Regional District of Central Okanagan

West Nile Virus Prevention Program, 2004 - 2008

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ABSTRACT

Each year since 2004, West Nile virus (WNv) Risk Reduction funding has been granted to the Regional District of the Central Okanagan (RDCO). Public education, mosquito surveillance, vector larval mapping and larval mosquito control have been carried out with this grant funding from the Ministry of Health Services (administered through the Union of BC Municipalities). This report is a summary of work conducted under that funding.

Public education expenditures included the presentation of a WNv education booth, as well both television and radio advertising. The booth was displayed on a number of occasions at Farmer's Markets and trade shows. Television and radio advertising was purchased in 2007, and radio advertising was purchased in 2008. The focus of the public education campaign was "personal protection from West Nile virus" and "mosquito control around the home."

The City of Kelowna operated adult mosquito traps at a number of sites during the summer months between 2004 and 2006, and the RDCO has also sampled adult mosquitoes periodically between 2004 and 2008. Mosquitoes captured were shipped to Kamloops for identification to species level. In all, 9,990 mosquitoes were captured by the City of Kelowna and the RDCO and identified to the species level. As well, the Interior Health Authority (IHA) operated adult mosquito traps at a number of trapping locations throughout the RDCO. The IHA traps were operated between June and September each year, and adult mosquitoes captured in the traps were shipped to the BC Centre for Disease Control (BCCDC) to determine if they were infected with WNv. Between 2003 and 2008, the IHA captured a total of 29,516 mosquitoes at six different trapping locations. None of the mosquitoes captured were found to be infected with WNv.

The RDCO monitors approximately 266 larval development sites annually, and when sufficient concentrations of larvae are present, they treat these sites with the biological larvicide, Vectobac 200G. Since 2004, the RDCO has applied 2771.0kg of larvicide to 366.19ha of surface water containing mosquito larvae. As well, over 10,000 catch basins in Peachland, Westbank, Lake Country and the City of Kelowna are treated each year with VectoLex when larvae are present, in some cases up to three times a year.

Introduction

1.1. History of West Nile Virus in North America

West Nile Virus (WNv) is a new and emerging disease in North America. It was first detected in New York City in the summer of 1999, after the deaths of countless American Crows (*Corvus brachyrhynchos*). That summer, 62 human cases of WNv were identified in New York, resulting in seven human deaths (CDC, 2007). At that time, it was unknown if the outbreak would be an isolated event, and there were questions surrounding the ability of the virus to survive North America's winters. The following spring, these questions were answered as the virus reappeared and rapidly started its "migration" across the continent. For the next two years, viral activity was confined primarily to the east coast of the U.S. and Canada, but in 2002 it advanced quickly across the continent and in 2003 there were large outbreaks in the Canadian prairies. In 2004 and 2005, activity increased in California and Oregon. Over the past three years, there have been large outbreaks in Idaho, and a state of emergency was declared in a few counties in 2006. As of the fall of 2008, WNv has not been detected in British Columbia in any population, including mosquitoes, birds, mammals or humans (except for a few travel-related human cases).

1.2. West Nile Virus Life Cycle

WNv is primarily a disease affecting birds, especially those of the Corvid Family (crows, ravens, jays, and magpies). It is transmitted from host to host through the bite of particular species of mosquitoes. While a number of mosquito species are considered potential vectors, (Section 6.0) it is widely accepted that the two primary species for concern in Western Canada are *Culex tarsalis* and *Culex pipiens*. These species play different roles in the transmission of the virus, but both can be considered equally important.

When a bird is bitten by an infected mosquito, the mosquito injects the West Nile virus into the bird. The immune systems of some bird species are able to fight the virus and do not allow the virus to significantly replicate. Members of the Corvid family, however, are especially susceptible to the virus, and inside of these birds, the virus replicates rapidly and is soon present in high concentrations in the blood. When other mosquitoes bite the infected bird, they contract the virus and become infected

themselves; approximately 9-12 days later, the newly infected mosquitoes are able to transmit the virus when they next bite.

In British Columbia, as in most of western Canada and the United States, the species of mosquito known as *Culex pipiens* is responsible for amplifying the virus in the bird population. This species of mosquito feeds almost exclusively on birds, and will take numerous blood meals in a summer, so it has a number of opportunities to contract the virus and then transmit the virus to a new host. Each time a female feeds, she lays a brood of eggs on stagnant water, which then hatch and the newly emerged larvae begin to feed. With each successive generation, the number of individual mosquitoes grows exponentially, simultaneously increasing the chance of a *Culex pipiens* feeding on an infected bird and communicating the virus. Populations of this insect usually peak in mid- to late- August, as do the number of cases of WNv in both birds and humans. *Culex pipiens* are common in urban settings and will readily breed in common water-holding containers such as bird-baths, old tires, eaves troughs, wheelbarrows, etc. This species can also breed in exceptionally large numbers in urban catch basins.

Once the virus has become amplified in the bird population, the risk of "spill-over" into other hosts increases. A second species of mosquito, *Culex tarsalis*, is most often implicated in this "bridging" of the virus from birds to mammals. Like *Culex pipiens*, this species of mosquito has multiple generations each summer and takes numerous blood meals. Some recent Canadian studies suggest that the number of generations produced in a summer is related to the number of degree-days above 16°C. The BC Center for Disease Control (BCCDC) has produced a "degree-day" map of BC and has found that many areas of the Okanagan, including much of the RDCO, fall in an annual degree-day range of 450-600 degree-days (Figure 1). This translates into a potential for 3-4 generations (or more) of *Culex tarsalis* per summer. In the early summer, *Culex tarsalis* plays a significant role alongside *Culex pipiens* in the amplification of the virus, and later in the summer becomes a significant vector of WNv to humans. What is different about this species is its willingness to take blood meals from bird hosts as well as mammal hosts, especially later in the summer. Therefore, if an individual of this species takes a meal from an infected bird, it may – during a subsequent feeding – transmit the virus to a human, horse, or other non-avian host.

In humans, the virus rarely causes serious illness; however, in approximately 20% of infections, humans can experience severe flu-like symptoms that may have lasting effects for as long as a year. In less than 1% of human cases, WNv can cause inflammation of the brain and/or spinal chord (a condition called meningioencephalitis), which can occasionally result in death.

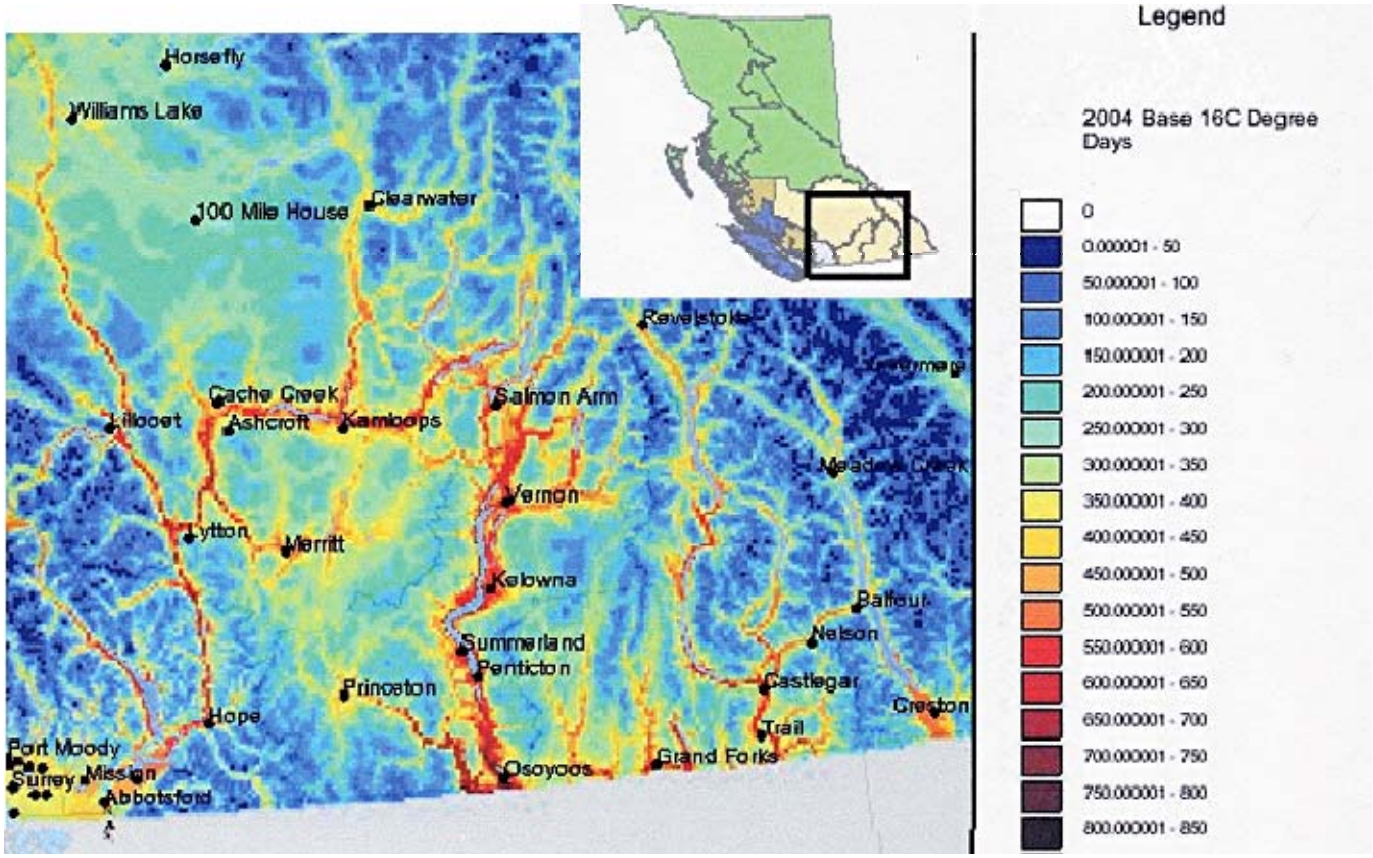

Figure 1. Base 16°C degree-day map for the Southern Interior of BC, 2004 (created in the BCCDC interactive West Nile virus website).

