West Nile Virus Vector Larval Mosquito Monitoring Report - 2015

February 2016

Toronto and Region Conservation for The Living City®

Acknowledgements

TRCA recognizes the contribution of our staff who worked diligently on the West Nile Virus Surveillance and Monitoring Program. We would also like to thank our regional public health partners for their support in 2015.

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City of Toronto
Region of Durham
Region of Peel
Region of York
Toronto Remedial Action Plan

Executive Summary

West Nile virus (WNV) is primarily a bird pathogen that first appeared in Ontario in 2001. Research results suggest that two key mosquito species, *Culex pipiens* and *Culex restuans,* are primarily responsible for spreading the disease to humans in Ontario (Kilpatrick *et al*. 2005; Hamer *et al*. 2009). Mosquito species, such as *Culex pipiens* and *Culex restuans*, which are capable of carrying and transmitting WNV are referred to as **vector** species. **Non-vector** mosquito species are referred to those which are not capable of transmitting the virus. Mosquito population dynamics are influenced by complex biological and environmental factors, therefore, forecasting an outbreak has been challenging. As a result, WNV management strategies undertaken collectively by the provincial and regional health agencies in Ontario focus on prevention through education and mosquito control measures.

The numbers of human WNV case fluctuate annually (Figure 1). In 2014, the summer temperature was very low, therefore a mild WNV year was observed in Ontario with only 11 cases. In 2015, a total of 33 human cases were reported in Ontario. In the Greater Toronto Area (GTA), 14 human WNV cases were reported (Public Health Ontario, 2015).

The WNV Larval Mosquito Surveillance and Monitoring Program was established in 2003 as a measure of due diligence and at the request of TRCA's regional public health partners. The program has a three-pronged approach, which includes public education and communication, collaboration with regional public health units, and larval mosquito monitoring. The two objectives of the program are to reduce WNV risk to residents and conservation area visitors, and to protect wetlands. In 2015, these objectives were achieved by identifying WNV hotspots and taking appropriate intervention measures, through public education, and through collaboration with regional public health partners. Wetlands are traditionally considered mosquito-friendly habitats, and as a result pose a higher risk of contribution to the incidence of WNV. However, monitoring data collected by TRCA since 2003 have shown that healthy-functioning wetlands generally do not support large populations of vector mosquito species. When a WNV vector mosquito hot spot is detected, appropriate control measures can be taken to eliminate mosquito larvae if warranted.

Larval mosquito monitoring was undertaken in 47 sites across TRCA jurisdiction from June 1 to August 28 in 2015. In total, 9722 mosquito larvae were collected, of which 7918 larvae were identified, including 7563 larvae from 41 wetlands and 355 larvae from 6 stormwater management ponds (SWMPs). The rest of larvae died prematurely during the rearing process, thus the numbers were not included in risk assessment or analyses. Although most mosquitoes were collected from wetlands, higher percentage of vector mosquito larvae was collected in SWMPs. Large numbers of one vector species, *Aedes vexans* were collected in a few isolated wetlands, possibly due to high precipitation received in the spring of 2015. This attributed to higher than normal percentage of vector mosquitoes (53%) collected in wetlands. In SWMPs, vector mosquito larvae represented 75% of larvae collected.

In total, 13 mosquito species including 8 WNV vector species and 5 non-vector species were identified. The most widespread species was *Culex territans,* found in 38 sites (81%). The two

key WNV vectors, *Culex pipiens* and *Culex restuans,* were found at 21 (45%) and 10 (21%) of the sampled sites respectively.

In total, eight sites were identified as hot spots of potential WNV risk. These identified hot spots were: Glen Haffy Conservation Area, Grenadier Pond in High Park, Eglinton Flats, Claireville Conservation Area, Albion Hills Conservation Area, Evergreen Brickworks, and two unnamed floodplain in Vaughan. With the assistance from our regional health partners, control measures were taken to reduce the presence of larvae at these sites.

Toronto and Region Conservation Authority continues to liaise with our regional public health partners and researchers in the field. Collaboration with partners is a crucial part of managing WNV on TRCA properties. TRCA's data are valuable as a tool in predicting the emergence of vector species adult mosquitoes and the WNV risk in the human population. In addition, TRCA's data will be used by researchers at York University in the development of a statistical model to predict the potential future distribution and development of *Aedes aegypti*, which is the main vector of the Zika virus, dengue fever, and chikungunya in Southern Ontario.

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1. Introduction

This report provides an overview of activities conducted by The Toronto and Region Conservation Authority (TRCA) through its West Nile virus (WNV) vector larval mosquito monitoring program in 2015. West Nile virus primarily exists between birds and bird-biting mosquitoes, however humans can be infected through the bite of a mosquito which had fed on infected birds. Humans are considered dead-end hosts whereby people can be infected by WNV, but do not spread it. The majority of people who become infected with WNV will have no symptoms or only mild flu-like symptoms. Severe cases of WNV illness, including the development of meningitis and encephalitis, are extremely rare but can be fatal.

Mosquito species that are capable of carrying and transmitting WNV are referred to as the **vector** species. Species that do not transmit the virus are called the **non-vector** species. There are 58 established mosquito species in Ontario, of which 13 species are WNV vectors. Studies (Kilpatrick *et al*. 2005; Hamer *et al*. 2009) suggested that *Culex pipiens* and *Culex restuans* are not only the primary species in spreading the disease among birds, but also the primary species that spread the disease into the human populations. Study (Tiawsirisup *et al*. 2008) also indicated that vector *Aedes vexans* is nearly as competent of carrying and transmitting WNV as *Culex pipiens*, therefore it is also a significant vector species. Most other mosquito species do not pose serious WNV threats and their larvae are important food sources for fish and other predatory aquatic organisms.

TRCA owns over 17,000 hectares of land, including natural and constructed wetlands, woodland pools, reservoirs, and ponds. These aquatic ecosystems have been considered "mosquito friendly" as a result of the permanent availability of standing water (Knight *et al*. 2003; Gingrich *et al*. 2006; Rey *et al*. 2006), and were original thought to be increasing the risk of WNV. The WNV Surveillance and Monitoring Program was initiated in 2003 as a measure of due diligence, and at the request of TRCA's regional public health partners (Regions of Peel, York, Durham and the City of Toronto). Selected natural habitats (collectively referred to as "wetlands" in this report) and stormwater management ponds (SWMPs) have been monitored for the presence of mosquito larvae in the summer since the launch of the program. Data collected have been used to identify sites of potential concern or vector mosquito "hot spots", which may require follow-up with appropriate management actions.

