habitat being sampled will, in part, determine the sampling method used. Field personnel should know the preferred breeding habitats and seasonal occurrence of species known or suspected to be present within an area.

Mosquito larvae of most genera, particularly *Culex*, *Aedes*, and *Anopheles*, are usually at the water's surface, frequently next to vegetation or surface debris. In larger ponds, they are usually near the margins. Concentrate dipping around floating debris and aquatic or emergent vegetation. If there is a strong wind, dip on the windward side where larvae and pupae will be most heavily concentrated. If possible, look for sites with larvae and pupae before beginning to dip. If rain is hitting the water's surface, wait until the rain stops.

A water body may have a number of different microhabitats which could contain different mosquito species. Microhabitats are places such as under tree roots, within clumps of emergent vegetation, under floating or overhanging vegetation, and in open water. Learn to recognize different microhabitats within an area and sample as many as possible in order to obtain an accurate picture of the area's species composition.

There are seven basic methods to dip for mosquito larvae. Choice of method or methods depends on the genus or genera of mosquitoes you suspect may be present and on the habitat, microhabitat, and weather conditions. Visit the Rutgers University Center for Vector Biology website for a reproduced article from the American Mosquito Control Association with more information and visuals on these methods.

One or more of these methods, properly used, can determine the mosquito species composition of most aquatic habitats, excluding sites whose openings are smaller than a dipper. Turkey basters or other syringe-type suction devices allow access to difficult places like plant axils, tree trunk or root holes, rock pools, tires, and various artificial containers used by some mosquito species. Other tools, such as a vial, measuring spoon, or tea strainer, can be used in these habitats with the sampling techniques described above.

Submerged Vegetation: *Coquillettidia perturbans* larvae have a modified siphon, toothed and spur-like, which they insert into submerged roots or stems of plants to take air from the plant itself. *Coquillettidia* larval habitats are usually freshwater swamps, grassy pools or along lake margins. Their favorite plants include cattails and other emergent vegetation.

Because *Coquillettidia* larvae are rarely found at the water surface, they cannot be sampled by the usual dipper technique. Sampling can be done by uprooting the plants and immediately placing them in a bucket of clear water. Vigorously shake the submerged parts to dislodge any larvae attached to the root mats or plant stems. After mud and debris have settled, larvae and pupae can be collected either by dipping from the water surface or pipetting from the bottom mud.

Guidelines for Using Encephalitis Vector Survey (EVS) Traps

The following guidelines are presented to improve the reliability of EVS trap usage in mosquito surveillance programs and encourage uniformity of EVS data throughout the state. See DOH Surveillance Tools for a video, checklist, and forms.

EVS Trap Operation

- Consider two traps as the minimum number in most situations and compare their data to detect differences that may have been due to outside influences on one of the traps.
- Operate the EVS traps on a regular schedule, between 2 and 7 nights per week, depending on mosquito populations and risk of mosquito-borne diseases.
- Trap at least one hour prior to dusk until one hour after dawn to ensure that surveillance is conducted during the primary host-seeking periods for most species.
- Use traps in combination with dry ice or other CO_2 source. A 4-5 lb. block in an insulated container mimics a large mammal's respiration and usually lasts long enough to cover the usual dusk to dawn trapping period. Hang the dry ice adjacent to the trap to draw mosquitoes as close as possible to the collection fan.
- Begin trapping at the beginning of mosquito season each year and continue the trapping program through the month of September or later, depending on mosquito activity. Washington mosquito activity usually begins in April and winds down in October; however, some species may carry activity into November while others hibernate as adults in secluded refuges by that time.

Trap Placement

- Keep away from exterior lighting (such as spotlights, windows, and lit vents), areas of strong winds, and sources of industrial smoke or fumes when setting up an EVS trap. Try to place the trap in open areas, away from buildings at a height of 5-6 feet above the ground unless specific information is needed on canopy dwellers. For most nuisance species, this height gives a reliable indication of activity.

