Duka Environmental Services Ltd.

REGIONAL DISTRICT OF CENTRAL OKANAGAN

Integrated Pest Management Program
Nuisance and Vector Mosquito Surveillance and Control
2022 Summary Report

Prepared for
The Regional District of Central Okanagan
Kelowna, British Columbia

Prepared by
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Langley, British Columbia

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EXECUTIVE SUMMARY

Regional District of Central Okanagan
2022 Nuisance and Vector Mosquito Surveillance and Control Program

The Regional District of Central Okanagan (RDCO) has provided residents, workers and visitors with mosquito surveillance and control services for over thirty years. Program services are provided to the City of Kelowna, the District of Lake Country, District of Peachland, Westbank First Nation and defined areas in the City of West Kelowna and RDCO Central Okanagan East Electoral Area.

The RDCO, centered around the City of Kelowna, has significant recreational and environmental value, providing residents and visitors with many outdoor summer activities and employment. Walking, cycling, camping, horseback riding, bird watching, biking, boating, sunbathing, beaches, golfing, wine tasting, and tours are just a few of these activities. Adult mosquito annoyance can often conflict with these activities. Besides the negative impacts on the lifestyle of residents, there can be considerable economic impact from mosquito annoyance on businesses and outdoor workers.

The goal of the annual mosquito control program is to reduce the potential for widespread adult mosquito annoyance and possibility of mosquito-borne disease, for the benefit of residents, workers, and area visitors. This is achieved by the suppression of larval mosquito populations using an integrated pest management (IPM) approach to their surveillance, prevention, and control. This approach focuses on the timely detection and treatment of larval mosquito populations using biological products and techniques. Where possible, and appropriate, suggestions are recommended that may reduce larval habitat, and which will enhance, or conserve, natural mosquito predators. Where required, larval mosquito populations were controlled using the bio-rational larvicide product VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis*, *Serotype H-14 Strain AM65-52*; PCP #18158) and VectoLex (*Bacillus sphaericus*; PCP # 28008, 28009).

Larval development habitats within the RDCO program include sloughs, back channels and low-lying fields, forested areas and undeveloped areas located along Mission Creek and adjacent to numerous small lakes. Snowmelt and precipitation run-off increases creek and lake levels to cause flooding and seepage water accumulations in adjacent areas. Natural, permanent, temporary, seepage and spring-fed ponds and marshes are also located throughout the control programs boundaries. Man-made display, landscape and settling ponds, drainage and roadside ditches, depressions in farm fields and in undeveloped or rural properties, golf courses etc., also provide potential larval mosquito development habitat. Some +300 development sites have been identified for routine surveillance and possible treatment within the defined boundaries of the control program.

In addition to natural and man-made waterbodies, containers including buckets, unused fountains and pools, livestock watering troughs, uncovered boats and equipment can all hold water to create a potential mosquito development habitat. These are typically found when responding to mosquito annoyance reports. When encountered they are either emptied or instructions provided to reduce or

eliminate their potential as a source of mosquitos. The most widespread larval development habitat within the RDCO is roadside catch basins. With over 12,000 located along public roadways and parking areas, they provide a potential source for adult mosquitos in residential, commercial, recreational, and industrial areas.

Public education initiatives included routine and regular radio, television and internet advertisements, social media, and website postings. These outreach activities helped residents understand that the control program can only suppress mosquito populations, not eradicate them, and that some adult mosquito annoyance may still occur. With the relaxation of restrictions this year, some public outreach activities were resumed and back for the first time since 2019, such as staffed information booths at the Canada Day celebrations and the annual used tire-round-up.

As a result of isolation/distancing protocols related to the ongoing COVID-19 pandemic, *Duka Ltd.* field biologists and technicians continued to manage their personal interactions with residents. Interactions with business operators or property owners and residents were accomplished through telephone conversations, emails, or if on site, held at a distance. Where required, doorknob hangers and notes were left by *Duka Ltd.* for owners and managers detailing observations and activities completed, or required, at the property for the purposes of mosquito surveillance and control.

Overall weather conditions for Kelowna area during the 2022 spring and summer, April through August, could be summarized as cooler and wetter when compared with 2017-2021 averages. Mean monthly temperatures for April through June were slightly below normal while July and August were normal, or above normal. Monthly precipitation totals for April through August totaled 134.1mm or about 175% of the recent, normal five-year average of 76.8mm. June 2022 was an especially “wet” month with over 4 times (399%) the average amount of precipitation recorded at UBCO Kelowna.

