West Nile Virus in the Thunder Bay District, 2021

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Thunder Bay District Health Unit

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EXECUTIVE SUMMARY

No human case of West Nile Virus (WNV) was reported from the District of Thunder Bay during 2021. No birds were submitted to the Canadian Wildlife Health Cooperative in Guelph during 2021. Mosquitoes collected in Centers for Disease Control and Prevention (CDC) adult mosquito light traps provided the information necessary to evaluate human risk from WNV.

Twelve CDC adult mosquito light traps were operated for one night per week in the city of Thunder Bay and the surrounding area during the nine-week period from 29 June to 24 August. Mosquitoes were collected on 108 trap-nights. Ten vector species (one enzootic and nine epizootic) were found in the light traps during the summer of 2021. The light traps collected a total of 5499 specimens. A total of 3131 individuals were identified (not including males) from the 5499 specimens collected in the light traps. The identified specimens contained 439 vectors. The vectors were pooled by species, then 20 pools of *Culex restuans* and three pools of *Ochlerotatus japonicus* were tested for WNV using Reverse Transcription-Polymerase Chain Reaction (RT-PCR). No mosquito pool tested positive for WNV. No mosquitoes were tested for Eastern Equine Encephalitis Virus (EEEV). *Culiseta melanura* which is the principal vector of EEEV was not collected in the light traps during 2021.

An estimate of the total number of each species of mosquito was calculated. The enzootic vector found was C*x. restuans* which totaled 50 individuals or approximately 0.91% of the 5499 mosquitoes. Epizootic vectors included *Aedes vexans* (n= 260) (4.73%) and *Ochlerotatus japonicus* (n= 3) (0.005%). Seven other epizootic species comprised less than one percent each of the mosquitoes collected.

A value of only 105.5 accumulated degree-days (AccDD) was recorded in Thunder Bay from 1 June to 31 August during 2021. A value of 380 AccDDs is required before there is a serious risk of a WNV outbreak.

The low incidence of the enzootic vector *Cx. restuans* (0.91%), the probable absence of *Culex pipiens,* as well as the low AccDD value made the amplification of WNV within the bird community to the point of "spill-over" an extremely unlikely event during the summer of 2021. The risk to humans of acquiring WNV was considered minimal. Neither larviciding nor adulticiding was considered necessary during 2021.

If the climate of Thunder Bay changes to one which is more similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), there will be increased risk from WNV because of increases of *Cx. restuans, Culex tarsalis, Cx. salinarius*, *Oc. japonicus* and perhaps the establishment of *Cx. pipiens.* Any increase in these extremely competent vectors would increase the risk of an outbreak of WNV in the District of Thunder Bay.

HISTORY OF WEST NILE VIRUS IN NORTH AMERICA

West Nile virus (WNV), a mosquito-vectored disease, first appeared in North America in New York City during August 1999 and subsequently spread across the continent. As of 11 January 2022 all of the contiguous continental states and Alaska reported either human or non-human WNV infections (Centers for Disease Control and Prevention 2022). A total of 2695 cases of WNV infections occurred in humans in the United States during 2021, resulting in 191 deaths (Centers for Disease Control and Prevention 2022).

WNV was first detected in Canada during 2001 when dead birds tested positive for the virus in southern Ontario (Public Health Ontario 2016). The first human cases of WNV in Canada occurred during 2002 in Ontario and Quebec (Table 1) (Public Health Ontario 2016). One peak in the incidence of infections (n=1481) occurred during 2003 (Table 1) when the disease spread across eastern Canada. A second peak (n=2215) occurred during 2007 (Table 1) when the disease entered the prairie region of Canada. Clinical cases of WNV were identified in 35 humans in Canada during 2021 (Public Health Agency of Canada 2022). WNV Cases reported up to 18 November 2021 were 22 from Ontario, 6 from Manitoba and 6 from Quebec (Public Health Agency of Canada 2021). No deaths were attributed to WNV in Canada during 2021 (Public Health Agency of Canada 2021).