1.3. SURVEILLANCE IN BRITISH COLUMBIA

The BCCDC and health authorities have been anticipating cases of WNv in British Columbia since the summer of 2003. In that year, the province began collecting and testing corvids (crows, jays, ravens, and magpies) for the presence of WNv. They also began using CDC light traps and gravid traps to attract and collect mosquitoes which were then ground up and tested for the presence of the virus. In the last six years, 6,225 corvids have been collected and tested, and 1,026,817 mosquitoes have been trapped. All of the *Culex* female mosquitoes were separated and tested as well as many batches of

females from other genera (BCCDC, 2008). To date, there has not been a single corvid or mosquito found to carry WNv. There have been a number of human WNv cases found in BC since 2003, including 18 cases in 2007; however, in each of the cases, the infected person acquired the illness while traveling outside of the province.

1.4. Overview of Grant Funding and Completed Activities

Each spring, starting in 2004, the Ministry of Health Services offered grant funding to Municipalities, First Nations bands, and Regional Districts for WNv education, mosquito control, and mosquito surveillance. This funding was administered through the Union of British Columbia Municipalities (UBCM). The Regional District of the Central Okanagan (RDCO) has applied for and received the maximum grant available each year plus has received additional funding under the WNv Crown Lands Initiative. This funding was used to create a mosquito control plan, to conduct public education campaigns, to map larval habitats and control larval mosquito populations, and to surveil and capture adult mosquitoes in the RDCO. This report summarizes all activities completed under this funding between 2004 and 2008, including a list of recommendations for future and further work (Section 11.0).

2.0 Planning for Mosquito Control

Following the first summer of WNv funding, it was felt that a written plan was needed that outlined methods for controlling mosquitoes to reduce the risk of WNv. In February 2005, BWP Consulting Inc was hired to produce two documents for the RDCO. The first, “Template for a Mosquito Control Program to Control Nuisance Mosquitoes and West Nile Virus Vectors within the Regional District of the Central Okanagan,” described a plan for mosquito control including an outline of methods for monitoring and treating larval mosquitoes and a discussion of adult mosquito surveillance methods and adult control.

The second, “Report of Priority Activities Recommended to the Regional District of the Central Okanagan for the Prevention and Control of West Nile virus” was a document that discussed specific monitoring and control for the WNv vectors *Culex pipiens* and *Culex tarsalis*.

3.0 STAFF & PUBLIC EDUCATION

As mosquitoes are the vectors for transmitting WNv between birds and humans, individuals can protect themselves from WNv by reducing their exposure to mosquitoes. There are numerous strategies that individuals can employ to reduce exposure to mosquitoes, including reducing mosquito bites, and reducing mosquito populations in their neighborhoods. Grant funding was used to present an information booth at the Kelowna Farmer's Market at the Orchard Park Shopping Centre, and to sponsor television and radio commercials to convey personal protective measures.

Also, RDCO staff used funding to attend the American Mosquito Control Association Annual Meeting which was held in Vancouver, BC in 2005 and to have BWP Consulting Inc provide training workshops for new hires.

3.1. PERSONAL PROTECTION ADVOCACY

An important part of WNv prevention includes educating the public on how to avoid being bitten by mosquitoes. *Culex* mosquitoes usually bite at dawn and at dusk, and so special precautions should be taken at these times to avoid being bitten. Individuals should wear long-sleeved, tight-knitted shirts and long pants during these prime biting times; also, active movement such as jogging or cycling rather than standing, sitting, or walking will reduce one's chance of being bitten. People should ensure that the screens on their windows and doors are in good repair as *Culex* species will find the tiniest holes through which they can enter dwellings. When people are active outside during periods of high mosquito activity, repellents containing DEET or lemon oil of eucalyptus should be applied to skin and clothing according to the label (generally, lemon oil of eucalyptus requires more frequent re-application than does DEET).

3.2. REDUCING MOSQUITO LARVAL DEVELOPMENT SITES

Since *Culex* and *Culiseta* mosquitoes will both readily breed in water-holding containers, homeowners are encouraged to reduce standing water around their homes. Water-holding items such as plastic containers, wheelbarrows, and swimming pool covers should be emptied or turned upside-down. Eaves troughs should be cleared of debris to ensure that they are draining properly. Bird baths and children's wading pools should be dumped and filled with fresh water twice per week. Pumps should be used in

ornamental ponds to circulate water (thus drowning larvae), or ponds should be stocked with goldfish (which consume larvae). Attempts should be made to educate the public and to enable people to identify mosquito larvae. Individuals should be encouraged to recognize the larvae and to remove the larvae from whatever container or pond which the larvae may occupy (many people mistake mosquito larvae for worms, tadpoles, or minnows).

3.3. TELEVISION AND RADIO ADVERTISING

As part of the education program, radio and television advertisements were developed to encourage homeowners to look for and eliminate standing water on their properties to aid in controlling mosquito populations, and to encourage personal protection and promote the use of insect repellents. Approximately $9000 was spent in both 2007 and 2008 on television and/or radio advertising. In 2007, RDCO partnered with the Regional District of the North Okanagan (RDNO) and the Regional District Okanagan-Similkameen (RDOS) to advertise on both the CHBC and CHAN television networks, as well as with Astral Media radio stations in the south Okanagan. In 2008, RDCO once again partnered with NORD and RDOS to advertise on radio.

3.4. PUBLIC EDUCATION EVENTS

On a number of occasions, West Nile Virus Education Booths have been set up at the Farmer's Market at the Orchard Park Shopping Centre. Booths have also been manned at the Mayor's Environmental Expo, the Kelowna Home and Garden Show, and at Farmer's Markets in Winfield and Peachland. Central to the education booth were a set of five poster boards, which contain information on the mosquito life cycle, mosquito control, mosquito surveillance, WNv prevention and the WNv transmission cycle. As well, live larvae were displayed, and adult mosquitoes were available for viewing. Literature including the Interior Health Authority WNv pamphlet "Put the Bite on West Nile Virus", a Health Canada pamphlet, an information sheet concerning DEET, and numerous handouts describing the WNv in horses was made available the booth. Finally, the Interior Health Corvid Collection Program was promoted, and the public was asked to report sightings of dead corvids to help in the surveillance of WNv. The booths were very popular, and reached a large number of people at each event.

4.0 ADULT MOSQUITO SURVEILLANCE

Adult mosquitoes were trapped in the RDCO to determine which species were present and to determine their relative numbers. Since only a few mosquito species are capable of transmitting WNv, it is important to know which species are present in an area, and to know the size of their populations when determining a level of risk for an area. The City of Kelowna collected adult mosquito samples each summer between 2004 and 2006. As well, the RDCO collected adult mosquitoes at a number of sites in 2008.

The Interior Health Authority (IHA) also collected mosquito samples from a number of sites within the RDCO between 2003 and 2008 to test for the presence of WNv within the mosquito population. Mosquito populations can provide early warning of the presence of the virus, before humans begin to show symptoms, and therefore surveillance of these populations can help prevent or minimize the severity of outbreaks in the human population.

4.1. METHOD OF ADULT SURVEILLANCE

Adult mosquitoes were captured with the use of CDC black-light mosquito traps (Figure 2). These traps were operated for one day per week using a 6V, 12amp-hour battery.

The CDC traps were equipped with photocells to detect dawn and dusk (when mosquitoes are most active). At dusk, a fluorescent black-light and a small fan were switched on automatically by the photo cell. Mosquitoes are attracted to the light and, when they come near the fan, they are blown into a collecting jar. In addition, a small beverage cooler was filled with dry ice and hung next to the trap. Dry ice sublimates into CO_2 which is a powerful mosquito attractant because it mimics mammal and bird breath. In some instances, when dry ice was not available, CO_2 sachets were used, which release CO_2 as the result of a chemical reaction between two reagents.

Figure 2. CDC mosquito black-light trap with dry ice canister.

Trapping locations in the City of Kelowna varied between 2004 and 2008 (Table 1). Each trap was visited approximately once a week and the contents were collected and couriered to Kamloops for identification of the adult mosquitoes.

Trapping methods used by IHA were identical to those used for adult surveillance, with the only difference being that samples were shipped to the BCCDC to test for the presence of WNv. As with the RDCO adult surveillance traps, trapping locations used by IHA varied from year to year.

Table 1. Summary of trapping locations used by the City of Kelowna and RDCO for adult mosquito sampling.

Year	Adult Trapping Location(s) for City of Kelowna and RDCO Adult Mosquito Sampling
2004	Gordon Road
2005	Belmont, Glenmore, Black Mountain, Hall Rd, N. Rutland, S. Rutland, Casorso Rd.
2006	Belmont, Glenmore, Black Mountain, Hall Rd, N. Rutland, S. Rutland, Casorso Rd
2008	Black Mountain, N. Kelowna, Trask Rd., Greenhow, Sanderson and Bradley, Glenrosa, Landfill

4.2. RESULTS OF ADULT MOSQUITO SURVEILLANCE

The following is a discussion of the results from the adult mosquito trapping conducted in the RDCO each year between 2004 and 2006 by the City of Kelowna, in 2008 by RDCO, as well as the results of the IHA adult mosquito trapping conducted between 2003 and 2008. Section 5.0 gives summary of all mosquitoes captured in the RDCO, Section 6.0 discusses the relative vector competency of each species, and Section 7.0 gives a brief overview of the biology of each mosquito species listed in this section.