- Try to set the traps along the edges of habitats to increase trapping efficiency. A trap located strictly in one ecosystem or habitat may exclude certain species. Trapping along the edge rather than middle of a swamp, for example, will provide a picture of those species found not only in the swamp, but also in the nearby upland.

Other Considerations

- Be aware that the males in the collection provide useful information. A large number of male mosquitoes indicate that a brood of females is about to emerge in that area.
- Be aware that differences do exist in the host seeking behavior of some species and that modifications of these general guidelines may be necessary to get complete surveillance data. Species that feed only during the daytime will not be accurately represented in dusk-dawn collections. A species that hunts in tree canopies will not be accurately sampled by a trap that is suspended five feet from the ground. Whenever possible, become familiar with the host-seeking habits of the mosquitoes being surveyed. Don't be afraid to experiment!
- Whenever possible, identify the collected mosquitoes within 24 hours.

Guidelines for Using Gravid Traps

Gravid traps are designed to attract female mosquitoes that have had at least one blood meal. Specimens may be collected for virus isolation.

Trap Placement

- Locate traps in or near residential areas to collect container-breeding *Culex* species. Protect traps from extreme environmental conditions (for example, wind or direct sun) and in secure areas (not conspicuous so they will not be disturbed or vandalized).
- Appropriate trap sites include: utility yards, window and stair wells, storm drains, boatyards, animal stables, transformer pits, cluttered backyards, tire storage yards, and cemeteries.
- There should be overhead cover (shrubs or refuse) so that the tub is not easily flooded in the event of rain. Punch holes in the sides of the container so excess water drains out.
- Locate traps where they can be visited daily. If after several visits the trap does not appear productive, move it to another location. The primary goal is to collect blood-fed female mosquitoes, so it is less of a priority to maintain consistent sites if there are poor yields.

Trap Set up

- If using a trap for the first time, be sure to rid the tubs of potential insect repellent properties associated with chemical components in some plastics. Immerse the tubs in a muddy pond for several days or fill with water and leave them out in the open for a week or two.
- At least two days before trapping, mix in a gallon jug or jerry can about one cup of rabbit pellet food (available from pet or feed stores) per one gallon of aged tap water (allowed sit out for two to three days to let the chlorine to evaporate). Let the concentrate incubate in a location inaccessible to mosquitoes. Change the media out as often as necessary to ensure a fresh mixture for each night of trapping.
- At the trapping site put around ¼ gallon of the premixed rabbit food concentrate in a tub and add aged water collected from a nearby natural source (such as a pond or stream) to bring the water level to within two inches

of the bottom edge of the fan housing tube.

- Position the trap bracket securely over the center of the tub and slide the collection bag (or screened tub) over the top of the trap tube. Be sure the bag is not askew and that it remains properly positioned, even in a breeze.
- Attach the battery to the terminal wires and make sure it is securely positioned. Test the trap making sure the fan turns freely and draws the air from below.
- Place the trap out in the late afternoon (for *Culex*). Gravid traps can attract some daytime species (for example, *Aedes*) if placed out earlier in the day.
- Assign the trap a number and note its location on a map.
- Depending on your situation, it may be advisable to label the traps with a warning stating "West Nile Virus Surveillance – Do Not Touch" and include your organization's name and a contact phone number.

Trap Servicing and Specimen Collection

- Visit the trap early the following day. Carefully remove the trap bag (or screened tub) containing mosquitoes and replace with an empty one. Tie off the open end. Note in a field notebook or on your data sheet the general number of mosquitoes taken from each particular trap (to be verified later in the laboratory) and any other relevant information. Either hang the bag in the servicing vehicle, or place props (such as a tongue depressors) around the bag so that it does not collapse and the mosquitoes are not crushed.
- The water can be used for multiple trap nights within a week (top it off with aged water to make up for evaporation), but dump the water at the end of one week of trapping and make a new batch of the rabbit pellet food water as described above. If this is not done, eggs laid could develop and contribute to mosquito breeding in the vicinity. (Note: before emptying the water examine the surface and collect any eggs in specimen jars for rearing and species confirmation).
- It is best to trap at the beginning of the week (Monday, Tuesday, and Wednesday) to give time for sorting and overnight mailing specimens before the weekend. This also allows for adjustments if there is some reason you can't trap on a given night (storms or holidays). Remember, the attractant concentrate needs to incubate for at least two days, so it should be prepared no later than Friday for the following week.