Table 1. Human infections and deaths in Canada from West Nile virus, 2002-2021 (Public Health Agency of Canada 2022).

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Clinical Cases	414	1481	25	225	151	2215	36	13	5	101	428	115	21	80	104	200	367	37	86	35
Deaths	11	10	2	12	2	8	0	0	0	4	6	4	0	0	7	8	26	0	3	0

ILLNESS CAUSED BY WEST NILE VIRUS

WNV is vectored by infected mosquitoes. Eighty percent (80%) of people infected with WNV are asymptomatic. Twenty percent (20%) of infected people develop West Nile fever which consists of fever, tiredness, headache, muscle aches, rash and/or swollen glands. Approximately one in 150 people infected with the virus will develop a life threatening manifestation called encephalitis, *i.e.* a swelling of the brain. Symptoms of West Nile encephalitis include fever, headache, stiff neck, disorientation, tremors, muscle weakness, paralysis and/or coma (Elliott *et al*. 2003). West Nile encephalitis is more common, but not restricted to people over 50 years of age. The severity of the disease increases with age (Drebot & Artsob 2006). From 4% to 14% of people with West Nile encephalitis will die as a result of their infection, whereas others may experience long-lasting, debilitating problems ranging from memory loss to muscle weakness (Elliott *et al.* 2003).

TRANSMISSION OF WEST NILE VIRUS TO HUMANS

West Nile virus is a mosquito-borne flavivirus which primarily infects birds, producing a transient high viraemia that ensures transmission of the virus back to feeding mosquitoes in an amplifying cycle. The amplification cycle does not occur in mammals. The virus replicates in only a few species of mosquitoes which act as the vectors of this disease. Humans can become infected as a result of bites from mosquitoes that have bitten infected birds. Other less common routes of transmission include: intrauterine, breast milk, blood transfusions, organ transplants, as well as needle stick or sharps injuries. Immuno-compromised patients and the elderly are at the greatest risk for encephalitis and death (Groner 2005).

MOSQUITO VECTORS

Mosquitoes either overwinter with the virus or become infected with WNV when they bite infected birds. According to Reisen *et al.* (2006), replication of the virus occurs in the mosquito at a temperature above 14.3˚C; however, work by Cuevas (in Hunter & Gasparotto 2015) indicates that the threshold temperature for the development of the virus is 16.3˚C. The Ontario Ministry of Health and Long-Term Care uses a value of 18.3˚C as the threshold temperature for the calculation of viral replication. Infected enzootic vector mosquitoes bite other birds, thus transmitting the infection to the new birds (Elliott *et al*. 2003). The virus undergoes replication in the newly infected birds. These birds then become a source of infection for other mosquitoes as this enzootic phase of the disease progresses in an amplifying cycle. If amplification begins during the early spring, then by mid-summer a large number of infected birds and mosquitoes are present which creates a high risk for human infection. The primary mosquitoes involved in the enzootic amplification process in southern Ontario are *Culex pipiens* and *Culex restuans*. These mosquitoes prefer to feed on birds but may also bite humans or other mammals (Wood *et al.* 1979). *Cx. pipiens* is now known to be attracted to humans at certain times during its lifecycle which means that this species also acts as an epizootic vector of WNV to humans (Russell 2008). Epizootic vectors, also called "bridge vectors", transmit WNV from birds to mammals. A third *Culex* species, *Culex tarsalis,* is the main mosquito species responsible for the transmission of WNV in western North America (Goddard *et al.* 2002). *Cx. tarsalis* has occasionally been found in the Thunder Bay District (Deacon 2013), but is primarily found in the prairies (Wood *et al.* 1979). *Cx. tarsalis* is a highly competent vector within the genus *Culex* because it feeds freely on both birds and mammals (Wood *et al.* 1979) thus acting as both the enzootic and epizootic vector of WNV. The ability of *Cx. tarsalis* to feed on birds and mammals (especially humans) probably accounts for the magnitude of the WNV outbreak in the prairies during 2007 (Table 1).