4.2.1. Results for 2004, Trap at Gordon Road

Seven samples were collected by BWP Consulting Inc. employees between July 5th and September 20th, 2004, and a total of 107 mosquitoes from seven species and six genera were identified (Table 2). *Culex pipiens* made up 27% of the total catch, *Culex tarsalis* made up 22% of the catch and *Culiseta inornata* made up 29% of the catch. The remainders of the samples included a few specimens from four different "nuisance" species. *Culex pipiens* and *Culex tarsalis* are the two most significant species with respect to WNv and *Culiseta inornata* is often considered to be a vector although it is not likely to be as important as the two *Culex* species.

Peaks of the mosquito populations seemed to occur in late-July through early-August. Female mosquitoes were seen in higher numbers than the males until the end of August, and in September the catch was almost exclusively males.

Table 2. Numbers of adult mosquitoes captured each week in a CDC black-light trap baited with octenol CO_2 packet at 4193 Gordon Road in Kelowna, BC, 2004.

	Date														
	13-Jul-04		21-Jul-04		5-Aug-04		12-Aug-04		2-Sep-04		8-Sep-04		20-Sep-04		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans			3	3	1		1								8
Anopheles freeborni			4		2									4	10
Ochlerotatus dorsalis					1										1
Coquillettidia perturbans					1	1									2
Culex pipiens	1	3	10	2	5	3	1			1				3	29
Culex tarsalis	2	2	4		8	5		2						1	24
Culiseta inornata	6	2	8		3	1	2		1	4		2		2	31
Mosquito unidentifiable					2										2
Total	**9**	**7**	**29**	**5**	**23**	**10**	**4**	**2**	**1**	**5**	**0**	**2**	**0**	**10**	**107**

4.2.2. Results for 2005, Seven Traps Throughout City of Kelowna

Samples were collected over the course of the summer at seven trapping locations throughout the City of Kelowna. The locations were named Belmont Area, Glenmore/North Glenmore, Black Mountain, Hall Road/Packers Road, North Rutland (Aldon Road), South Rutland (Thompson Road), and Casorso Road (Upper Mission), but detailed trap locations were not specified (Table 3 - Table 9).

The trap located at Belmont caught considerably more mosquitoes than any of the other traps, with *Coquillettidia perturbans* (known as the cattail mosquito, because it burrows into the sides of cattail reeds to breathe) comprising the majority of the mosquitoes captured here. The two primary WNv vector species, *Culex tarsalis* and *Culex pipiens*, were present at all of the sites, and at some (including Belmont, Glenmore, Rutland and Casorso Road) they were relatively abundant.

Table 3. Summary of mosquitoes captured by weekly trapping at Belmont in 2005.

	Date																							
	30-Jun		06-Jul		13-Jul		20-Jul		27-Jul		03-Aug		10-Aug		17-Aug		24-Aug		31-Aug		Total
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	
Anopheles freeborni							2	1	1												**4**
Anopheles punctipennis												1									**1**
Aedes vexans							1														**1**
Culiseta incidens																1					**1**
Culiseta inornata	1		5	0	1		2	4	2		2	1	1	3	6	2	2	1		1	**34**
Culex pipiens			2	10	3	1	8	7	17	7	22	4	28	26	11	4	11	5	1	1	**168**
Culex tarsalis			3	2	3		7	5	4	2	1	1	2	3		1	2		1		**37**
Coquillettidia perturbans			505	84	104	102	109	37	79	5	14	1	3		3						**1046**
Total	**1**	**0**	**515**	**96**	**111**	**103**	**130**	**54**	**103**	**14**	**39**	**8**	**34**	**32**	**20**	**8**	**15**	**6**	**2**	**2**	**1293**

Table 4. Summary of mosquitoes captured by weekly trapping at Glenmore/North Glenmore in 2005.

	Date																				
	30-Jun		06-Jul		13-Jul		20-Jul		27-Jul		03-Aug		10-Aug		17-Aug		24-Aug		31-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Culiseta incidens					1			2					1		1				No mosquitoes seen		**5**
Culiseta inornata			3		2		4			1			2				1				**13**
Culex pipiens			1	1	1	5	2			1		2	4	2	5	2	7				**33**
Culex tarsalis		1	2		1		1		2								2				**9**
Unidentifiable			1								1										**2**
Total	**0**	**1**	**7**	**1**	**5**	**5**	**7**	**2**	**2**	**2**	**1**	**2**	**7**	**2**	**6**	**2**	**10**	**0**	**0**	**0**	**62**

Table 5. Summary of mosquitoes captured by weekly trapping at Black Mountain in 2005.

	Date																		
	30-Jun		13-Jul		20-Jul		27-Jul		03-Aug		10-Aug		17-Aug		24-Aug		31-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans											1								**1**
Culiseta alaskaensis	1																		**1**
Culiseta impatiens															2	2			**4**
Culiseta incidens	1		1						1		2		1						**6**
Culiseta inornata	9	11	3		7	6	4	5			14	12	12	11				1	**95**
Culex pipiens	1		1		1	1	1		2	1	1	1		2					**12**
Culex tarsalis	2			1	2		7	2			3	4	5	1					**27**
Ochlerotatus canadensis			1																**1**
Ochlerotatus fitchii							1												**1**
Ochlerotatus increpitus	5				1		1				2								**9**
Total	**19**	**11**	**6**	**1**	**11**	**7**	**14**	**7**	**3**	**1**	**23**	**17**	**18**	**14**	**2**	**2**	**0**	**1**	**157**

Table 6. Summary of mosquitoes captured by weekly trapping at Hall Road/Packers Road in 2005.

	Date												
	30-Jun		06-Jul		10-Aug		17-Aug		24-Aug		31-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Anopheles punctipennis	1								No mosquitoes seen				**1**
Anopheles freeborni					2								**2**
Aedes vexans	2												**2**
Culiseta incidens	3	1	1	1	2	1							**9**
Culiseta inornata	4		2										**6**
Culex pipiens		1		1		1		5			1		**9**
Culex tarsalis	2	3	1		1		1						**8**
Ochlerotatus communis	1												**1**
Ochlerotatus increpitus			1										**1**
Total	**13**	**5**	**5**	**2**	**5**	**2**	**1**	**5**	**0**	**0**	**1**	**0**	**39**

Table 7. Summary of mosquitoes captured by weekly trapping at North Rutland in 2005.

	Date																					
	30-Jun		06-Jul		13-Jul		20-Jul		27-Jul		03-Aug		10-Aug		17-Aug		24-Aug		31-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Anopheles earlei																				1	**1**
Anopheles freeborni													1					2			**3**
Anopheles punctipennis											1										**1**
Aedes vexans	2	2	1		1										3						**9**
Culiseta impatiens																			1		**1**
Culiseta incidens	1		1				1				3	1	3				1		1	1	**13**
Culiseta inornata	3		4	1	3	1			1		3		2		1				1		**20**
Culex pipiens	3	5	5	5	3	4	3	4	12	5	23	4	12	4	8	13	10		6	3	**132**
Culex tarsalis	2		7	1	7	1	5		5		5		7	2	1	2	1	1	1	4	**52**
Coquillettidia perturbans	1	1	9	3	11		7		6		1	1									**40**
Unidentifiable					2		5	1	3				1						5		**17**
Total	**12**	**8**	**27**	**10**	**27**	**6**	**21**	**5**	**27**	**5**	**36**	**6**	**26**	**6**	**13**	**15**	**12**	**3**	**15**	**9**	**289**

Table 8. Summary of mosquitoes captured by weekly trapping at South Rutland in 2005.

	Date																			
	13-Jul		20-Jul		27-Jul		03-Aug		10-Aug		17-Aug		24-Aug		31-Aug					
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂			**Total**
Culiseta incidens							2								No mosquitoes seen				**2**
Culiseta inornata							35	3											**38**
Culex pipiens		1			1	1	1				1			1					**6**
Culex tarsalis						1	4	1											**6**
Ochlerotatus increpitus							1												**1**
Total	**0**	**1**	**0**	**0**	**1**	**2**	**43**	**4**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			**52**

Table 9. Summary of mosquitoes captured by weekly trapping at Casorso Road (Upper Mission) in 2005.

	Date										
	30-Jun		06-Jul		17-Aug		24-Aug		31-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Culiseta inornata	2										**2**
Culex pipiens	27	7	23	4	1	3	1	1	5		**72**
Culex tarsalis			1						1		**2**
Coquillettidia perturbans			1								**1**
Total	**29**	**7**	**25**	**4**	**1**	**3**	**1**	**1**	**6**	**0**	**77**

4.2.3. Results for 2006, Seven Traps Throughout City of Kelowna

As in 2005, traps were set on an approximately weekly basis at seven locations throughout the City of Kelowna. The same seven locations used in 2005 were once again used in 2006 (Belmont Area, Glenmore/North Glenmore, Black Mountain, Hall Road/Packers Road, North Rutland (Aldon Road), South Rutland (Thompson Road), and Casorso Road (Upper Mission)) (Table 10 - Table 16).