The objectives of the WNV Vector Mosquito Larval Monitoring and Surveillance Program are to reduce WNV risk and protect wetlands on TRCA properties through the following three approaches:

- **Public Education and Communication:** to respond to public inquiries on WNV related issues and address standing water complaints.

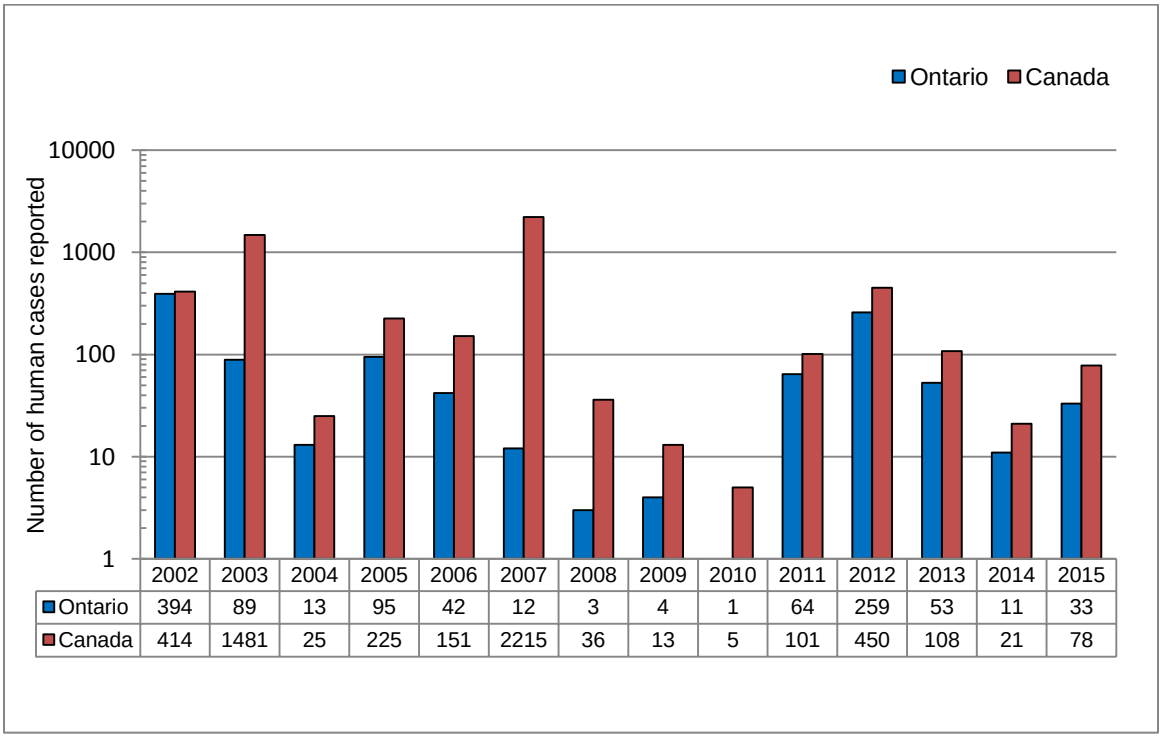
- **Collaboration with Regional Health Units:** to participate in WNV advisory committees and share information and data.

- **Monitoring and Surveillance:** to identify sites of potential concern through larval mosquito monitoring and take appropriate control measures if deemed necessary.

In Canada, the number of human WNV cases fluctuates annually (Figure 1), driven by various environmental and biological factors. In 2015, a total of 78 human cases were reported from three provinces: Quebec – 40, Ontario – 33, and Manitoba – 5 (Public Health Agency of Canada, 2015). Within TRCA's jurisdiction, 16 human WNV cases were reported in 2015.

Ontario's provincial and regional health agencies continued to monitor adult mosquitoes, larval mosquitoes, and human cases as part of the WNV surveillance programs. Adult mosquitoes monitoring is crucial for determining the immediate risk of humans contracting WNV. Larval mosquito surveillance provides information allowing regional public health units to eliminate/reduce mosquito larvae through larvicide application. Human surveillance information is used to alert the health care professionals of an outbreak, and also provides clues about who may be at higher risk for serious health effects from WNV. The more comprehensive dead bird surveillance program had been terminated since 2009 in Ontario; however, The Canadian Wildlife Health Cooperative continues to test dead birds for WNV in collaboration with Ontario laboratories and The National Microbiology Laboratory in Winnipeg.

Figure 1. Human West Nile virus cases in Ontario and in Canada, 2002 – 2015



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ontario	394	89	13	95	42	12	3	4	1	64	259	53	11	33
Canada	414	1481	25	225	151	2215	36	13	5	101	450	108	21	78

2. Public Education and Communication

Public Education and Communication of the program focused on prevention through increasing public awareness and addressing standing water concerns on TRCA properties.

2.1 Increasing public awareness of West Nile virus

In 2015, TRCA continued to increase public awareness of WNV by:

- Providing up-to-date related information, and making the annual reports such as this one available on TRCA website (http://www.trca.on.ca/the-living-city/monitoring/west-nile-virus.dot).
- Sharing tips on personal protection against mosquito bites with staff and providing the latest TRCA and public health monitoring updates.
- Displaying posters and brochures containing WNV information in TRCA offices and Conservation Areas.

2.2 Standing Water Complaints

2.2.1 Standing Water Complaint Procedure

Complaints or inquiries regarding standing water or mosquito activities were addressed according to TRCA's Standing Water Complaint Procedure (Appendix A); it includes the following steps:

1. Acquire background information (location, name of the complainant, contact information, and the nature of the complaint).

2. Evaluate the location for its proximity to an existing sampling station, and the sensitivity of the area (i.e. is this an Environmental Sensitive Area (ESA) or not).

3. Property Management Division is consulted to review property ownership, management agreements and land regulation information.

4. For non-TRCA property or property under management agreement, the respective regional public unit is notified. For TRCA properties, if deemed necessary, monitoring activity following the methods described in Section 4.1 is undertaken.

5. When a potential hotspot is identified, and if larviciding is deemed appropriate, the following agencies are notified:
   - Respective regional public health unit.
   - Manager and Director at TRCA – for approval to proceed with the larvicide treatments.
   - The Ministry of the Environment and Climate Change (MOECC) – to obtain the permit for larviciding.
   - The Ministry of Natural Resources and Forestry (MNRF) – to review the sensitivity of the area.

6. Notify the complainant with the results of the investigation.

2.2.2 Standing Water Complaint Sites

In 2015, TRCA did not receive any standing water complaints.