Cx. pipiens and *Cx. restuans* prefer to lay their eggs in man-made structures that contain water such as street-side catch basins, road-side ditches, and man-made containers (tires, bottles, buckets, bird baths, roof gutters, swimming pool covers, etc.) where the eggs develop into larvae, then pupae and finally adults (Wood *et al.* 1979). *Cx. tarsalis* lays its eggs in permanent and semi-permanent ponds, irrigation and roadside ditches with emergent vegetation, as well as temporary pools or artificial containers (Wood *et al.* 1979).

"Bridge vectors" (epizootic vectors) are generalist feeders, biting both birds and mammals. "Bridge vectors" are responsible for transmitting WNV from birds to humans during a "spill-over" (the epizootic phase of the disease) which occurs during the late summer. The "spill-over" occurs only when a large number of infected birds are present. Currently *Aedes vexans* is the principal "bridge vector" in Ontario; however, this species is only moderately effective as a vector of WNV (Turell *et al.* 2001). *Ae. vexans* breeds in temporary pools, marshes, and swamps (Wood *et al.* 1979) and is abundant in the District of Thunder Bay. *Ochlerotatus canadensis* is another "bridge vector" species which is sometimes abundant in the District of Thunder Bay. Larvae are found in small open ponds, temporary woodland pools, roadside ditches, cattail and sedge marshes, and muskeg pools (Wood *et al.* 1979). *Oc. canadensis* is considered a moderately effective “bridge vector” of WNV (Belton 2007).

Cx. pipiens, Cx. restuans, Cx. tarsalis, Ae. vexans, and *Oc. canadensis* are found in close proximity to human populations, which makes these mosquitoes important in the transmission of WNV. Both enzootic and epizootic vectors are required in high numbers near humans before WNV can be transmitted to humans.

OBJECTIVES OF THE WEST NILE VIRUS SURVEILLANCE PROGRAMME, 2021

1. A risk analysis of West Nile Virus activity in the Thunder Bay District was to be completed.
2. Adult mosquitoes in the District of Thunder Bay were to be collected using Centers for Disease Control (CDC) adult mosquito light traps.
3. Adult mosquitoes were to be identified to species and the prevalence of West Nile Virus in vector species was to be determined using Reverse Transcription-Polymerase Chain Reaction (RT-PCR).
4. The habitat used by *Cx. tarsalis* in the District of Thunder Bay was to be identified, if possible.
5. Larval mosquito habitat was to be identified and inspected in the city of Thunder Bay.
6. Human cases of WNV within the District of Thunder Bay were to be reported.
7. Geographic Information Systems (GIS) mapping was to note:
   - Mosquito species distributions
   - Larval habitat locations
   - Catch basin data
   - High-risk locations
8. All municipalities within the District of Thunder Bay were to be offered a West Nile Virus information presentation outlining the TBDHU Action Plan and research findings, if desired.
9. Science-based information was to be used to determine the need for chemical control of larval and/or adult mosquitoes.
10. The 2021 report on West Nile Virus activity in the District of Thunder Bay was to be completed.

LARVAL MOSQUITO SURVEILLANCE

No complaint about potential larval mosquito habitat in the form of standing water was received during 2021. Larval mosquito habitat sampling should continue as necessary in 2022.

Adult Mosquito Surveillance

Twelve CDC adult mosquito light traps were operated for one night per week for nine weeks from 29 June to 24 August during 2021 for a total of 108 trap-nights. One trap was relocated by request. The remaining 11 traps were in the same fixed, secure locations as 2020. Seven light traps were located within the city of Thunder Bay and five in the surrounding area (Fig. 1).