Twenty different species of mosquito were identified in Kelowna in 2006 as compared to only 11 species in 2005. Sampling commenced earlier in 2006 as compared with 2005 (late-May versus late-June). As well, dry ice was used consistently in 2006 and only sporadically in 2005. Overall mosquito numbers were also up at most of the trapping locations in 2006 compared with 2005. Factors contributing to this increase include the earlier sampling commencement and consistent use of dry ice as an attractant, but include an increase in standing water in 2006. Heavy precipitation in May caused an increase in the number and size of larval development sites throughout the Southern Interior. Increased numbers of mosquitoes, especially *Culex tarsalis* and *Culex pipiens* was seen throughout the southern portion of the province in 2006 as compared with 2005.

Table 10. Summary of mosquitoes captured by weekly trapping at Belmont in 2006.

	Date																								
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		24-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans	1		3					1					1				2						1		**9**
Anopheles freeborni	2						2		1				1				1								**7**
Anopheles punctipennis													1		1										**2**
Culiseta inornata	2				2		9		2	2	2	2	1		2				2						**26**
Culex pipiens	1		1		2		2	1	7	1	4		10	1	3	3		1	6		5	1	2	1	**52**
Culex tarsalis	1		3		13		11		8	1	4	2	10	2	11	2	4		3		1				**76**
Coquillettidia perturbans			6	8			19	4	23		41	1	21	3	5	2			2						**135**
Ochlerotatus dorsalis							1																		**1**
Ochlerotatus fitchii	1																								**1**
Ochlerotatus increpitus	12		3				6				2														**23**
Ochlerotatus sticticus			3		1																				**4**
Unidentifiable	3																								**3**
Total	**23**	**0**	**19**	**8**	**18**	**0**	**50**	**6**	**41**	**4**	**53**	**5**	**45**	**6**	**22**	**7**	**7**	**1**	**13**	**0**	**6**	**1**	**3**	**1**	**339**

Table 11. Summary of mosquitoes captured by weekly trapping at Glenmore in 2006.

	Date																									
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		23-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans															1										**1**
Anopheles punctipennis													1												**1**
Culiseta incidens	2		2																				1	1	**6**
Culiseta inornata					2		1						2		4				3		2				**14**
Culex pipiens	1		1								2		2	1	3	5	20	4			14		20		**73**
Culex tarsalis	7		2			1	1		2		12		13		10	3	7		8	2	10				**78**
Ochlerotatus dorsalis			1																25	2	1		1		**30**
Ochlerotatus increpitus			4		1																				**5**
mosquito unidentifiable															1		1		20*						**22**
Total	**10**	**0**	**10**	**0**	**3**	**1**	**2**	**0**	**2**	**0**	**14**	**0**	**18**	**1**	**19**	**8**	**28**	**4**	**56**	**4**	**27**	**0**	**22**	**1**	**230**

Table 12. Summary of mosquitoes captured by weekly trapping at Black Mountain in 2006.

	Date																									
	31-May		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		23-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans											2												**2**
Aedes cinereus																				1			**1**
Anopheles freeborni									1		1				2		1						**5**
Culiseta incidens	1		1										1				1		1		1		**6**
Culiseta inornata			2	2	6	1	6	12	3		8	1	24	16	13	7	13	3	9	4	5	5	**140**
Culex pipiens											3		3	1			2	1			2	1	**13**
Culex tarsalis			2		1		12		5		19		37	1	3		16		4		6		**106**
Ochlerotatus canadensis													2		1		1						**4**
Ochlerotatus euedes							1																**1**
Ochlerotatus excrucians																	2						**2**
Ochlerotatus fitchii	1		1				1										1						**4**
Ochlerotatus increpitus	2		6		6	1	1		1				4		1		1		2				**25**
Ochlerotatus mercurator															1								**1**
Ochlerotatus provocans	1																						**1**
Ochlerotatus sierrensis				2																			**2**
Ochlerotatus unidentifiable			1						2						1								**4**
Total	**5**	**0**	**13**	**4**	**13**	**2**	**21**	**12**	**12**	**0**	**33**	**1**	**71**	**18**	**22**	**7**	**38**	**4**	**16**	**5**	**14**	**6**	**317**

Table 13. Summary of mosquitoes captured by weekly trapping at Hall Road in 2006.

	Date																								
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		24-Aug				
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**		
Anopheles freeborni	3						3		1						1		1		3				**12**		
Anopheles punctipennis	1																1						**2**		
Culiseta incidens																		1	6	1			**8**		
Culiseta inornata							2				1		2	1						1			**7**		
Culex pipiens					1						1	1	3		4	2	1		1		2		**16**		
Culex tarsalis					1		1	1	1				4				5		1	1	1		**16**		
Ochlerotatus excrucians							1																**1**		
Ochlerotatus fitchii													1										**1**		
Ochlerotatus increpitus	2		2				10		1		1						1						**17**		
Ochlerotatus sticticus			1		1																		**2**		
Total	**6**	**0**	**3**	**0**	**3**	**0**	**17**	**1**	**3**	**0**	**3**	**1**	**10**	**1**	**5**	**2**	**9**	**1**	**11**	**3**	**3**	**0**	**82**		

Table 14. Summary of mosquitoes captured by weekly trapping at North Rutland in 2006.

	Date																							
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		23-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans			1				1																		**2**
Anopheles freeborni	1								1																**2**
Culiseta incidens			1																						**1**
Culiseta inornata							1								1										**2**
Culex pipiens									6		2		10		9		27		8		36		49		**147**
Culex tarsalis							3		8		10		12		14		4		11		7		4		**73**
Ochlerotatus increpitus	1																								**1**
mosquito unidentifiable											1								17*						**18**
Total	**2**	**0**	**2**	**0**	**0**	**0**	**5**	**0**	**15**	**0**	**13**	**0**	**22**	**0**	**24**	**0**	**31**	**0**	**36**	**0**	**43**	**0**	**53**	**0**	**246**

Table 15. Summary of mosquitoes captured by weekly trapping at South Rutland in 2006.

	Date																								
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		09-Aug		16-Aug		24-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans	1		3																						**4**
Anopheles punctipennis																							1		**1**
Culiseta incidens											1		2	1											**4**
Culiseta inornata	1						3				1														**5**
Culex pipiens			4	1	1		3	1	3		9		11	4	4	1	4		10	4	18	1	8	2	**89**
Culex tarsalis	1				3		2		2		1	2	3				1		3		1		1		**20**
Ochlerotatus fitchii									1																**1**
Ochlerotatus increpitus							1				2		1												**4**
Total	**3**	**0**	**7**	**1**	**4**	**0**	**9**	**1**	**6**	**0**	**14**	**2**	**17**	**5**	**4**	**1**	**5**	**0**	**13**	**4**	**19**	**1**	**10**	**2**	**128**

Table 16. Summary of mosquitoes captured by weekly trapping at Casorso Road in 2006.

	Date																							
	31-May		13-Jun		21-Jun		29-Jun		06-Jul		12-Jul		17-Jul		26-Jul		03-Aug		16-Aug		24-Aug		
Species	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	**Total**
Aedes vexans			2		1				1														**4**
Anopheles earlei															1								**1**
Culex pipiens			2		15		12				17	1	26	2	4	2	44	1	33		25	2	**186**
Culex tarsalis					4		13				1		2			1	1		2				**24**
Culiseta incidens																	1						**1**
Culiseta inornata							2																**2**
Coquillettidia perturbans							1						1										**2**
Ochlerotatus increpitus	6						3																**9**
Ochlerotatus sierrensis					1		1				1												**3**
Ochlerotatus sticticus			2																				**2**
Total	**6**	**0**	**6**	**0**	**21**	**0**	**32**	**0**	**1**	**0**	**19**	**1**	**29**	**2**	**5**	**3**	**46**	**1**	**35**	**0**	**25**	**2**	**234**

4.2.1. Results for 2007

Adult mosquitoes were sampled in 2007 and examined by RDCO staff. A detailed breakdown of the species composition is not available.

4.2.1. Results for 2008

The RDCO set traps on a three occasion at up to seven sites throughout the district (Table 17 - Table 23). Dry ice was used to bait the traps, and samples were sent to Kamloops for identification to species level.

The largest number of mosquitoes was captured in the first week of sampling. This is as would be expected, since nuisance mosquito populations were likely peaking in mid- to late- June. Accordingly, the most common species captured in 2008 was the nuisance mosquito *Aedes vexans*.

Table 17. Summary of adult mosquitoes captured by RDCO at Black Mountain in 2008.

	Date				
	03-Jul		30-Jul		
Species	♀	♂	♀	♂	**Total**
Culex tarsalis	2				**2**
Culiseta inornata	2				**2**
Coquillettidia perturbans			1		**1**
Ochlerotatus excrucians			4		**4**
Ochlerotatus hendersoni			1		**1**
Ochlerotatus increpitus			1		**1**
Total	**4**	**0**	**7**	**0**	**11**

Table 18. Summary of adult mosquitoes captured by RDCO at Scandia (North Kelowna) in 2008.

	Date						
	03-Jul		18-Jul		30-Jul		
Species	♀	♂	♀	♂	♀	♂	**Total**
Aedes cinereus			2				**2**
Aedes vexans	362		115				**477**
Anopheles freeborni			2				**2**
Culex tarsalis			4		3		**7**
Culiseta inornata			2		4	3	**9**
Coquillettidia perturbans			2				**2**
Ochlerotatus fitchii			2				**2**
Ochlerotatus implicatus			2				**2**
Ochlerotatus increpitus			172				**172**
Ochlerotatus sticticus			29				**29**
Total	**362**	**0**	**332**	**0**	**7**	**3**	**704**

Table 19. Summary of adult mosquitoes captured by RDCO at Trask Road in 2008.