3. Collaboration with Regional Health Units

The collaboration efforts with our regional public health partners involved workshops, notification of hot spots and advisory committee participation. Biologist at TRCA provided larval mosquito identification training to Durham Region, Halton Region, and the City of Hamilton Public Health staff. In total, 19 public health staff received training on how to identify species of mosquitoes commonly collected in southern Ontario.

In 2015, TRCA identified 8 hotpots for potential WNV risk and public health units assisted TRCA in larviciding these hotspots as a preventive measure.

Participation in regional West Nile virus advisory committees is an important part of liaising with public health partners. In addition, an Order from the Peel Region Medical Officer was issued under the *Health Protection and Promotion Act*, R.S.O. 1990, c. H.7 to facilitate mosquito reduction activities within the Heart Lake Wetland Complex in Brampton if needed.

4. Larval Mosquito Monitoring

4.1 Methods

4.1.1 Monitoring Site Locations

The 2015 larval mosquito monitoring program began on June 1, sampling 41 wetlands and 6 SWMPs across TRCA's jurisdiction (Figure 2). Two new monitoring sites were added in 2015: Granger Wetland North Pond and the Evergreen Brickworks Wetland.

Granger Wetland North Pond was included in the 2015 based on the monitoring results obtained in 2014. Granger Wetland South Pond was identified as a hot spot in 2014, and due to the close proximity of these two ponds, Granger Wetland North Pond was added as a routine monitoring station.

TRCA, in partnership with Toronto Water, and Toronto Parks, Forestry & Recreation has restored a section of Mud Creek - a tributary of the Don River - located adjacent to the Evergreen Brick Works. Due to the recreational use of this location, the Evergreen Brick Works Wetland was added as a routine monitoring station in 2015.

4.1.2 Sampling and Identification of larval mosquitoes

Each monitoring station was sampled five times in approximately two- week intervals between June and August. The waterbody at each station was divided into four comparatively equal quadrants, and one sample was taken within each quadrant. Each sample was consisted of dipping with a standard mosquito dipper (diameter = 13cm; Figure 3) 10 times. During sampling, field technicians used several dipping techniques to ensure that all types of potential mosquito habitats were sampled (Figure 3). Samples were not collected during a rain event because raindrops disturb the water surface and consequently cause mosquito larvae to disperse (O'Malley, 1995).

Collected mosquito larvae were taken back to the lab (Figure 3), enumerated, and reared in rearing chambers until they reached maturity (fourth instar stage). The larvae were then preserved in 70% ethyl alcohol and identified to species under a dissecting microscope using mosquito taxonomic keys (Wood *et al.,* 1979; Darsie and Ward, 2005). Those larvae that died before reaching maturity were not identified.

4.1.3 WNV Risk Assessment

WNV risk ranking was assessed for each site based on the number of vector larvae found in a sample after each site visit, according to the modified Wada's method of ranking (Wada, 1956):

- Sites with no vector larvae were ranked as "***Nil***" risk;
- Sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk;
- Sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk;
- Sites with >31 vector larvae per 10 dips were ranked as "***High***" risk sites.

Risk ranking was applied to each vector species independently, instead of the cumulative number of vector larvae found due to species variation in WNV transmission abilities.

Sites with "high" risk ranking or vector hot spots were addressed, the respective regional health unit was informed and if warranted, the sites were treated with larvicide.

Since mosquitoes can only carry WNV after biting an infected bird, mosquito larvae do not need blood meals thus do not carry the virus. When a site is ranked as high-risk, it does not imply that the virus is present and poses immediate threat to the public. The risk ranking merely indicates the presence of vector mosquito species which could potentially spread WNV to human populations after they emerge as adult mosquitoes, not the presence of the virus.