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Appendix C: Mosquito Control

Mosquito Control

Management

Responsibility for mosquito control rests with state and local agencies. Control programs managed by public agencies are either components of local health jurisdictions or are independent districts organized specifically for mosquito control. Mosquito control is often accomplished by identifying larval habitat and treating the water with a material to kill larvae. Many available materials are biological in origin and are highly specific for mosquitoes, with little or no effect on other organisms. Adulticiding with chemical pesticides is usually done only if adult populations are large enough to cause extreme annoyance to many people or when the threat of disease transmission to people is high. Control of irrigation water in agricultural areas to avoid excess runoff is an important mosquito control method. In recent years, eliminating small bodies of water has ceased to be a mosquito control option because of habitat preservation concerns.

Integrated Pest Management

The current interests in ecology and environmental impact of mosquito control measures, and the increasing concerns about insecticide resistance emphasize the need for integrated control programs. Integrated pest management (IPM) is an ecologically based strategy that relies heavily on natural mortality factors and seeks out control tactics that are compatible with or disrupt these factors as little as possible. IPM includes the use of pesticides, but only after systematic monitoring of mosquito populations indicates a need. Ideally, an IPM program considers all available control actions, including no action, and evaluates the interaction among various control practices, cultural practices, weather, and habitat structure. This approach uses a combination of resource management techniques to control mosquito populations with decisions based on surveillance. Fish and wildlife specialists and natural resources biologists should be involved in planning control measures whenever delicate ecosystems could be impacted by mosquito control practices.

A good IPM program can control mosquitoes more effectively while reducing pesticide exposure to humans and the environment. Such programs feature surveillance of mosquito populations and disease monitoring, resident education, action to maximize natural controls and minimize mosquito breeding sites, and larviciding when necessary.

The underlying approach of mosquito control is based on the fact that the greatest control impact on mosquito populations that are concentrated, immobile and accessible. This emphasis focuses on habitat management and controlling the immature stages before the mosquitoes emerge as adults. This policy reduces the need for widespread pesticide application in urban areas.

Mosquito Control Programs

Modern mosquito control programs in the U.S. are multifaceted and include surveillance, habitat reduction, and a variety of larval and adult mosquito control strategies.

Surveillance methods include studying habitats and monitoring mosquito traps, biting counts, and public complaints and reports. Seasonal records are kept in concurrence with weather data to predict mosquito larval presence and adult flights.

Habitat reduction addresses eliminating or modifying the aquatic habitat to prevent mosquitoes from reproducing, such as collecting and disposing of artificial containers that may become larval habitats. If habitat modification is not feasible, biological control using fish may be possible. Contact WDFW before introducing fish into water bodies that are not contained or have the potential to reach waters of the state.

Mosquito control officials often apply biological or chemical larvicides, with selective action and moderate residual activity, to aquatic habitats. To have the maximum impact on the mosquito population, larvicides are applied when immature stages are concentrated in the breeding sites and before the adult forms emerge and disperse.

Aquatic Mosquito Control

Larvicides can be applied from the ground or aerially, but most treatments are made to relatively small areas with larval concentrations. Active ingredients below may be used in Washington for aquatic mosquito control. The Washington State Department of Agriculture has a guide to registered products: http://www.kellysolutions.com/WA/pesticideindex.htm.