	Date						
	03-Jul		18-Jul		30-Jul		
Species	♀	♂	♀	♂	♀	♂	**Total**
Aedes cinereus	194		3		23		**220**
Aedes vexans	3948		7	1	165		**4121**
Culex pipiens	21			1			**22**
Culex tarsalis	43		5		3		**51**
Culiseta inornata	65		7	12			**84**
Coquillettidia perturbans					13		**13**
Ochlerotatus canadensis	65						**65**
Ochlerotatus excrucians					3		**3**
Ochlerotatus fitchii			1		3		**4**
Ochlerotatus increpitus	43				109		**152**
Ochlerotatus sticticus	22				13		**35**
Total	**4401***	**0**	**23**	**14**	**332**	**0**	**4770**

*these results were extrapolated, 204 mosquitoes were actually identified

Table 20. Summary of adult mosquitoes captured by RDCO at Greenhow in 2008.

	Date						
	03-Jul		18-Jul		30-Jul		
Species	♀	♂	♀	♂	♀	♂	**Total**
Aedes cinereus			3				**3**
Aedes vexans			18		44		**62**
Anopheles earlei			1	1			**2**
Anopheles freeborni			2				**2**
Culex pipiens			2	3			**5**
Culex tarsalis	4		1	1	2		**8**
Culiseta incidens				1			**1**
Culiseta inornata	5		2	1			**8**
Coquillettidia perturbans	38		16		2		**56**
Ochlerotatus excrucians					42		**42**
Ochlerotatus fitchii			1		3		**4**
Ochlerotatus increpitus	335		41		101		**477**
Ochlerotatus minnesotae				4			**4**
Ochlerotatus sticticus			1				**1**
Total	**382***	**0**	**88**	**11**	**194**	**0**	**675**

*This sample was damaged, these counts are estimates only

Table 21. Summary of adult mosquitoes captured by RDCO at Sanderson and Bradley in 2008.

	Date		
	03-Jul		
Species	♀	♂	**Total**
Anopheles earlei	1		**1**
Culiseta incidens	1		**1**
Ochlerotatus communis	3		**3**
Ochlerotatus cataphylla	1		**1**
Ochlerotatus increpitus	36		**36**
Ochlerotatus sierrensis	1		**1**
Total	**43**	**0**	**43**

Table 22. Summary of adult mosquitoes captured by RDCO at Glenrosa in 2008.

	Date		
	18-Jul		
Species	♀	♂	**Total**
Culex pipiens	4		**4**
Culex tarsalis	2		**2**
Coquillettidia perturbans	3		**3**
Ochlerotatus canadensis	3		**3**
Ochlerotatus communis	5		**5**
Ochlerotatus fitchii	1		**1**
Ochlerotatus increpitus	2		**2**
Ochlerotatus unknown		3	**3**
Total	**20**	**3**	**23**

Table 23. Summary of adult mosquitoes captured by RDCO at Landfill in 2008.

	Date		
	18-Jul		
Species	♀	♂	**Total**
Culex pipiens	16	5	**21**
Culex tarsalis	66	4	**70**
Culiseta inornata	2	4	**6**
Coquillettidia perturbans	1		**1**
Ochlerotatus dorsalis	12		**12**
Ochlerotatus flavescens	12		**12**
Total	**109**	**13**	**122**

4.2.2. Results of IHA Adult Mosquito Trapping, 2003 – 2007

The IHA set traps at three locations in 2003 (Gordon Road, at the Bear Creek Provincial Park on Westside Road, and in Lake Country at 10786 Highway 97N). The Gordon Road site continued to operate each year between 2003 and 2008, while the other two traps were discontinued after 2003. A site was added in 2004 in Peachland, but was only sampled for one year. Hardy`s Slough was also added as a trapping location in 2004, and this site was used annually until 2007. Finally, an adult mosquito trap was set behind the Scandia in North Kelowna each year between 2005 and 2007. A summary of the mosquitoes captured at each of these traps is given in Table 24- Table 29.

Table 24. Summary of adult mosquitoes captured at Gordon Road site in Kelowna by IHA between 2003 and 2008.

	Aedes and *Ochlerotatus* species	*Anopheles* species	*Coquillettidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species	Total
2003	51	0	4	5	3	0	8	71
2004				64	1			102
2005	1965	9	120	88	34	0	64	2280
2006	1187	6	123	38	12	0	8	1374
2007	2861	22	546	168	24		71	3692
2008	3157	3	128	76	27	0	23	3414

Table 25. Summary of adult mosquitoes captured at Bear Creek Provincial Campground by IHA in 2003.

	Aedes and *Ochlerotatus* species	*Anopheles* species	*Coquillettidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species	Total
2003	143	17	3	40	85	0	160	448

Table 26. Summary of adult mosquitoes captured at 10786 Highway 97N (Lake Country) by IHA in 2003.

	Aedes and *Ochlerotatus* species	*Anopheles* species	*Coquillettidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species	Total
2003	5	0	0	3	1	0	16	25

Table 27. Summary of adult mosquitoes captured in Peachland by IHA in 2004.

	Culex pipiens	*Culex tarsalis*	Total
2004	0	0	18

Table 28. Summary of adult mosquitoes captured at Hardy`s Slough in Westbank by IHA between 2004 and 2007.

	Aedes and *Ochlerotatus* species	*Anopheles* species	*Coquillettidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species	Total
2004				35	2			103
2005	30	11	2842	61	24	1	45	3014
2006	1420	6	4392	160	35	1	26	6040
2007	25	5	5541	463	25		771	6830

Table 29. Summary of adult mosquitoes captured at Scandia in North Kelowna by IHA between 2005 and 2007.

	Aedes and *Ochlerotatus* species	*Anopheles* species	*Coquillettidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culex territans*	*Culiseta* species	Total
2005	541	0	2	78	21	0	22	664
2006	588	27	5	265	45	0	10	940
2007	416	6	4	50	11		14	501

Total numbers of mosquitoes, as well as total numbers of the vector species of concern (*Culex pipiens* and *Culex tarsalis*) were highest at the Gordon Road and Hardy`s Slough sites. Overall captures were higher in the later years of the study at all of the sites primarily due to the consistent use of dry ice as an attractant. The Scandia site also yielded significant numbers of adult mosquitoes, and the Bear Creek site used in 2003 captured more mosquitoes than any other trapping site utilized in that year. It would appear likely that the use of dry ice as an attractant at that site would yield overall numbers at least equivalent to those seen at other sampling locations utilized by IHA.

All of the mosquitoes trapped at the IHA sites were identified to genus, and those that were found to be of the genus *Culex* were further identified to species. The *Culex* mosquitoes were tested in pools (batches) of up to 50 specimens to determine whether they were infected with WNv, and all of the samples from all of the sites over the six years between 2003 and 2008 tested negative for the virus.

5.0 SUMMARY OF ADULT MOSQUITO TRAPPING IN THE RDCO, 2003 - 2008.

A total of 9,990 specimens representing 25 species of mosquitoes from all six of BC's genera were captured at the 13 trapping locations in the City of Kelowna.

The Interior Health Authority captured a further 29,516 specimens from six genera. The IHA traps typically caught more mosquitoes than the traps in the City of Kelowna because they were usually set in more rural areas and near floodwater habitats that produced large numbers of *Aedes* mosquitoes, while the City of Kelowna traps tended to captured few *Aedes* mosquitoes, but plenty of *Culex* mosquitoes which prefer catch basins, ditches and containers.

Overall, the majority of the mosquitoes captured were of the floodwater type (*Aedes* and *Ochlerotatus* genera), and the most common species was *Aedes vexans*. In most cases, these mosquitoes are not considered a major problem in terms of WNv, but they can pose serious problems as persistent and ferocious nuisance mosquitoes (Section 7.1.1).

Both of the most important species for transmitting WNv, *Culex tarsalis* and *Culex pipiens*, were found to be plentiful in the City of Kelowna, RDCO and the IHA trapping sites. The numbers of these two species captured in the light traps began to decrease in early-August. According to the BC Centre for Disease Control Mosquito Surveillance and Control Subcommittee, studies out of Manitoba, southern Ontario and Massachusetts have shown that up to 90% of *Culex* mosquitoes that emerge after mid-August enter a reproductive diapause and do not seek a blood meal. Therefore, although the actual numbers of these mosquitoes may be very high in the environment, they are not attracted to the light traps and their true numbers are underestimated.

Other species that have the ability to be WNv vectors, although to a much lesser degree, were also present in light traps, including *Culiseta inornata,* and *Coquillettidia perturbans*.

The following Section (Section 6.0) contains an overview of potential WNv vector mosquitoes as predicted by Peter Belton, PhD, Mosquito Expert from Simon Fraser University. Section 7.0 contains short summaries of the biology of most of the genera and mosquito species captured in the RDCO.

6.0 SUMMARY OF WEST NILE VIRUS VECTOR COMPETENCY FOR BC MOSQUITO SPECIES

Although it is widely accepted that *Culex pipiens* and *Culex tarsalis* are the two primary vectors of WNv in western Canada, Peter Belton (2007), a retired professor from Simon Fraser University and an expert in the field of mosquito biology, has assembled a list of *potential* WNv vectors that are present in British Columbia, and has assigned them "vector competency" ratings.