Figure 2. Location of West Nile virus monitoring program sites, 2015

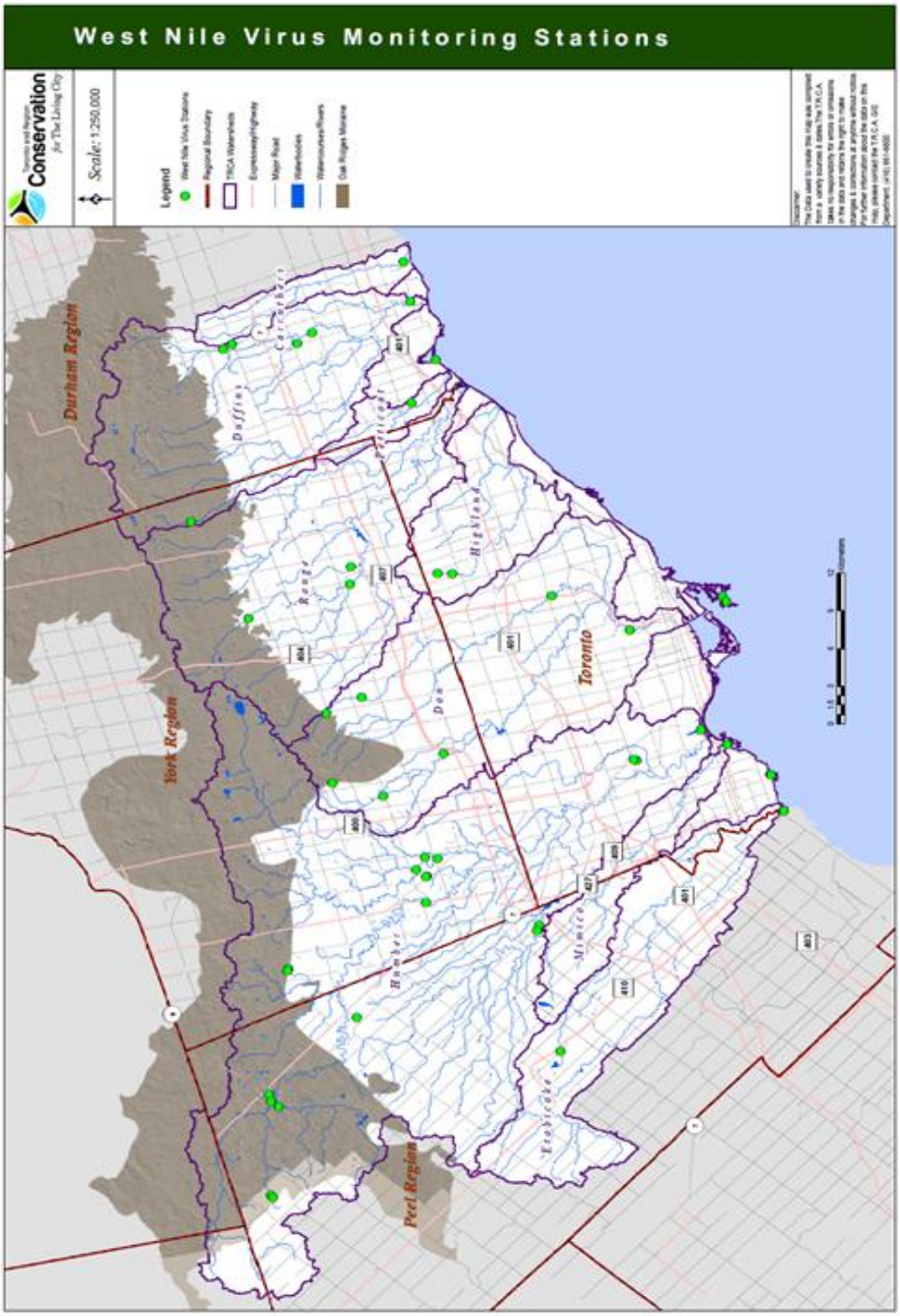


Figure 3. Sampling Larval Mosquitoes

(Top) Field technician sampling with a standard mosquito dipper; (middle) Mosquito Larvae being numerated in the lab; (bottom) Mosquito larvae were identified and preserved in ethyl alcohol.

4.2 Results

4.2.1 Mosquito diversity

In total, 7,918 mosquito larvae representing 13 species were identified from 47 routine monitoring stations. Mosquito larvae that died prematurely were not identified, thus excluded from the analyses and risk assessment in the following sections. A higher percentage (n=1804; 18%) of mortality during the rearing process was observed this year. In total, 524 (5%) larvae that died during the rearing processed were from the sites treated with larvicide in early June (after being identified as hotspots during the first sampling event). The larvicide applied in these locations is a natural occurring bacterium called *Bti* which targets mosquito larvae and is activated only when ingested. Death can occur with hours or up to weeks. In the lab, we observed the affected mosquitoes stopped advancing into their next life stage, and then died after a few days during the rearing process.

Species of mosquitoes collected included five non-vector species (*Culex territans, Culiseta morsitans, Ochlerotatus implicatus, Psorophora ferox*, and *Uranotaenia sapphirina)* and eight WNV vector species (*Aedes cinereus, Aedes vexans*, *Anopheles punctipennis, Anopheles quadrimaculatus, Culex pipiens*, *Culex restuans*, *Culex salinarius,* and *Ochlerotatus trivittatus)*. The most widespread species was *Culex territans,* a non-vector species, which inhabited 38 of the 47 (81%) monitoring sites. It was also the most abundant, in total, 3620 specimens were collected and identified. Two key WNV vectors, *Culex pipiens* and *Culex restuans,* were found at 21 (45%) and 10 (21%) of the sampled sites respectively. *Culex pipiens* were collected in more sites in 2015, indicating a wider distribution compared to 2014, *Culex restuans* occurrence remained similar to previous years. *Aedes vexans* were collected at eight sites; however they occurred in high numbers (e.g 412 mosquitoes were collected from one site during a sampling event). As in previous years, higher mosquito diversity was observed in wetlands compared to SWMPs. This finding may be attributed to the facts that more wetland sites were sampled, and wetlands generally provide more diverse habitats and shelter.

4.2.2 Wetlands

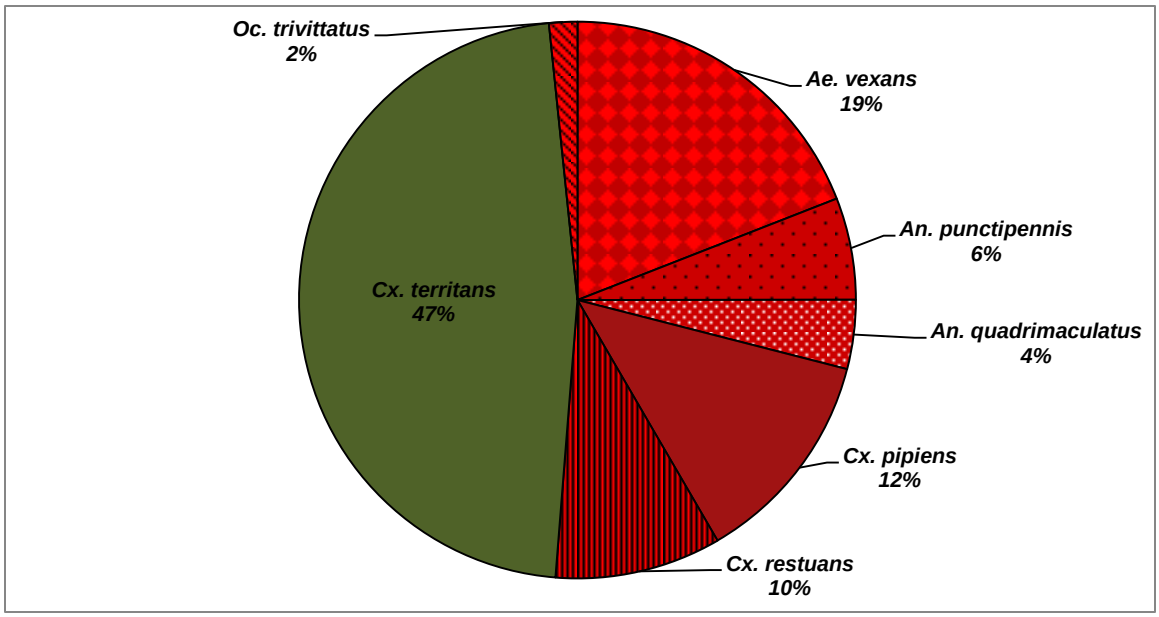
In total, 7563 mosquito larvae of 13 different species were identified. Similar to the findings from previous years, the predominant non-vector species was *Culex territans* (47%). The predominant vector species was *Aedes vexans* (19%) in 2015 as opposed to *Culex pipiens (*Figure 4). The high numbers of *Aedes vexans* could be attributed to the amount of precipitation received early in the season, noting that in 2010, similar trend showed that higher precipitation in the month of June caused higher abundance of *Aedes vexans* (Figure 5). Three hotspots were treated in early in June because of high concentrations of *Aedes vexans* mosquitoes (Table 1).

Combined species abundance in wetlands showed that vector and non-vector species were fairly equally presented (Figure 6), however monitoring results also show that most wetlands (n=33; 80%) posed minimal risk for harbouring WNV vector mosquitoes. The percentage of vector to non-vector mosquito species ratio fluctuated from year to year driven by environmental factors (Figure 6).