Aquatic Mosquito Control Agents		
Agent	**Mechanism of Action**	**Important Information**
Bacillus sphaericus (H-5a5b)	It produces a protein endotoxin only active against the larval stage and must be ingested and digested before being activated. *B. sphaericus* has the unique property of being able to control mosquito larvae in highly organic aquatic environments such as waste lagoons or storm water catch basins.	• A naturally occurring, spore-forming bacterium found worldwide in soil and aquatic environments. • First registered for the control of Culex mosquitoes, *B. sphaericus* use has been expanded to include control of several *Aedes*, *Anopheles*, *Psorophora*, and *Coquillettidia* species. • Not acutely toxic to freshwater and saltwater invertebrates, honeybees, or may fly larvae, does not appear to harm fish or other marine life, and is not toxic to birds on a sub-chronic basis. • Not pathogenic, infective, nor toxic in laboratory animals by the oral, dermal, pulmonary or intra-venous routes of exposure. In humans, mild skin and eye irritation can occur with direct contact. • Available in various formulations such as corn cob granules, water dispersible granules, and water-soluble pouches. • Provides up to six weeks of control because the protoxins and spores remain suspended in the water column for extended periods and because the bacteria multiply in dead larvae. Duration of control depends on habitat factors such as water depth, flushing, and chemistry.

Aquatic Mosquito Control Agents		
Agent	**Mechanism of Action**	**Important Information**
Larvicide oils	Oils are petroleum or mineral based and form a coating on the water to drown larvae, pupae, and emerging adult mosquitoes.	• Oils are typically a product of last resort to control mosquito pupae, a non-feeding stage. • Typically persist for 12 to 15 hours and then evaporate. • If misapplied, the oils can be toxic to fish, aquatic invertebrates, amphibians, waterfowl, furbearers and fish. Consult the Department of Fish and Wildlife about larvicide oils.
Bacillus thuringiensis israelensis (*Bti*)	When ingested by larvae, *Bti* encysts and produces a protein crystal that disrupts the lining of the larvae's intestine causing it to stop eating and die.	• Naturally occurring soil bacterium. • The primary material used for mosquito control because of its low toxicity to non-target species. • Highly pathogenic against mosquitoes, highly selective for the first through third larval instars, and black flies, and has some virulence against certain other Diptera. • Extensively studied and is not toxic to bees, and has no reported effect on fish or amphibians when applied at field application rates. Several studies found no effect on warm-blooded mammals. Labels indicate that direct contact with the products may cause mild eye or skin irritation. • Available in liquid, pellet, granular, and briquet formulations. A number of Bti products are available for residential use in water bodies, such as lined ornamental ponds. • Does not persist long after application, with toxicity persisting from 24 hours to over one month. • Larval toxicity can depend on the species, its feeding activity, and other possible factors such as UV light, water quality, pH, temperature, agitation, and sedimentation.

Aquatic Mosquito Control Agents		
Agent	**Mechanism of Action**	**Important Information**
Methoprene	Methoprene mimics an insect growth-regulating hormone to prevents normal maturation of larvae. Unable to metamorphose, the mosquitoes die as pupae.	• Classified as a biochemical pesticide because it controls mosquitoes by interfering with the life cycle rather than by toxicity. It is effective for controlling first through fourth mosquito larvae instars. • Comes in various formulations such as briquets, liquid, pellets, wettable powder, water soluble pouches, and granules. Some methoprene products can be used in standing water in containers around the home. • Depending on the formulation used and environmental factors, residual control ranges from five to 150 days. Methoprene is not persistent in the environment, degrading rapidly in water due to transformation by sunlight and microorganisms. • The toxicity of methoprene to birds and fish is low, and it is nontoxic to bees. It has no lasting adverse effects on populations of invertebrates or other non-target aquatic organisms when used according to label instructions. Methoprene mosquito control products present minimal acute and chronic risk to freshwater fish, freshwater invertebrates, and estuarine species. Methoprene has very low acute oral and inhalation toxicity potential and is not an eye or skin irritant. Methoprene is also of low acute dermal (skin) toxicity and is not a human skin sensitizer.