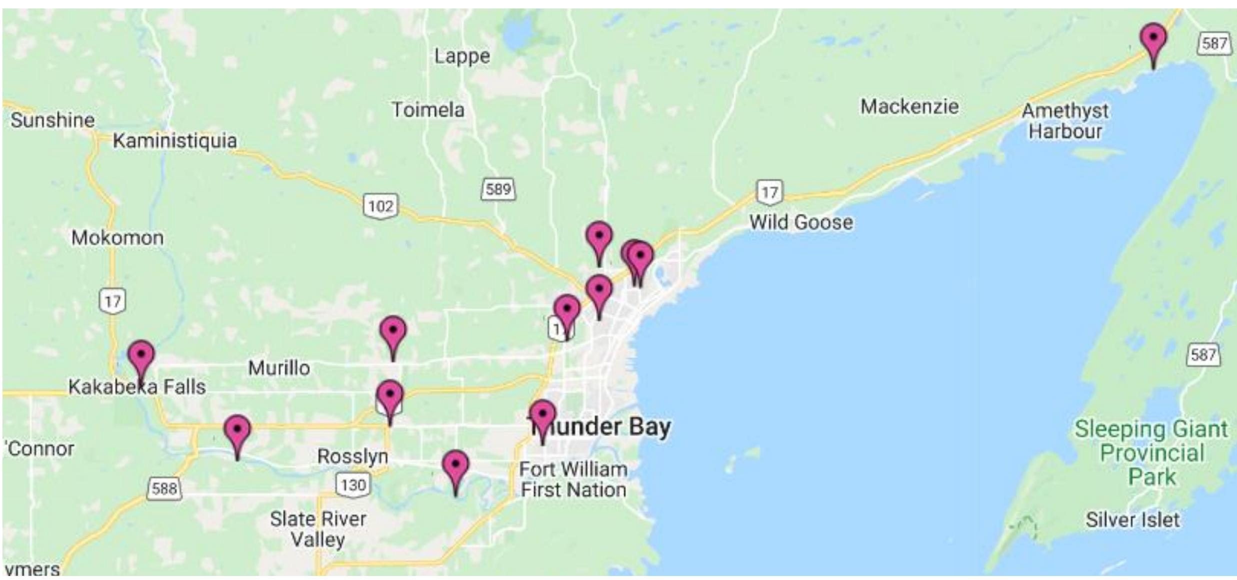

Fig. 1 Location of CDC adult mosquito light traps in the city of Thunder Bay and surrounding area, 2021.

The contents of the light traps were analysed by Entomogen Inc. All the mosquitoes were identified to species unless the trap contained more than 150 individuals. These larger samples were counted and sub-sampled with at least 150 individuals identified randomly. The remaining mosquitoes were referred to as “extras”. The light traps collected “extras” on 12 occasions during the 2021 trapping season. Entomogen Inc. also performed the viral analyses of selected vector mosquitoes as directed by Public Health Ontario (2014).

Ten vector species (one enzootic and nine epizootic) were found in the light traps. The light traps collected a total of 5499 specimens. A total of 3131 individuals were identified from these specimens, of which 439 were vectors. An additional 16 individuals were unidentified males (males do not blood feed; therefore, they do not transmit WNV). The vectors were pooled by species, then 20 pools of *Cx. restuans* and three pools of *Ochlerotatus japonicus* were tested for WNV using Reverse Transcription-Polymerase Chain Reaction (RT-PCR). No mosquito pool tested positive for WNV. No mosquitoes were tested for Eastern Equine Encephalitis Virus (EEEV). *Culiseta melanura* which is the principal vector of EEEV was not collected in the light traps during 2021.

The estimated number of each species of the unidentified specimens was based on the ratio of the individuals identified to the individuals remaining as "extras" in the light traps per sampling event. The number of identified individuals of each species was multiplied by this ratio to obtain an estimate of the approximate total number of individuals of each species collected on that night. After this conversion, males numbered 19 individuals, non-vector species numbered 4964 individuals and vector species numbered 516 individuals (Fig. 2). These values are a more accurate reflection of the number of each species within the mosquito community throughout the entire summer.