Isolated vector mosquito hot spots (n = 8; Table 1) continued to occur and environmentally friendly larvicide, *Bacillus thuringiensis israelensis (Bti)* was used to treat these hot spots. *Bti* is a bacterium found naturally in soils, and since 1982, it has been used successfully worldwide as a biological pest control agent to combat mosquitoes and black flies (Health Canada 2011). The pest control contractor displayed signs to notify the public prior and during larvicide treatments. The eight identified hot spots were: Glen Haffy Conservation Area, Grenadier Pond in High Park, Eglinton Flats, Claireville Conservation Area, Albion Hills Conservation Area, Evergreen Brickworks, and two unnamed floodplain in Vaughan. Full mosquito monitoring risk assessment results for each monitoring station can be found in Appendix B-1 to B-4.

Figure 4. Mosquito species composition in wetlands in 2015.

(non-vector species are indicated in green and vector species are indicated in red)



Note: Other 6 less common species collectively represented less than 1% of the mosquito collected, therefore excluded from the figure.

Figure 5. Summer Precipitation and *Aedes vexans* abundance, 2009-2015

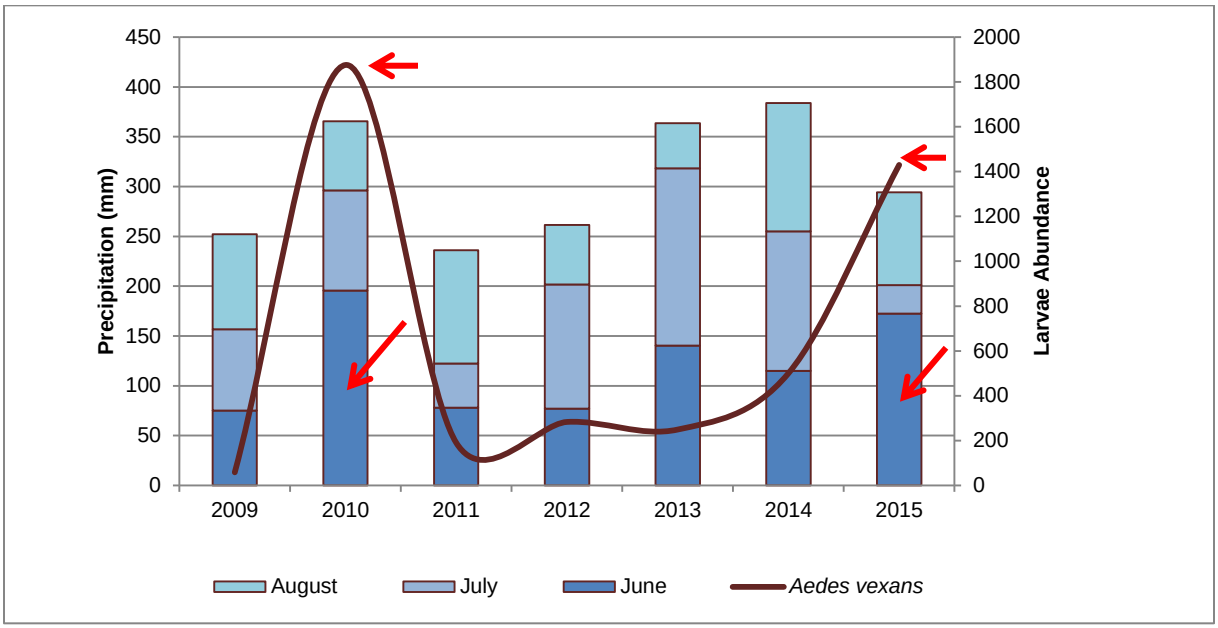
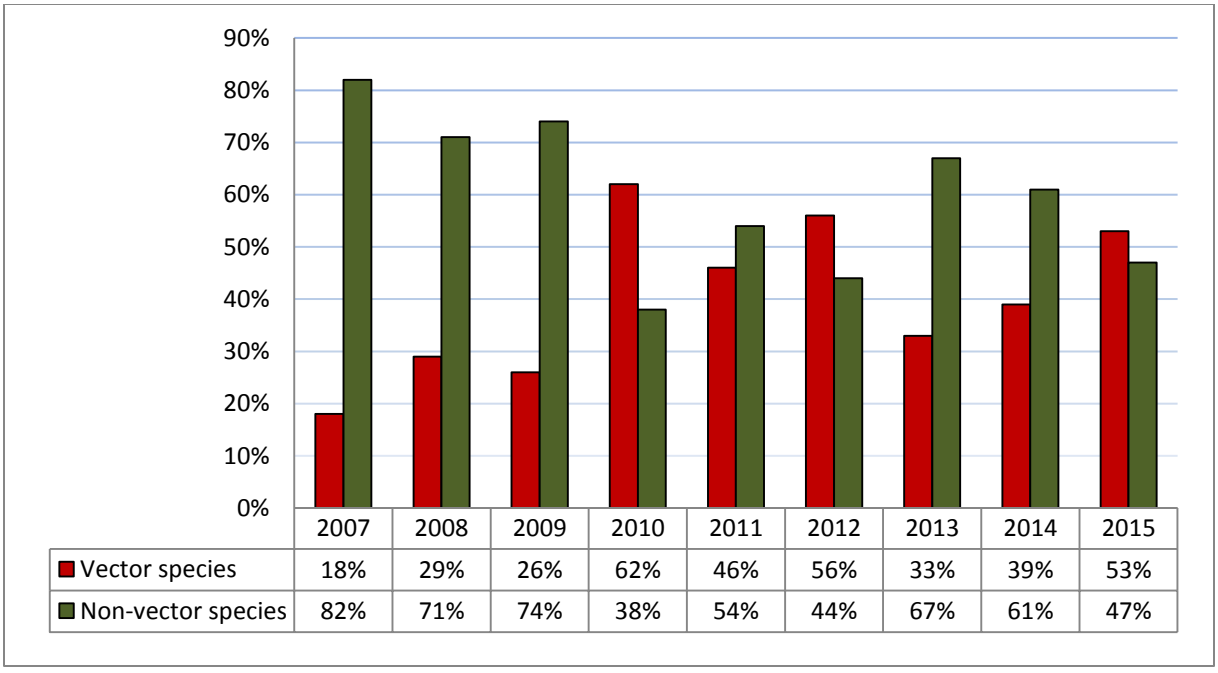


Figure 6. Vector and Non-vector Mosquito species abundance in Wetlands, 2007-2015