Aquatic Mosquito Control Agents		
Agent	**Mechanism of Action**	**Important Information**
Monomolecular surface films	Monomolecular surface film disrupts the cohesive properties and prevent mosquitoes from using the water's surface as an interface to breathe or egg-laying, in effect drowning mosquitoes. Monomolecular surface film kills larvae and pupae by preventing them from keeping their breathing tubes above the water's surface.	• Non-petroleum oil that acts by altering the water habitat. It is in the alcohol ethoxylate group of surfactants, which are used in detergent products. • Mosquitoes that require little or no surface contact for breathing, such as *Coquillettidia* species, require properly timed applications at surface contacting stages – the pupae to emerging adult – for maximum impact. Since MSF kills mosquitoes with a physical mechanism, it is not effective in habitats with persistent unidirectional winds of over ten miles per hour, or in choppy water. • Generally considered non-toxic to most non-target wildlife, however, some species, such as midges that require attachment to the water surface, have been shown to be affected. MSF poses minimal risks to the environment when used as directed. MSF is not a skin irritant, is only a mild eye irritant on prolonged or repeated contact, and is considered to be non-toxic by animal tests. • The film persistence depends on temperature, water flow, amount of bacteria, and the duration & strength of the wind. MSF typically persists on the water's surface for 5 – 22 days.
Chemical larvicides **(restricted or emergency use only)**	Temephos and malathion are acetylcholinesterase inhibitors, causing acetylcholine buildup in nerve cells and eventual neurotoxicity in the central nervous system.	• Organophosphate pesticides malathion and temephos can be applied only as restricted-use larvicides under the Department of Ecology's aquatic mosquito control permit. • Temephos is not allowed in lakes, streams, or the littoral zone of water bodies. Temephos can be used only in highly polluted and high organic waters with no surface water runoff and may be applied in response to the development of pesticide resistance or a public health emergency. • Malathion may be used for control of mosquito larvae only under agreement between Washington State Department of Ecology and DOH in response to a public health emergency.

Aquatic Mosquito Control Agents		
Agent	**Mechanism of Action**	**Important Information**
Spinosad	Causes excitation of the nervous system in insects, leading to muscle contractions and paralysis.	• Fermentation product of *Saccharopolyspora spinosa*, a naturally-occurring soil bacteria. • Low toxicity to humans & mammals, low to moderate toxicity to birds & fish, and high toxicity to honeybees and certain invertebrates. Negligible toxicity to honeybees after sprays have dried. • Degrades quickly in the presence of sunlight, with a half-life of less than one day in water and 2-16 days on leaves. In the absence of sunlight, the half-life is 30-259 days in water.

Adult Mosquito Control

The main objective of mosquito control is to decrease the risk of a human outbreak of mosquito-borne disease. This should be primarily accomplished by using integrated pest management principles and:

- Continuing to emphasize reduction in mosquito habitats.
- Larviciding where feasible and practical.
- Using personal protection measures against mosquitoes, especially for those with risk for severe disease or high risk of exposure.

Adulticiding is supplementary to these measures and is a local decision that should be based on the considerations listed (in no particular order) below.

Triggers for Adulticiding

Adulticiding should be considered when there is evidence of mosquito-borne epizootic activity at a level suggesting high risk of human infection (such as high mosquito infection rates, multiple positive mosquito species including key bridge vectors, horse or mammal cases indicating escalating epizootic transmission, or a human case with evidence of epizootic activity) and abundant adult vectors. In general, a positive mosquito pool does not itself constitute evidence of an imminent threat to human health and warrant mosquito adulticiding, but intensifying surveillance may be recommended to identify any increasing threats.