It is important to understand the factors that must be met for a mosquito to be considered a good WNv vector. First, the mosquito must be willing to bite birds. In a natural setting, WNv can only be contracted from birds, as other hosts contain insufficient amounts of the virus to be infectious. Next, the mosquito must have the correct receptors in its gut to accept the virus and transfer it into the mosquito's circulatory system. Later, the mosquito must be able to transfer the virus from its circulatory system into its salivary glands so it can inject the virus during its next blood meal. This brings us to the next point: a mosquito must be willing to take more than one blood meal in its life, and must be a long-lived species, since it can take up to two weeks for the virus to be transported to a mosquito's salivary glands and render that mosquito infectious. Another factor is the temporal distribution of a species: WNv tends to be at its worst in July and August, so the vector must be present in high numbers during this time of the year. Finally, in order to be a human vector, the mosquito must not only be willing to bite birds, but it must also be willing to bite humans.

With all of these factors considered, *Culex tarsalis* should be identified as the most significant concern as a human vector in British Columbia and *Culex pipiens* as the most significant vector within bird populations. However, Peter Belton has included 21 British Columbian species in his list, based on a United States Centre for Disease Control list of species that has tested positive for the virus (indicated by a P in the Table 30) and a system of ranking discussed in Turell *et al*. (2005). Peter Belton has assigned mosquitoes a relative competency ranking of 0 to '++++' (Table 30). Species not included in the study by Turell *et al*, (2005), but still given consideration by Peter Belton based on their ability to transmit other viruses, are ranked with a question mark.

Table 30. Mosquito species in British Columbia identified as potential human West Nile Virus Vectors (Belton, 2007).

Potential Vectors in BC	Positive (P)	Competence (+)	Feeding preference, biology
Culex tarsalis	P	++++	Birds, mammals[3]
Ochlerotatus togoi		++++?	Birds, mammals[4]
Culex pipiens	P	+++	Mostly birds[3]
Coquillettidia perturbans	P	+	Birds, mammals[2]
Culiseta inornata	P	+++	Birds, mammals[3]
Culiseta morsitans	P	++?	Mostly birds[5]
Ochlerotatus dorsalis	P	+++	Mammals, occasionally birds[1]
Ochlerotatus melanimon	P	+++	Mammals, occasionally birds[1]
Ochlerotatus canadensis	P	++	General feeder[1]
Ochlerotatus sierrensis		+	Mammals[4]
Ochlerotatus sticticus	P	+?	Mammals[1]
Aedes vexans	P	++	Mostly mammals[1]
Aedes cinereus	P	+?	Birds? mammals[1]
Anopheles punctipennis	P	+?	Mammals, birds?[3]
Anopheles earlei	P	+?	Mammals, birds?[3]
Ochlerotatus hendersoni		+++?	Birds? mammals[1]
Culiseta incidens		++?	Mostly mammals[3]
Ochlerotatus fitchii	P	0?	Mostly mammals[1]
Ochlerotatus provocans	P	0?	Mostly mammals?[1]
Culex territans	P	0?	Mostly amphibia[3]
Culiseta impatiens	P	0?	Mostly mammals[5]

1 Eggs overwinter, one or two generations/year
2 Larvae overwinter, one generation/year
3 Females overwinter, several generations/year
4 Eggs and larvae overwinter, several generations/year
5 Females overwinter, one generation/year

7.0 BIOLOGY OF MAJOR MOSQUITO SPECIES COLLECTED IN THE RDCO

7.1. *ANOPHELES* SPECIES

Anopheles species of mosquitoes are quite different in appearance than other mosquitoes, with narrow wings and long slender bodies. When standing, their hind legs are well elevated from their bodies, distinguishing them from other mosquito species. Because of these anatomical differences, they have been placed in their own subfamily. Females overwinter as adults and hide in culverts, bridges, inside eaves, and in the roofs of sheds (Belton, 1983). In urban areas, they hibernate in burrows, caves, hollow trees, and other sheltered places (Belton, 1983). They prefer fresh, clean water, and they lay eggs singly among vegetation at the edges of water bodies. *Anopheles* species have been implicated in the transmission of malaria, and were no doubt involved in malarial outbreaks in Canada in the 19th century. All three of the *Anopheles* species were captured in the RDCO.

7.1.1. *Anopheles earlei*

Female *Anopheles earlei* overwinter in buildings, caves and mammal burrows, as well as hollow logs and tree trunks (Wood *et al.* 1979). When they overwinter, they are not blood-fed and have not laid eggs, but feed soon after leaving hibernation (Wood *et al.* 1979). In the southern part of the province, they are capable of two generations per year, weather permitting. The species is widely distributed throughout BC, and the females are vicious biters, able to attack in weather so cold that other mosquitoes are not capable of flying (Belton, 1983). Because of their ferocity, they can be localized pests when present in significant numbers. Belton (2007) gives this species a vector competence rating of '+'.

7.1.2. *Anopheles freeborni*

Anopheles freeborni females overwinter in various sites including talus slopes, abandoned mines and buildings, and root cellars. They tend to breed in pools and sloughs formed by creeks, large marshes and irrigated pastures in Washington (Wood *et al.* 1979). In California, rice fields are a significant breeding site (Wood *et al.* 1979). They are capable of rearing in slightly saline water (salinity as much as 5%). It is potentially an effective vector of malaria and has been found naturally infected with

Western Equine Encephalitis, but is never found in high enough concentrations to be important for disease transmission. Belton (2007) does not include this species on his list of vector competency.

7.1.3. *Anopheles punctipennis*

Anopheles punctipennis is the only anopheline found on Vancouver Island to date, and is fairly widespread throughout the province. Larvae are found in almost any kind of standing water (Belton, 1983), and there are generally two or three generations annually (Wood *et al.* 1979). Females bite humans freely after dark and are persistent in entering houses, but are not found in high enough concentrations to be a concern as a disease vector (Belton, 2983). Belton (2007) gives this species a vector competence rating of '+'.

7.2. *AEDES* AND *OCHLEROTATUS* SPECIES

Until recently, all of the "floodwater" species (*i.e.* laying their eggs on moist soil rather than on the water's surface) of mosquitoes in BC were classified as *Aedes*, but a number of species have now been reclassified into the genus *Ochlerotatus*. However, the life cycle and the physiology of *Aedes* and *Ochlerotatus* species are similar.

Aëdes is the Greek word for disagreeable (Belton, 1983), and is an accurate reflection of these species in terms of both numbers and ferocity. *Aedes* and *Ochlerotatus* species lay their eggs at the edges of water bodies and rely on warm temperature and/or low oxygen levels in flood-water to induce their eggs to hatch. Most of the floodwater species peak in late June (following snowmelt and then river flooding) and die in late summer and the populations over-winter as eggs. Mosquitoes that are viewed as nuisance species (*i.e.* present in high numbers and biting ferociously) are generally from this group, as large areas of habitat often become active at once with rising floodwaters and therefore huge batches of mosquitoes hatch at the same time. This is due primarily to the fact that eggs laid by most species remain viable for a number of years, and therefore egg concentrations in the soil can become very dense. Adults are generally short-lived (two to six weeks), and generally seek shade during hot summer days as they are prone to desiccation. Most species have only one generation each year, although some species are capable of two or more generations when conditions are suitable. Sixteen species of *Aedes* and *Ochlerotatus* mosquitoes were trapped in the RDCO, and the more common species are discussed below.

7.2.1. *Aedes cinereus*

Aedes cinereus is present throughout British Columbia and is capable of completing up to three generations per year (Belton, 1983; Wood *et al.*, 1979). Larvae have been found in rain pools, swamps and flood water (Belton, 1983). This species is not known to fly any great distance, and is generally considered a minor pest although isolated populations may be aggressive and persistent biters, even during the heat of the day (Belton, 1983). This species is also given a vector competence rating of '+' or low in Belton's (2007) list of potential West Nile Virus vectors.

7.2.2. *Aedes vexans*

Aedes vexans is considered the worst mosquito pest in Canada (Wood *et al.*, 1979). This species appears in extremely large numbers in almost any habitat where there are permanent, semi-permanent, or transient pools that have been flooded from snowmelt or rain. In the heat of summer, these mosquitoes can mature from the egg to adult in as short as five days, existing as larvae for as little as three days (Wood *et al.*, 1979). Eggs of *Aedes vexans* can remain viable in the soil for many years, and because not all individuals hatch when submerged, multiple cycles of flooding and drying are needed for all eggs to hatch (Wood *et al.*, 1979). Adult *Aedes vexans* are notorious fliers, capable of flying as far as 20 to 50 km or riding low jet streams for hundreds of kilometres, and are vicious biters as well (Belton, 1983). This can make control difficult to say the least. Specimens of *Aedes vexans* have been found carrying the western equine encephalitis (WEE) virus in Alberta, Saskatchewan and north western United States (Belton, 1983). Belton (2007) has included *Aedes vexans* as a potential West Nile Virus vector with a vector competence rating of '++', but it is not clear if this species is actually capable of transmitting WNV.

7.2.3. *Ochlerotatus canadensis*

Ochlerotatus canadensis eggs usually hatch in temporary woodland pools as early as the beginning of April, although some eggs seem to have a delayed hatching mechanism as they have been observed hatching throughout the summer as late as August (Woods *et al.*, 1979). Belton (1983) reports that this species in usually not considered a pest in BC due to its low numbers. However, it can be a persistent biter in the forest and tends to bite on the lower legs. This species is rated '++' as a WNv vector

(Belton, 2007) since individuals of this species have tested positive for the virus in other areas of North America.