	2007	2008	2009	2010	2011	2012	2013	2014	2015
Vector species	18%	29%	26%	62%	46%	56%	33%	39%	53%
Non-vector species	82%	71%	74%	38%	54%	44%	67%	61%	47%

Table 1. Identified WNV Vector Mosquito Hotspots, TRCA - 2015

Site	Region	Vector species	Identified on
Eglinton Flats	Toronto	*Culex restuans*	June 5, 2015
Floodplain (Vaughan)	York	*Aedes vexans*	June 11, 2015
Albion Hills Conservation Area	Peel	*Aedes vexans*	June 15, 2015
Claireville Conservation Area	Peel	*Aedes vexans*	June 16, 2015
High Park – Grenadier Pond	Toronto	*Culex pipiens*	July 13, 2015
Evergreen Brickworks	Toronto	*Culex pipiens*	July 28, 2015
Glen Haffy Conservation Area	Peel	*Anopheles punctipennis*	August 5, 2015
Floodplain 2 (un-named)	York	*Aedes vexans*	August 6, 2015

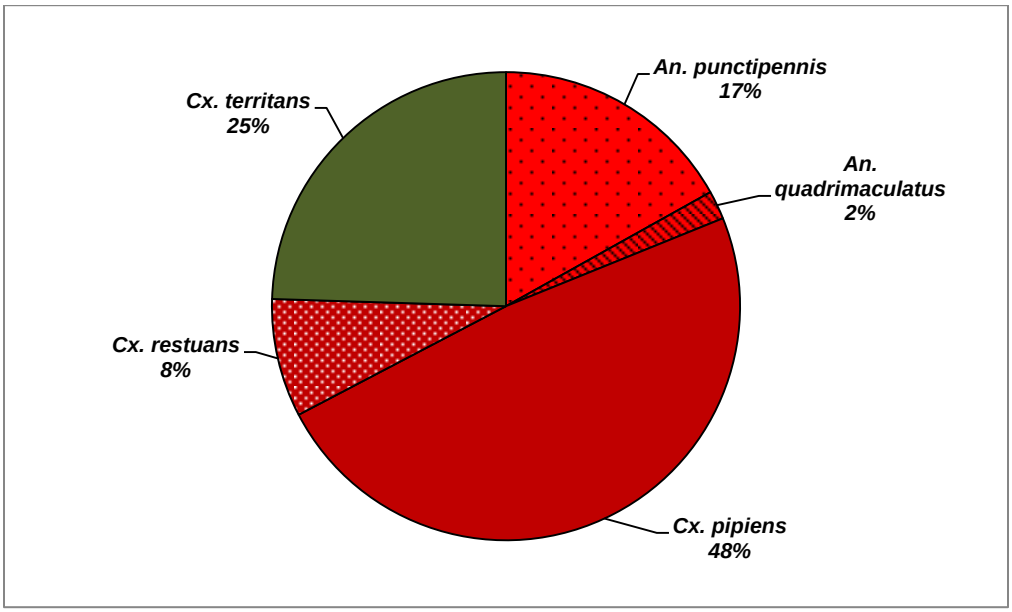
4.2.3 Stormwater Management Ponds

From the 6 SWMP monitoring sites, 355 mosquito larvae were identified, which consisted of 267 (75%) vector and 87 (25%) non-vector mosquito species larvae. The most abundant mosquito species was *Culex pipiens* (48%), while the non-vector species, *Culex territans* only represented 25% of the larvae collected (Figure 7). Since 2014, the L'Amoreaux Park North Pond, which was identified as a hot spot annually had not been identified as a *Culex pipiens* hotspot. The reason for this reduction in *Culex pipiens* presence is not clearly known. As sediment removal re-establishes the effectiveness of SWMP, maintenance work is scheduled for the L'Amoreaux Park Ponds (North and South) in 2016.

None of the sampled SWMPs were identified as hot spots for WNV vector mosquitoes this year. Full mosquito monitoring risk assessment results for each monitoring station can be found in Appendix B-1 to B-4.

Figure 7. Mosquito species composition in stormwater management ponds, 2015.

(non-vector species are indicated in green and vector species are indicated in red)



4.3 Surveillance of West Nile virus in Ontario

In 2015, number of WNV human cases increased to 33 cases from 11 cases in 2014 in Ontario (Figure 1). This could be attributed to warmer summer temperatures in 2015, which contrasted with the cool summer condition and low abundance of vector mosquitoes documented in 2014. Most human cases were reported in urban areas in Ontario because of the large numbers of catch basins, which are the preferred development site for the *Culex* mosquito vector species. Public Health Units continued to treat these catch basins on a regular basis in the summer months (4-5 treatments to be repeated at 3-week intervals).

5. Conclusions

The results from the 2015 program supported the findings from the previous TRCA studies. Generally, wetlands do not pose threats of WNV transmission. Monitoring results showed that most wetlands (n=40; 85%) posed minimal risk for harbouring WNV vector mosquitoes.

Compared to 2014, a moderate increase in WNV infection rate in humans was observed in Ontario. West Nile virus vector hotspots continued to occur; eight hot spots were detected and treated with the assistance provide by the City of Toronto Public Health, York Region Public Health, and Peel Region Public Health. The ability to detect hot spots, and subsequently take appropriate control measures continue to highlight the importance of regular and continuous seasonal monitoring of mosquito abundance.

Collaboration with Regional Public Health units is crucial in proactively managing WNV vector hot spots in a timely manner on TRCA properties.

It is difficult to predict the annual level of WNV activity. However in general, temperature is the major influencing factor. As the past winter had been very mild, Ontario could experience a higher year of WNV activity in the summer of 2016. This is because with the mild winter conditions, more hibernating *Culex* spp. female mosquitoes are expected to survive into this coming spring.

TRCA's data are valuable for regional public health partners to use as a tool in predicting the emergence of vector species adult mosquitoes and the WNV risk in the human population. In addition, TRCA's data will be used by researchers at York University in the development of a statistical model to predict the potential future distribution and development of *Aedes aegypti*, which is the main vector of the Zika virus, dengue fever, and chikungunya in Southern Ontario.