Where to Adulticide

Typically small amounts of adulticides are dispersed to drift through the habitat; barrier treatment by compounds with residual characteristics may be used at property borders near mosquito habitats. Consider the terrain in the proposed spraying area. Coverage by truck spraying may be inadequate if substantial vegetation borders a road. If dense vegetation like trees, shrubs, or hedges interferes with truck applications consider application with backpack sprayers, or altering truck routes to apply spray more efficiently. Aerial application may be considered when all other methods of application are inadequate and/or inefficient but should be limited to the immediate area where the vector population has been documented by vector surveillance and to adjacent areas considered at risk for imminent disease transmission. The Washington State Department of Ecology gives guidance in situations involving spraying near water or for applications hindered by vegetation.

Human Population Density

Also consider the population density in an area with evidence of intense epizootic activity. In a rural area with few people, the cost and potential risks of transmission may not justify the use of adulticides. A heavily populated area has stronger indications for considering adulticides, since the goal of spraying is to lower the risk of a human outbreak of mosquito-borne disease.

Mosquito Population

Information from mosquito surveillance can help determine when to conduct mosquito control, and help monitor the effectiveness of control activities. While all mosquito species do not need to be tested for viruses, those that are tested can give valuable information for control decisions. What may be more important than testing mosquitoes is knowing the abundance and species of the vector population in the locality. The best way to do this is by mosquito trapping but systematic mosquito trapping requires trained staff and is time intensive. For localities without this capacity, there are other potential sources of information on mosquito activity. Staff can visually inspect areas around human population centers for habitats likely to be conducive to mosquito breeding. Staff can also personally observe mosquito activity.

Lag Time

It is important to look at the dates that the positive surveillance specimens (mosquitoes, birds, and/or mammals) were collected. Usually the specimens were collected about one week earlier. In the time between collection date and test result date, new circumstances may alter a decision to use adulticides. For example, a county may have sprayed since the collection date, a weather event may have adversely affected mosquitoes, or mosquito habitat may have been modified resulting in a reduced need to spray.

Arbovirus Surveillance Results Over Time

Arbovirus surveillance information may be monitored over time by county or even smaller jurisdictions, such as towns, to determine what is happening with an outbreak. For example, if there has been a consistently good system to record arboviral detections in mosquitoes, and the number of arboviral detections drops for several weeks in a row after adulticiding, that may indicate that the spraying was effective in reducing the transmission cycle between vector and host. Such analyses should not be graphed by day (because of day-to-day instability in reporting), but analysis by week should be helpful.

Local Perspectives on Adulticiding

Different communities have varying perspectives on the benefits of mosquito control which should be considered in deciding whether to use adulticides. Decisions can be difficult, as people can have strong opinions on both sides of the issue. All pesticides used for mosquito control are United States Environmental Protection Agency (EOA); persons applying restricted-use pesticides must also be tested and licensed by the Washington State Department of Agriculture. For further information about toxicity of the common pesticides used for mosquito control, see the EPA site: https://www.epa.gov/mosquitocontrol/pesticides-used-control-adult-mosquitoes.

Before events force a decision regarding whether to use adulticides, a local health jurisdiction should assess its ability to conduct or assist in the coordination of adult mosquito control if needed. Some of the questions to consider include:

- Who in the community is qualified to apply mosquito control pesticides?
- What equipment is available in the community to conduct adult mosquito control?
- Where are the amplification and vector species of mosquitoes located and at what times of the year do they appear?
- Can local mosquito surveillance be improved to reduce the cost of mosquito control?
- Will the community need to contract with commercial businesses or others for public health mosquito control?
- Who will be the lead for public health mosquito control?
- How will the community be involved and informed during the decision process?
- How can we evaluate the effectiveness of adult mosquito control?

The decision for adulticiding is basically a risk assessment: whether or not a community believes the risk of contracting a mosquito-borne disease is greater than the risk from applying pesticides for mosquito control. It is also a cost assessment which must take into account medical costs (and access to health care), life years lost (for fatalities), costs of spraying campaigns, etc.

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Appendix D: Arboviral Surveillance in Birds and Mammals

Arbovirus Surveillance in Birds

Arboviral surveillance can involve testing domestic flocks or reporting or testing wild birds but most jurisdictions do not conduct any routine bird surveillance.