Cx. restuans, an enzootic vector recovered from the light traps, totaled 50 individuals (Fig. 3), about 0.91% of all the mosquitoes collected. The epizootic vectors were *Ae. vexans* (n= 260) (4.73%), *Anopheles punctipennis* (n= 46) (0.84%), *Anopheles quadrimaculatus* (n= 6) (0.11%), *Anopheles walkeri* (n= 7) (0.13%), *Oc. canadensis* (n= 30) (0.55%), *Oc. japonicus* (n= 3) (0.005%), *Ochlerotatus stimulans* (n= 53) (0.10%), *Ochlerotatus triseriatus* (n= 60) (0.11%), and *Ochlerotatus trivittatus* (n=1) (0.002%) (Fig.3). The majority of the non-vector mosquitoes consisted of *Cq. perturbans* (n=4289) (78.00%), the cattail mosquito which is an aggressive biter, active at dusk and abundant from July to early August. *Cq. perturbans* does not vector WNV. *Cx. pipiens,* one of the main enzootic vectors of WNV in southern Ontario, could possibly

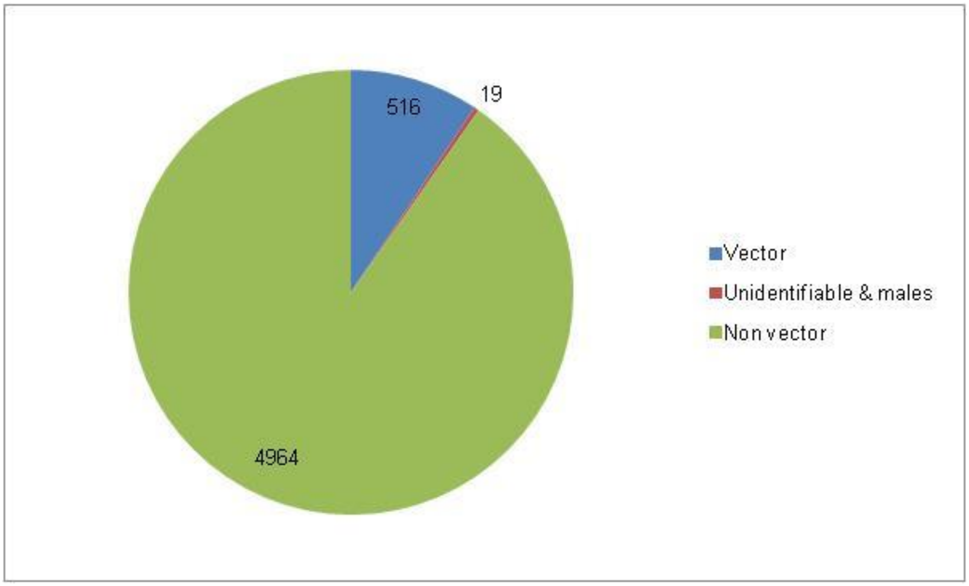

Fig. 2 Number of male, non-vector and vector mosquitoes collected in the city of Thunder Bay and surrounding area, 2022.