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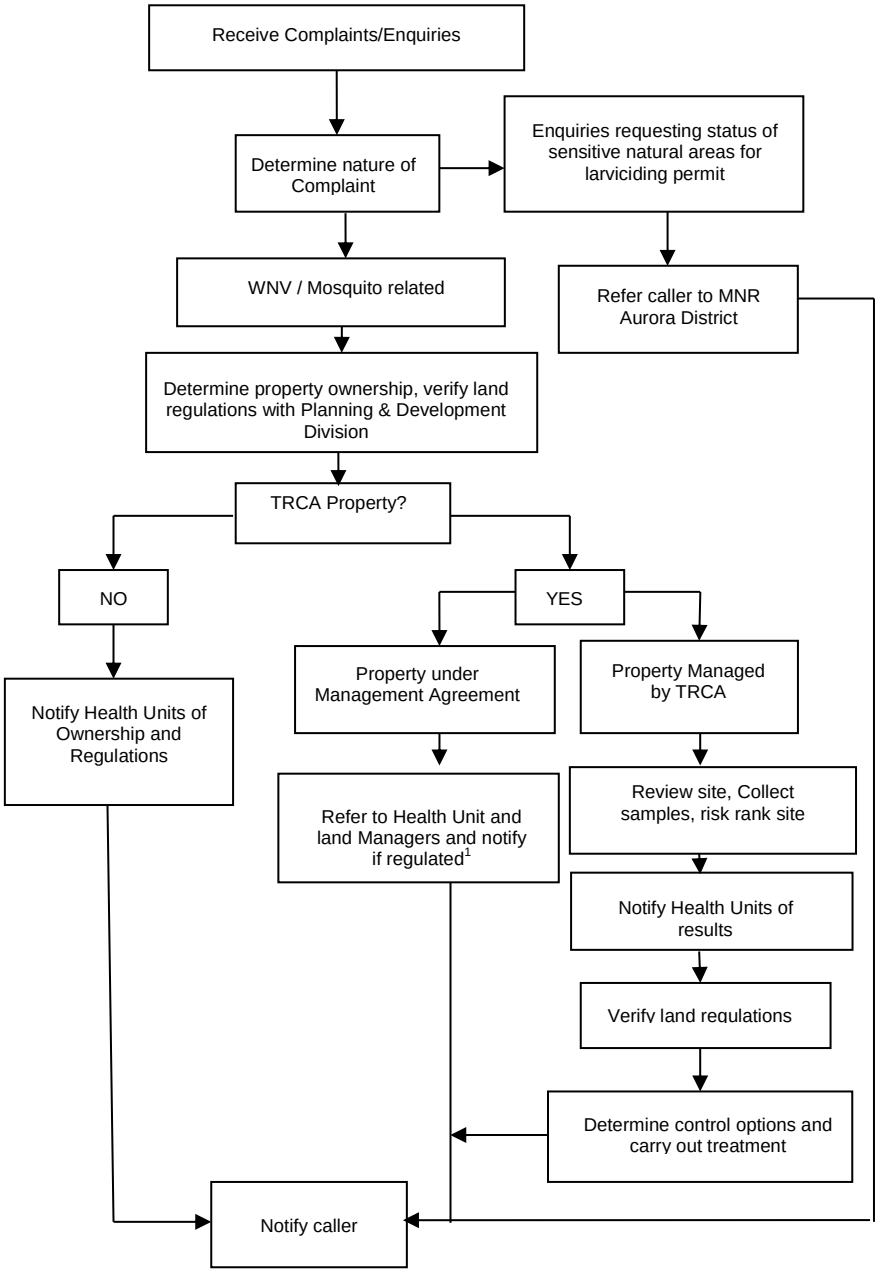
Appendices

Appendix A. TRCA Standing Water Complaint Procedure



Appendix B-1 Monitoring and Risk Assessment Results in Durham Region - 2015

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Wetland sites are indicated by black fonts and Stormwater Management Ponds (SWMPs) are indicated by **orange** font.

Site	Sampling Event	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*	*Oc. trivittatus*
Altona Forest	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Low	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Low	Low	Nil	Nil	Nil
	5	Moderate	Low	Nil	Low	Nil	Nil
Carruthers Swamp Complex	1-5	Nil					
Claremont Wetland-1	1	Nil	Low	Nil	Nil	Nil	Nil
	2	Nil	Moderate	Nil	Nil	Nil	Nil
	3	Nil	Low	Low	Nil	Nil	Nil
	4	Nil	Moderate	Moderate	Nil	Nil	Nil
	5	Nil	Moderate	Nil	Nil	Nil	Nil
Claremont Wetland-2	1	Nil	Nil	Low	Nil	Nil	Nil
	2	Nil	Nil	Low	Nil	Nil	Nil
	3	Nil	Low	Moderate	Nil	Nil	Nil
	4	Nil	Nil	Moderate	Nil	Nil	Nil
	5	Nil	Nil	Moderate	Nil	Nil	Nil
Frenchman's Bay Promenade	1-3	Nil					
	4	Nil	Low	Nil	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Greenwood Marsh	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Moderate	Low	Nil	Nil	Nil
	5	Nil	Low	Nil	Nil	Nil	Nil
Greenwood Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Low	Low	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Low	Nil	Nil	Nil	Nil
	5	Nil	Moderate	Low	Low	Nil	Nil
Lower Duffins	1	Nil	Nil	Nil	Moderate	Low	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Low	Low	Nil	Nil	Nil
	5	Nil	Moderate	Low	Nil	Nil	Nil

Appendix B-2 Monitoring and Risk Assessment Results in Peel Region - 2015

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.
Wetland sites are indicated by black fonts and Stormwater Management Ponds (SWMPs) are indicated by **orange** font.

Site	Sampling Event	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatu*	*Cx. pipiens*	*Cx. restuans*	*Oc. trivittatus*
Albion Hills Pond-1	1-3	No risk					
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Low	Nil	Nil
Albion Hills Pond-2	1	High	Low	Nil	Nil	Low	Low
	2	Nil	Nil	Low	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4-5	Nil					
Albion Hills Pond-4	1	Nil	Low	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Low	Nil	Nil	Nil
	4	Nil	Moderate	Moderate	Nil	Nil	Nil
	5	Nil	Low	Low	Nil	Nil	Nil
Claireville Wetland-1	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Moderate	Nil	Nil	Nil
	4	Nil	Moderate	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
Claireville Wetland-2	1	High	Nil	Nil	Nil	Nil	Moderate
	2	High	Low	Nil	Moderate	Nil	Moderate
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
Glen Haffy Trout Pond-1	1	Nil	Nil	Low	Nil	Nil	Nil
	2	Nil	Low	Nil	Nil	Nil	Nil
	3	Nil	Moderate	Low	Nil	Nil	Nil
	4	Nil	High	Moderate	Nil	Nil	Nil
	5	Nil	Moderate	Moderate	Nil	Nil	Nil
Glen Haffy Trout Pond-2	1	Nil	Low	Nil	Nil	Nil	Nil
	2	Nil	Low	Nil	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	4-5	Nil	Nil	Nil	Nil	Nil	Nil
Heart Lake	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	Nil	Low	Nil	Nil	Nil	Nil
Marie Curtis	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
SWMP-174	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Moderate	Low	Nil	Nil	Nil
	5	Nil	Low	Low	Nil	Nil	Nil

Appendix B-3 Monitoring and Risk Assessment Results in Toronto - 2015

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.
Wetland sites are indicated by black fonts and Stormwater Management Ponds (SWMPs) are indicated by **orange** font.