Domestic Flock Surveillance

Sentinel chicken flocks have previously been used in Washington to detect WEE, SLE, and WNV. Caged chickens placed in areas of known mosquito activity have blood samples taken periodically to test for antibodies to the diseases of concern. Additional testing can identify geographical spread of arboviruses. Only staff trained in taking blood samples should be involved in such efforts.

Dead Bird Surveillance

If a jurisdiction chooses to track dead bird sightings, reports should include: caller identification, date dead bird, precise location, bird species, and condition of the bird. The reports should be reviewed periodically and mapped to detect areas of heavier sightings.

Clusters of dead corvids have had some predictive value for increased risk of WNV transmission to humans and can indicate where to increase educational campaigns. Substantial number of other types of dead birds in one location are typically from other causes such as pesticides or natural poisons. Report bird die-offs to the Washington State Department of Fish and Wildlife or United States Fish and Wildlife Service office in the area.

For guidance on how to handle dead bird calls and concerns about avian influenza see: https://doh.wa.gov/avian-influenza and https://agr.wa.gov/departments/animals-livestock-and-pets/avian-health/avian-influenza.

Arbovirus Surveillance in Mammals

In some geographic regions, horses can also be important sentinels of arboviral epizootic activity and human risk, especially for WNV. WNV, WEE, and SLE can be locally acquired in horses, while other arboviruses are typically associated with travel. Veterinarians, veterinary service organizations, and state agriculture departments are essential partners in any surveillance activities involving equine arboviral disease.

Surveillance

The goals of equine disease surveillance are to use data on horse arboviral disease cases to assess the threat of human disease, identify geographic areas of high risk, and assess the need for and timing of interventions.

Widespread use of horse WNV vaccines may decrease the incidence of WNV disease and thus decrease the usefulness of horses as sentinels. Yearly vaccination of horses in Washington State against WNV is strongly recommended. Vaccines for eastern equine encephalitis (EEE) virus, western equine encephalitis (WEE) virus, and Venezuelan equine encephalitis (VEE) virus are also available in bi- or trivalent forms, and many now include WNV.

Reporting of Possible Cases

Veterinarians should report possible cases of WNV, SLE, Japanese encephalitis, EEE, WEE, VEE, and Jamestown Canyon Virus (California serogroup) in equines or other animals to:

Washington State Department of Agriculture Reportable Animal Disease Form
State Veterinarian's Office
360.902.1878

In support of local WNV diagnostic efforts, the Washington Animal Disease Diagnostic Laboratory (WADDL) tests for antibodies in equine serum and cerebrospinal fluid (CSF), for viral nucleic acids using polymerase chain reaction (PCR), and for antigens using immunohistochemical (IHC) analysis. Practitioners with suspected equine WNV cases can contact WADDL at 509.335.9696. Horses with encephalitis may also require rabies testing, and veterinarians should contact their local health jurisdiction to discuss potential rabies cases.

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Appendix E: Glossary

Glossary

Adulticide: Pesticide used to control insects at the adult stage of development.

Amplification: A general increase in the number of parasites or pathogens in a given area.

Amplifying host: A parasite host in which the number of parasites or pathogens increases and therefore the number of infected vectors feeding on that host may also increases.

Antigen: A protein or carbohydrate capable of stimulating an immune response. An **epitope** or **antigenic determinant** is a molecular region on the surface of an antigen capable of eliciting an immune response and of combining with the specific antibody produced by such a response.

Arbovirus: Any of various ribonucleic acid (RNA) viruses transmitted by arthropods; derived from the term **ar**thropod-**bo**rne **virus**.

Arthropod: Invertebrate animals in the phylum Arthropoda, a group that have a segmented body, jointed appendages, a usually chitinous exoskeleton molted at intervals. Includes insects, arachnids, and crustaceans.

Bridge Vector: An arthropod species that acquires a disease-causing agent from an infected wild animal and then transmits the agent to a human. For example, *Culex salinarius* is a mosquito whose females feed on both birds from which they may acquire West Nile virus and on mammals to which they may transmit the virus during the taking of a subsequent blood meal.