7.2.4. *Ochlerotatus communis*

Ochlerotatus communis is one of the most abundant and widely distributed species, occurring throughout the forested part of Canada as well as the northern US and northern Eurasia (Wood *et al.* 1979). Larvae generally rear in shaded pools (Belton, 1983), and in the Ottawa area, develop in large numbers in deciduous forest pools with a high tannic acid content (Wood *et al.* 1979). Eggs generally hatch in early spring, and female adults bite fiercely throughout the day. Although it is a fierce biter, it is not considered a major pest in BC due to relatively low numbers (Belton, 1983) except in northern areas. It is not included on the list of potential vectors (Belton, 2007).

7.2.5. *Ochlerotatus dorsalis*

This species thrives on the interior plateau, breeding in saline swamps and pools as well as fresh water (especially irrigation seepages) (Belton, 1983). It is capable of traveling many kilometers, and females of this species are vicious biters both during the day and at night (Belton, 1983). When conditions are favourable, *Ochlerotatus dorsalis* may have two or more summer generations, resulting in a very large population (Wood *et al.* 1979). Belton (2007) gives *Ochlerotatus dorsalis* a vector competence rating of '+++', primarily because Western Equine Encephalitis and West Nile Virus have occasionally been isolated in adult females.

7.2.6. *Ochlerotatus euedes*

Ochlerotatus euedes are relatively uncommon throughout Canada (Woods *et al.,* 1979). Larvae of this species are often collected along with larvae of *Ochlerotatus fitchii* and *Ochlerotatus excrucians*. This species is known to readily bite humans, although it is seldom present in high enough numbers to be considered a pest in BC (Belton, 1983). It is not included on the list of potential vector species (Belton, 2007)

7.2.7. *Ochlerotatus excrucians*

Ochlerotatus excrucians can be found throughout Canada south of the arctic tundra (Woods *et al.*, 1979). Larvae of this species can be found in almost any ground pool, but seem to prefer the edges of larger semi-permanent marshes. Adults are large in size and will survive well into late summer. When present females are fierce biters, but

rarely occur in large numbers in British Columbia (Belton, 1983). This species does not appear on the list of potential WNv vectors (Belton, 2007).

7.2.8. *Ochlerotatus fitchii*

Ochlerotatus fitchii occur nearly everywhere in Canada south of the tree-line, (Woods *et al.,* 1979). Larvae of this species are often collected in the same locations as the larvae of *Ochlerotatus excrucians* or early in the spring in snowmelt pools with *Ochlerotatus increpitus* (Belton, 1983; Woods *et al.*, 1979). It is described as an aggressive pest mosquito of the southern interior and can be a nuisance at elevations as high as 1500m (Belton, 1983). Although individuals of this species have been found infected with WNv, they are unlikely to transmit the illness.

7.2.9. *Ochlerotatus flavescens*

Ochlerotatus flavescens is physically the largest *Ochlerotatus* species in Canada. It is common only in the open prairies, but occurs in low numbers throughout Canada (Woods *et al.*, 1979). It is a ferocious biter of humans, cattle, horses and birds, but is rarely in large enough numbers to be considered a significant pest (Belton, 1983).

7.2.10. *Ochlerotatus increpitus*

Ochlerotatus increpitus is fairly widespread and numerous throughout BC, with larvae found in flood waters, irrigation seepage and rain or snowmelt pools (Belton, 1983) as well as roadside ditches and shaded pools (Wood *et al.* 1979). While female *increpitus* are an important pest in Nevada and Utah, they are generally not common enough in Canada to be considered a significant pest (Wood *et al.* 1979). However, in those localized areas of BC where large numbers are found, the females are eager biters and can be a serious pest of cattle (Belton, 1983). Belton (2007) does not include this species on his list of potential WNV vectors.

7.2.11. *Ochlerotatus sierrensis*

Ochlerotatus sierrensis larvae develop in tree-holes. Larvae have also been found in tires and hollow stumps in the province (Woods *et al*., 1979). As this species rarely occurs in high numbers, it is not considered a significant pest in British Columbia. Peter Belton (2007) includes this species on his list of potential vectors, with a rating of "+".

7.2.12. *Ochlerotatus sticticus*

Ochlerotatus sticticus is primarily a floodwater mosquito and is therefore usually associated with the floodplains of large rivers and widespread excessive precipitation (Wood *et al.*, 1979). With each peak of a river, a fresh hatch of *Ochlerotatus sticticus* can appear (Belton, 1983). This species is almost always associated with *Aedes vexans* (Wood *et al.*, 1979). Eggs of *Ochlerotatus sticticus* can remain viable for about five years, so there may be years when this species may not appear at all as it waits for a significant flood (Belton, 1983). Like *Aedes vexans, Ochlerotatus sticticus* are ferocious biters and readily enter houses day and night (Belton, 1983). This species is not considered to be a strong West Nile Virus vector in British Columbia, with a vector competence rating of '+' (Belton, 2007).

7.3. *COQUILLETTIDIA* SPECIES

7.3.1. *Coquillettidia perturbans*

The genus *Coquillettidia* has replaced the genus *Mansonia* in most of the recent literature, although *Mansonia* is still used by some authors. Only one species from this genus, *Coquillettidia perturbans,* is found in Canada. They are often called 'cattail mosquitoes,' as the siphon of the larvae and 'trumpets' of the pupae are modified to attach themselves to the outside of a cattail and burrow through the side, leaving the body of the larvae protruding (Belton, 1983). This exposure to the air inside the cattail fulfils their oxygen requirements, enabling them to remain buried in the mud at the bottom of the swamp (Wood *et al.* 1979). The marshes where they are found must remain permanently wet, because although there is only one generation per year, larvae are present year-round and are killed by drought, especially in the winter (Wood *et al.* 1979). Females are strong fliers and feed on both birds and mammals, and will occasionally feed more than once before laying eggs (Wood *et al.* 1979). For this reason, Belton (2007) has given them a vector competency rating of '+'.

7.4. *CULEX* SPECIES

Culex is the Latin word for 'mosquitoes' and was used to describe all mosquito species prior to 1818, at which time the genera *Anopheles* and *Aedes* were named (Belton, 1983). There are only three species of *Culex* in British Columbia (*Culex tarsalis*, *Culex pipiens,* and *Culex territans*). *Culex* females lay their eggs in rafts on the

surface of almost any water, and all species found in BC overwinter as fertilized females. As well, all *Culex* species in BC can produce several generations a year, providing that the summer is warm enough. These mosquitoes are generally not considered a nuisance as they are usually found in lower concentrations and are not particularly aggressive biters of humans (they tend to prefer either birds or amphibians). Because they have multiple broods in their lifetime, they have the potential to transmit viruses such as WNv and other encephalitis such as Western Equine Encephalitis. This is because they must take a blood meal before laying each batch of eggs, and after feeding on an infected host, the female has the potential to transmit the virus to her next host. Two of the three species of *Culex* were found to be plentiful in the RDCO between 2003 and 2008.

7.4.1. *Culex tarsalis*

Culex tarsalis breeds in permanent and semi-permanent ponds, irrigation ditches and sewage ponds (Belton, 1983), spreading to small temporary pools and artificial containers as numbers increase through the summer (Wood *et al.*, 1979). In general, they prefer warm, stagnant water with high concentrations of organic materials. *Culex tarsalis* overwinters as adults, hiding in caves, rock piles and talus slopes. Adults feed primarily between sunset and sunrise, with peak activity occurring within two hours after sunset (Wood *et al.*, 1979).

This species will readily feed on both birds and mammals, which is why it is the major vector of Western Equine Encephalitis and West Nile Virus (Belton, 2002; Wood *et al*., 1979). Both Western Equine Encephalitis and West Nile Virus are primarily diseases of wild birds, so when populations of both birds and *Culex tarsalis* are high, the risk of Western Equine Encephalitis and West Nile Virus increase and is likely to start showing up in mammal populations, especially in unvaccinated horses (Belton, 2002; Wood *et al*., 1979). This species is rated at '+++' for vector competence in British Columbia (Belton, 2002).

7.4.2. *Culex pipiens*

This species is known as the "northern house mosquito" and will breed in almost any type of water container, ditch, seepage or flooded field (Belton, 1983; Wood *et al.,* 1970). It is often associated with pollution in the form of human or animal fecal waste (Wood *et al*., 1979). Adult females can overwinter in basements, rock slides and culverts. This species shows a strong preference for birds, although they will also bite mammals and reptiles (Belton, 2002; Wood *et al*., 1979). This species has been known to transmit western equine encephalitis, St. Louis encephalitis and is a listed as a potential vector of West Nile Virus in British Columbia with a competence rating of '++' (Belton, 1983; 2002).

7.5. *CULISETA* SPECIES

The life-history of *Culiseta* mosquitoes is similar to that of *Culex*, with females laying their eggs directly on the surface of water (with the exception of *Culiseta morsitans*, which lay their egg rafts on vegetation at the margin of their larval development sites) (Belton, 1983). Females of most species lay multiple broods each year, and most overwinter as fertilized females. Members of these genera tend to prefer the cooler, temperate climates that are typical of Canada. Three species of *Culiseta* were captured in the RDCO.

7.5.1. *Culiseta incidens*

Culiseta incidens is a very common species, and in 1932 was considered the commonest and most widespread species in the province (Belton, 1983). This was due to the fact that almost every rain barrel in the lower mainland was infested with larvae all summer long, which reflects this mosquito's propensity for breeding in artificial containers and having multiple broods each year. They are also found in ditches and permanent and semi-permanent pools and are capable of tolerating polluted waters (Wood *et al.* 1979). They overwinter in rock slides and talus slopes and emerge early in the spring, and their large size coupled with their early appearance often causes strong reactions from people, even though they are not significant biters of humans. Females generally take blood meals from large mammals, but Belton (1983) has noted that they appear to feed more freely on humans during warm (> 20°C) evenings in the lower mainland. Belton (2007) gives this species a vector competence rating of '++' primarily

because of its widespread distribution, although it has not been found to be infected with WNV.