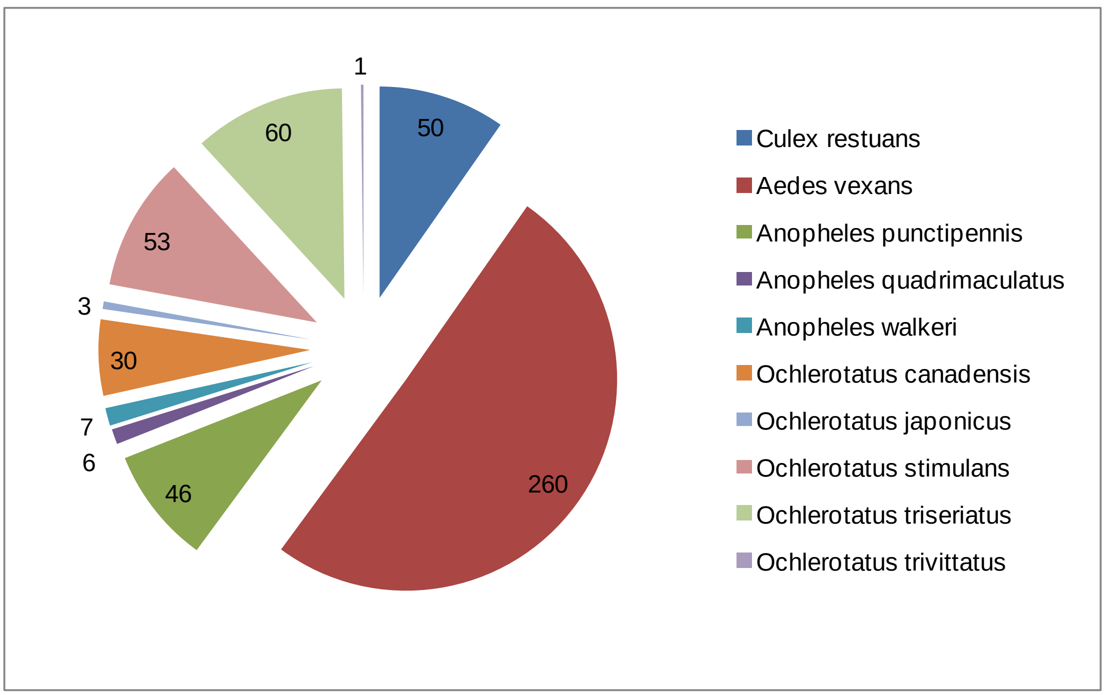

Fig. 3 Number of individuals of vector mosquito species collected in the City of Thunder Bay and surrounding area, 2022.

be present in the District of Thunder Bay, but has not been positively identified after 18 years of monitoring. Female *Cx. pipiens* and *Cx. restuans* are considered difficult to separate as species;

however, the identification of males is possible. Hundreds of *Culex* larvae have been reared to the adult stage during each year of this survey. All adult males have been positively identified as *Cx. restuans* only.

Cx. salinarius is a competent vector of WNV (Andreadis *et al.* 2004) as is *Cx. tarsalis.* Neither species was recovered during 2021. These species are widespread in the District of Thunder Bay, but they occur only in low numbers (Deacon 2014). *Oc. japonicus* is another competent vector of WNV (Moberly *et al.* 2005, Andreadis *et al.* 2004, Goddard *et al.* 2002) and was found in low numbers during 2017, 2018, 2019, 2020 and 2021. Monitoring must continue to follow the changes in the abundance and distribution of *Cx. tarsalis*, *Cx. salinarius* and *Oc. japonicus* to evaluate the potential threat that these species pose to public health.

The Ontario Ministry of Health and Long-Term Care (OMHLTC) now uses accumulated degree-days (AccDD) (based on average daily temperatures above a threshold temperature of 18.3˚C) to evaluate the risk of a WNV outbreak. The replication of WNV in mosquitoes depends on ambient temperature. The risk of a serious WNV outbreak occurs only if mosquitoes and the virus experience at least 380 AccDD, although human cases do occur at 100 to 125 AccDD (Public Health Ontario 2013). Based on the OMHLTC threshold temperature of 18.3˚C, a value of 105.5 AccDD was calculated from daily maximum/minimum temperatures recorded during 2021 at the Thunder Bay CS station (Environment Canada 2021a) and the Thunder Bay Airport Nav Canada station (located 600 m from the CS station) from 6 to 24 August while the CS site was refurbished (Environment Canada 2021b). The value of 105.5 AccDD is well below the required 380 AccDD for an outbreak; however, human cases might occur.

The low incidence of the enzootic vector *Cx. restuans* (0.91%) and the absence of *Cx. pipiens*, as well as the low AccDD value of 105.5 made the amplification of WNV within the bird community to the point of “spill-over” an extremely unlikely event during the summer of 2021. The risk to humans of acquiring WNV was considered minimal. If the climate of Thunder Bay changes to one which is similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), there will be increased risk from WNV because of increases of *Cx. restuans, Cx.*

tarsalis, Cx. salinarius, *Oc. japonicus* and perhaps the establishment of *Cx. pipiens*. Any increase in these extremely competent vectors would result in increased risk of an outbreak of WNV in the District of Thunder Bay.