Site	Sampling Event	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*	*Oc. trivittatus*
Col. Samuel Smith Main Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Low	Nil	Nil	Nil
	4	Nil	Low	Nil	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Col. Samuel Smith Mini Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Low	Nil	Nil	Nil
	3-5	Nil					
High Park Grenadier Pond	1	Nil	Low	Nil	Low	Low	Nil
	2	Nil	Nil	Nil	Moderate	Low	Nil
	3	Nil	Nil	Nil	High	Low	Nil
	4	Nil	Nil	Low	Low	Nil	Nil
	5	Nil	Nil	Nil	Moderate	Low	Nil
L'Amoreaux North Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Moderate	Moderate	Nil
	4	Nil	Low	Low	Moderate	Nil	Nil
	5	Nil	Low	Nil	Moderate	Low	Nil
L'Amoreaux South Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	Nil	Low	Nil	Nil	Nil	Nil
Milne Hollow	1-4	Nil					
	5	Nil	Low	Nil	Nil	Nil	Nil
Mimico Amphibian Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Low	Nil	Nil
	4	Nil	Nil	Nil	Low	Nil	Nil
	5	Nil	Nil	Nil	Low	Nil	Nil
Topham Pond	1	Low	Nil	Nil	Moderate	High	Nil
	2	Nil	Nil	Low	Moderate	Moderate	Nil
	3-5	Nil					
TTP Goldfish Pond	1-5	Nil					
TTP Tri-Pond	1-3	Nil					
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
Woodland Pond	1	Nil	Nil	Nil	Moderate	Low	Nil
	2	Nil	Nil	Nil	Low	Nil	Nil
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	Moderate	Nil	Nil
	5	Nil	Low	Low	Moderate	Nil	Nil
Brickworks Pond 1	1	Nil	Nil	Nil	Moderate	Low	Nil
	2	Nil	Nil	Nil	Nil	Nil	Nil
	3	Nil	Nil	Nil	Nil	Nil	Nil
	4	Nil	Nil	Nil	High	Moderate	Nil
	5	Nil	Nil	Low	Moderate	Low	Nil

Appendix B-4 Monitoring and Risk Assessment Results in York Region - 2015

Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.

Wetland sites are indicated by black fonts and Stormwater Management Ponds (SWMPs) are indicated by **orange** font.

Site	Sampling Event	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*	*Oc. trivittatus*
Boyd Conservation Area	1-2	Nil					
	3	Nil	Nil	Low	Nil	Nil	Nil
	4	Nil	Low	Nil	Low	Nil	Nil
	5	Nil	Low	Nil	Nil	Nil	Nil
Bruce's Mill	1-2	Nil					
	3	Nil	Low	Nil	Nil	Nil	Nil
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
Cold Creek Pond	1-3	Nil					
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
Cold Creek Wetland	1-4	Nil					
	5	Nil	Low	Low	Nil	Nil	Nil
Earth Rangers	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Low	Nil	Nil	Nil
	3	Nil	Moderate	Low	Low	Nil	Nil
	4	Nil	Low	Moderate	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Granger Wetland South	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Low	Nil	Nil	Nil
	3	Nil	Low	Low	Low	Nil	Nil
	4	Nil	Low	Moderate	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Granger Wetland North	1-2	Nil					
	3	Nil	Nil	Low	Nil	Nil	Nil
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Keffer Marsh	1-2	Nil					
	3	Nil	Low	Nil	Low	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	Nil	Low	Nil	Nil	Nil	Nil
Killian Lamar	1-2	Nil					
	3	Nil	Nil	Nil	Low	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	Nil	Nil	Low	Nil	Nil	Nil
Kortright Centre Marsh	1	Moderate	Nil	Low	Nil	Nil	Nil
	2	Nil	Low	Low	Nil	Nil	Nil
	3	Nil	Low	Moderate	Nil	Nil	Nil
	4	Nil	Nil	Low	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil

Appendix B-4 Monitoring and Risk Assessment Results in York Region – 2015 (Continued)
Sites with no vector larvae were ranked as "***Nil***" risk; sites with <2 vector larvae per 10 dips were ranked as "***Low***" risk; sites with 2 - 30 vector larvae per 10 dips were ranked as "***Moderate***" risk; and sites with >31 vector larvae per 10 dips were ranked as "***High***" risk.
Wetland sites are indicated by black fonts and Stormwater Management Ponds (SWMPs) are indicated by **orange** font.

Site	Sampling Event	*Ae. vexans*	*An. punctipennis*	*An. quadrimaculatus*	*Cx. pipiens*	*Cx. restuans*	*Oc. trivittatus*
Stouffville Reservoir	1-2	Nil					
	3	Nil	Nil	Low	Nil	Nil	Nil
	4	Nil	Low	Low	Nil	Nil	Nil
	5	Nil	Nil	Moderate	Nil	Nil	Nil
Toogood Pond	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Low	Nil	Low	Nil	Nil
	3-5	Nil					
un-named wetland - Vaughan	1	High	Low	Nil	Moderate	Moderate	Moderate
	2	Nil	Moderate	Nil	Moderate	Moderate	Nil
	3	Nil	Low	Low	Low	Nil	Nil
	4	Nil	Nil	Nil	Nil	Nil	Nil
	5	High	Moderate	Nil	Nil	Nil	Low
Un-named Wetland 1	1	Moderate	Low	Nil	Low	Moderate	Moderate
	2-3	Nil					
	4	Nil	Low	Nil	Nil	Nil	Nil
	5	Nil	Nil	Nil	Nil	Nil	Nil
un-named Wetland 2	1-3	Nil					
	4	High	Low	Nil	Low	Nil	Low
	5	Nil	Low	Low	Nil	Nil	Nil
SWMP-88.2	1	Nil	Nil	Nil	Nil	Nil	Nil
	2	Nil	Nil	Nil	Nil	Low	Nil
	3	Nil	Nil	Nil	Moderate	Moderate	Nil
	4	Nil	Low	Nil	Moderate	Nil	Nil
	5	Nil	Moderate	Low	Low	Nil	Nil
SWMP-139	1-3	Site Under Construction					
	4-5	Nil					