7.5.2. *Culiseta inornata*

Culiseta inornata is a widespread mosquito, but since it prefers large mammals to man, it is seldom considered a pest. It breeds in deep woodland ponds, seepage ditches and polluted open water (Belton, 1983). This species overwinters as adults in mammal burrows and crevices, and emerges very early in the spring when it is still too cold for other species. These are the large mosquitoes often seen "hovering" close to people at dusk very early in the spring. Larvae have been found in ice-covered ponds (Wood *et al.,* 1979). This wide-spread species is listed as a potential West Nile Virus vector with a competence rating of '+++' (Belton, 2007).

7.5.3. *Culiseta morsitans*

In most of Canada, *Culiseta morsitans* overwinter as eggs, or possibly as larvae deep in silt or peat at the bottom of deep ponds (Belton, 1983). It has a fairly northern distribution, and has been found in a few widely scattered locations in BC (Belton, 1983). It is usually found in shaded conditions, associated with springs, sphagnum bogs and cedar swamps. They are almost exclusively bird feeders (Belton, 1983; Wood *et al.* 1979) and females captured in flight or reared from larvae would not take a blood meal (Belton, 1983). However, because they lay multiple batches of eggs each year (Wood *et al.* 1979) and feed on birds, Belton (2007) has given them a vector competence rating of '++'.

8.0 PREVENTION OF WEST NILE VIRUS THROUGH MOSQUITO ABATEMENT

In British Columbia, we have been able to watch the WNv as it has spread across North America and we have consequently learned and benefited from activities and studies that have occurred in response to its spread. During the virus's progression across the continent, numerous studies have shown that cases of WNv infection can be reduced with comprehensive mosquito abatement. In a recent study in Cook County Illinois, it was shown that areas that employed mosquito control conducted with Integrated Pest Management principles (primarily larviciding, with adulticiding conducted only when necessary) yielded fewer cases of WNv than areas of the county where mosquito abatement was not adequate (Ruiz et al, 2002). Next, a study by Haramis (2004) suggested that areas with intensive larval control in catch basins resulted in fewer cases of WNv than in areas where less intensive control or no control had taken place. In Michigan, it was found that individuals living in areas with no abatement programs were nearly eight times more likely to be infected with WNv compared to residents in areas with comprehensive mosquito control programs (Walker, 2004). Finally, a study in Fort Collins, Colorado suggested that adulticiding resulted in significantly lower numbers of vector species and seemed to significantly reduce the number of cases of WNv infection (Nasci, 2004). All of these studies concluded that reductions in mosquito numbers due to larviciding and/or adulticiding efforts resulted in reduced transmission of the virus to humans.

WNv vector mosquito control is different from nuisance mosquito control in that it targets specific species of mosquitoes. These targeted mosquitoes, namely *Culex tarsalis* and *Culex pipiens*, are usually not considered a nuisance and so are rarely targeted in nuisance control programs, thus deeming a need for a separate focused control program. They often live in different habitats than do nuisance mosquitoes and they tend to be more prevalent in July and August, when most nuisance species tend to decrease in numbers.

9.0 LARVAL MOSQUITO SURVEILLANCE

The RDCO has a database of approximately 266 sites known to produce nuisance and/or WNv vector species (Table 31). The original database utilized in 2003 consisted of all of the sites that the RDCO has traditionally treated as part of their ongoing nuisance program. Since 2004, sites have been added each year as they are discovered and evaluated for the presence of larvae. On July 26, 2004, staff used a helicopter to fly over the entire RDCO so they could take photos of potential WNv vector larval development sites. On September 27, 2007 staff used the helicopter again to searching for larval development sites on Crown Lands. During the flights, GIS coordinates were collected to enable staff to visit the sites and verify if they were in fact producing mosquito larvae. Those sites found to contain mosquito larvae were added to the permanent database. Information on the individual sites, as well as information regarding larval treatment of those sites, is available online at the RDCO website (http://www.regionaldistrict.com/mosquito). Each year, the RDCO hires between eight and ten university and high school students to assist in larviciding activities, as well as in public education. Typically, most or all of the students are offered the opportunity to acquire their Pesticide Applicators Certificate – those that do not take the course work in the company of a certified applicator.

Table 31. Summary of larval development sites throughout the RDCO.

Location of Sites	Number of Sites
Airport	35
Crown Lands	32
Downtown Kelowna	7
Gallagher's	29
Glenmore	31
Mission	25
Rutland	21
Westside/Peachland	33
Winfield/Oyama	53
City of Kelowna	148
Total Sites Monitored	**266**

Each site in the database was monitored for the presence of larvae throughout each breeding season. In addition, a number of catch basins were monitored regularly

within the City of Kelowna, Peachland, the new Westside District Municipality, the District of Lake Country, as well as various other locations throughout the RDCO. Catch basins are important larval development sites for *Culex pipiens* larvae. Under provincial legislation, all water that is to be treated for mosquito control must first be sampled to confirm the presence of larvae.

9.1. METHOD OF LARVAL SURVEILLANCE

In both surface water and catch basin sites, A 300 ml mosquito dipper was used to "dip" water from a suspected larval development site to check for the presence of larvae. When sampling catch basins, the grate cover was removed because the dipper does not fit through the slats. The number of larvae per dip and the genus of the larvae were recorded at each larval development site.

9.2. RESULTS OF LARVAL SURVEILLANCE

Larval development sites were visited each year, between the months of May and September, and monitored for the presence of larvae. Once sufficient larvae were found to be present in a given site, larviciding activities commenced.

Catch basins within the City of Kelowna, Peachland, the new Westside District Municipality, the District of Lake Country, as well as various other locations throughout the RDCO were monitored on a monthly basis. A small number of sites (approximately 50) in each area were monitored for the presence of larvae. When sufficient larvae were present in the majority of the catch basins monitored, larviciding commenced.

10.0 LARVAL TREATMENT

The RDCO conducts its West Nile virus program under the Provincial Pesticide Use Permit held by the Ministry of Health. The nuisance control program is conducted under a Pest Management Plan.

Three larvicides were used in the RDCO between 2003 and 2008: Vectobac 200G (PCP #18158); Altosid Pellets (PCP # 21809) and VectoLex CG (PCP # 28008).

Vectobac 200G contains metabolites of the bacteria *Bacillus thuringiensis* var *israelensis* (*Bti*), Altosid contains the active ingredient methoprene which is a mosquito growth regulator, VectoLex CG contains the live bacteria *Bacillus sphaericus*. These

larvicides are highly specific to mosquito larvae, and when applied according to the label, other insects, amphibians, fish, birds, and mammals that ingest the product are unharmed.

Vectobac 200G is a granular products formulated on ground corn cob so that it can be easily dispersed onto the surface of mosquito larval development habitats by hand or by helicopter. This larvicide has no residual action and will only kill the larvae that are present in the water at the time of application. In many sites, multiple applications were necessary as new generations of larvae appeared in the sites. All treatments were made by hand or with a Backpack Blower.

Altosid Pellets are charcoal-based pellets that allow for slow release of methoprene. This product can be applied once and is effective for 30 days. It was used to treat larvae in catch basins in 2005 and then again for a short time in 2006 until VectoLex became available on the market.

The third product, VectoLex CG, was registered for use in Canada in 2005 and since then, the RDCO has used this product in their catch basin treatment program. It is formulated with live bacteria that replicate in a mosquito's stomach and kill the mosquito when it is in its third or fourth instar. In habitats like catch basins, where there are numerous generations of *Culex pipiens* each summer, this product can have a 30 to 60 residual action.

Table 32. Summary of larviciding treatment in the RDCO between 2004 and 2008.

Year	No. of applications	Total *Bti* applied (kg)	Total area treated (ha.)
2004	336	358	47.75
2005	522	734	97.86
2006	476	433	54.35
2007	700	745	99.43
2008	609	501	66.80

Including the areas of Peachland, Westbank, Lake Country, and the City of Kelowna, slightly over 10,000 catch basins were treated as many as three times per year. In 2008, slightly more than 30 kg of VectoLex CG were used, and this amount was typical for the preceding years as well.

11.0 RECOMMENDATIONS

It is expected that WNv will eventually find its way to British Columbia, and when it does, it is predicted that the RDCO is at high risk of seeing cases. This prediction is based on the high numbers of *Culex tarsalis* and *Culex pipiens* captured as adults in light traps and as larvae in confirmed larval development sites within the Regional District. It is also substantiated by the presence of high-degree days in the area (Figure 1), which impacts the number of generations of *Culex tarsalis* that develop in an area. Given this prediction, the following recommendations have been developed:

1. It is recommended that the RDCO continue to apply for funding (if it is available) to continue their WNv program.

2. It is recommended that the RDCO continue to search for and map vector habitats and to control larvae in standing water, marshes and catch basins.

3. It is recommended that public education continue as funding allows.

4. It is recommended that an adult mosquito surveillance program continue. Predictions have been made based on trap counts and vector presence. These numbers can change from year to year, and sometimes even with a change in trap location of just a few hundred meters. Also, it is important to continue surveillance as a means of assessing the effectiveness of a larviciding program. Larviciding efforts in any given year will only impact adult populations in that same year. This is due to the fact that there is a limited control area and therefore there will be recruitment of adult mosquitoes from outside the treatment area, and because of the exponential growth of multi-generational mosquito populations. It is impossible to completely eliminate adult mosquitoes, and a small number of survivors are capable of producing a large population in future years if no larviciding is conducted.

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