BIRD SURVEILLANCE

No birds from the District of Thunder Bay were submitted to the Canadian Wildlife Health Cooperative in Guelph for WNV testing during 2021.

HUMAN SURVEILLANCE

No human cases of WNV were noted in the District of Thunder Bay during 2021, although two cases were reported during 2007 (Deacon 2008). In 2005 mosquitoes tested positive for WNV to the east of the TBDHU in the Algoma Health District (Entomogen 2005) and one human case of WNV was reported to the west of the TBDHU in the Northwestern Health Unit during 2006 (Northwestern Health Unit 2006). Although the risk of an individual acquiring WNV in the District of Thunder Bay remains low, continued monitoring of the adult mosquito community is necessary and the identification of larval habitat is essential in the event that control measures are necessary in the future.

WEST NILE VIRUS CONTROL MEASURES

Neither larviciding nor adulticiding was required within the Thunder Bay District. WNV control measures in the Thunder Bay District focused on reducing mosquito-breeding sites on private and municipal property, and on providing information to the public about the prevention of mosquito bites. During 2021 this information was disseminated to the public through pamphlets and the media.

CONCLUSIONS

A low potential for an outbreak of WNV in the District of Thunder Bay existed during 2021. *Cx. pipiens*, an extremely competent vector of WNV, as well as *Cx. restuans, Cx. tarsalis* and *Cx. salinarius* were not collected. The abundance of *Cx. restuans* in the District of Thunder Bay was so low that WNV posed a minimal risk to human health during 2021. The risk of an outbreak of WNV will increase only when the climate in the District of Thunder Bay changes to one more typical of southern Ontario or western Canada. Any climate change which increases the numbers of the extremely competent vectors *Cx. restuans, Cx. tarsalis, Cx. salinarius*, *Oc. japonicus* and perhaps allows the establishment of *Cx. pipiens* would increase the risk of an outbreak of WNV in the District of Thunder Bay.

More information is required about larval habitat, the adult mosquito communities and catch basins when the numbers of enzootic vectors increase in the light traps. Public outreach encouraging the reduction of artificial breeding sites, and personal protection measures to reduce exposure to mosquitoes should continue. A larviciding programme to augment these proposed actions should be considered only if there is a significantly increased risk of human infection by WNV. Contingency plans for pesticide treatment should be considered to prepare for the possibility that changing weather related to global climate change creates conditions more conducive for the transmission of WNV in Thunder Bay.

RECOMMENDATIONS FOR 2022

1. Complete a risk analysis of West Nile Virus activity in the Thunder Bay District.

2. Continue the adult mosquito surveillance programme within the city of Thunder Bay and surrounding area using CDC light traps.

3. Identify adult mosquitoes to species and determine the prevalence of West Nile Virus in vector species using Reverse Transcription-Polymerase Chain Reaction (RT-PCR).

4. Continue to inspect larval mosquito habitat that has been reported by, and is of concern to the public.

5. Monitor catch basins if the number of enzootic vectors increases in the light traps but only when weather permits.

6. Investigate the biology of *Cx. tarsalis* and *Oc. japonicus,* if weather permits, to determine where these critical species occur in the Boreal forest.

7. Report human cases of WNV within the District of Thunder Bay.

8. Use Geographic Information Services (GIS) to note:

- Mosquito species distributions
- Larval habitat locations
- Catch basin data
- High-risk locations

9. Offer all municipalities within the District of Thunder Bay a West Nile Virus information presentation outlining the TBDHU Action Plan and research findings, if desired.

10. Determine the need for chemical control of larval and/or adult mosquitoes using science-based information.

11. Complete the 2022 report on West Nile Virus activity in the District of Thunder Bay.

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