Carrier: A bearer and transmitter of a causative agent of an infectious disease; especially one who carries the causative agent of a disease systemically but is immune to it.

CO_2: Carbon dioxide, an attractant for adults of many mosquito species.

Diptera: A large group (Order) of insects that includes mosquitoes, flies, gnats, and midges. Diptera have a single pair of wings, along with small knobbed structures called "halteres" that help maintain equilibrium. Diptera undergo complete metamorphosis, changing form during development (see larvae and pupae). Some diptera are disease vectors while others are important pollinators, pest predators, and parasites.

Encephalitis: An inflammation of the brain that can be caused by viruses and bacteria, including some viruses transmitted by mosquitoes.

Endemic: Continuously present at the expected frequency in an area; restricted or peculiar to an area (endemic disease or endemic species).

Enzootic: Animal disease that is peculiar to or constantly present in an area.

Epidemic: Affecting or tending to affect a disproportionately large number of individuals within a population, community or region at the same time. (i.e., at a higher than expected frequency). Refers either to a disease brought in to an area where it is not consistently present or to a temporary increase in the number of cases of an endemic disease.

Epidemiology: A branch of medical science that deals with the incidence, distribution, and control of disease in a population; or the sum of the factors controlling the presence or absence of a disease or pathogen.

Gonotrophic cycle: The cycle the female mosquito goes through that begins with the search for a host and the taking of a blood meal, involves the maturation of a batch of oocytes (eggs), and ends with oviposition.

Gravid: Full of eggs, as in "trap for gravid females" also called "gravid trap."

Host: Living animal or plant affording subsistence or lodgment to a parasite. Parasites are organisms that are metabolically dependent upon the host.

Instar: The stage between successive molts, the first instar being between hatching and the first molt.

Larva (plural **larvae**): the immature stage between the egg and the pupa, of an insect with complete metamorphosis. Larvae differs radically from adults.

Larvicide: Pesticide used to control insects at the larval stage of development.

Morbidity: The relative incidence of disease.

Multivoltine: Having several broods in a season, as in "multivoltine species."

Oviposit: To lay or deposit eggs.

Parous: Having produced offspring.

Predation: A mode of life in which food is primarily obtained by the killing and consuming animals.

Pupa, (plural **pupae**): The immature stage between the larva and adult, of an insect with complete metamorphosis.

Recrudescence: A new outbreak after a period of abatement or inactivity.

Recrudesce: To break out or become active again (e.g., West Nile virus may be a chronic infection in birds that recrudesces during times of stress for the bird, such as migration, mating, and when establishing territory).

Reservoir: A populations of vertebrate or invertebrate hosts in which the pathogen is endemic (i.e., permanently maintained). The concept is usually applied to non-human populations with periodic individual cases or epidemics in humans or epizootics in different animals.

Sequela (plural **Sequelae**): A later or secondary effect of disease or injury.

Seroconversion: The production of antibodies in response to an antigen.

Seropositive: Having or being a positive serum reaction, especially in a test for the presence of an antibody.

Seroprevalence survey: Testing of blood for antibodies to an infectious organism in a defined group; "prevalence" refers to the percentage of people with a particular characteristic at a given point in time. A "West Nile Virus Seroprevalence Survey" determines the percent of persons with antibodies to West Nile virus, at a given point in time, within an area sampled.

Teneral: Recently molted adult mosquitoes, usually still pale and soft-bodied individuals.

Transovarial: With regard to West Nile virus, capability of an infected mosquito to pass the virus to offspring, also known as vertical transmission. Infection in male mosquitoes must be due to transovarial transmission since male mosquitoes do not take blood meals so cannot be infected that way.

Trap night: One trap operated for one night. Three traps operated for one night each or one trap operated for three nights would equal three trap-nights.

Vector: Carrier of a pathogen from one host to another

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DOH 333-149 2025

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