A total of 26 different mosquito species were collected as either larvae or adults during 2022. Of these, some 46% (12 species) have been identified by the BC Centres for Disease Control as potential vectors of West Nile virus, and six of these; *Aedes dorsalis, Aedes vexans, Culiseta inornata, Culiseta incidens, Culex pipiens* and *Culex tarsalis* are listed as competent (++) to highly competent (++++) vectors.

A total of 1150.35 kilograms of VectoBac 200G were applied to a total area of 153.38 hectares of active larval mosquito development habitat. Some 184 sites were treated on a total of 888 separate occasions. Although many sites were treated on 1 or 2 occasions during 2022, numerous sites were treated between 6 – 8 times and several sites were treated on 10 - 13 occasions. A total of 22,983 water-holding catch basins were treated during two treatment campaigns in 2022.

All applications were completed under the auspices of the BC Ministry of Environment-accepted RDCO, Pest Management Plan # 142-0030-21/26 for Mosquito Control. Year-end program reporting; the *Pesticide Use Follow-up Report* and the *Annual Report for Confirmation Holders* required for the PMP will be completed by *Duka Ltd.* and submitted to the BCMOE on behalf of the RDCO.

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1.0 INTRODUCTION

Duka Environmental Services Ltd. (*Duka Ltd.*), an environmental services firm with extensive experience in integrated pest management, and a specialization in mosquito and biting fly surveillance and population of management are retained were retained by the Regional District of Central Okanagan (RDCO) to coordinate the management and delivery of an effective nuisance and vector mosquito surveillance and control program.

The methodologies and procedures employed for this mosquito surveillance and control program are a hybrid of the most current approaches and standard techniques. Developed by *Duka Ltd.* over some thirty-five operational seasons, and through collaboration with mosquito and vector control professionals worldwide, it has been carefully, and specifically, adapted for the unique conditions of the local program area. Predictive indices for larval mosquito development onset and distributions use winter snowpack, local lake and creek or river levels, precipitation totals and monthly mean temperatures. These indices have enabled *Duka Ltd.* to develop an adaptive approach to effective, efficient, and timely mosquito population surveillance, management and forecasting of larval development onset and distributions. This approach is a model of environmental compatibility and sustainable operations which will suppress local mosquito populations.

A public education and information strategy, mosquito population surveillance, monitoring and control methods are described in the *Regional District of Central Okanagan Mosquito Control Pest Management Plan*, PMP # 142-0030-21/26. The procedures employed for this program support the principles of Integrated Pest Management (IPM) and include physical site reduction or modification, the conservation and enhancement of natural predator populations and habitats, and the use of biological, larval control products. Where required, and when other solutions are impractical, or won't effectively reduce mosquito development, the bio-rational larvicide products VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis,* PCP #18158) and VectoLex® CG and WSP (Bacillus sphaericus, PCP # 28008, 28009) are used.

Mosquito surveillance and control services were provided to residential and rural property owners, farmers, businesses, parks, campgrounds, golf courses and other outdoor recreational and tourist facilities. The goal of the annual larval mosquito surveillance and control program is to limit the potential for widespread adult mosquito annoyance, and possibility of mosquito-borne diseases, for the benefit of residents, businesses, workers, and visitors to the RDCO, Kelowna, Peachland and area.

All annual government regulatory agency conditions, notifications and reporting of operations are completed by *Duka Ltd*., on behalf of the RDCO, and as required by this PMP and the applicable regulations and legislation.

2.0 PUBLIC EDUCATION AND INFORMATION

Public input is invaluable to any community function, and it is a key component of all successful, pro-active mosquito control programs. Residents, business operators and other stakeholders were encouraged to contact RDCO, or *Duka Ltd.* offices directly, to report potential mosquito development habitat and adult mosquito annoyance.

All requests for service, or for more program information are initially followed-up through telephone or email contact, as requested. Where indicated, *Duka Ltd.* field personnel completed on-site inspections, often with property residents, to locate and review potential larval mosquito habitats (waterbodies). In addition to providing residents with information on how they can reduce larval development and annoyance around their properties, education initiatives help residents understand that the control program can only suppress mosquito populations, not eradicate them, and that some mosquito annoyance may be anticipated at certain locations, times of day and during some years.

Because of concerns with COVID-19 transmission again this season, field personnel were limited in their ability to be as personable with residents, property owners and workers as in previous seasons. *Duka Ltd.* personnel followed BCCDC and BC Provincial Health Officer recommended physical distancing protocols when interacting with the public. When personal interactions were required to access a property, equipment, or for the purpose of conversation, *Duka Ltd.* personnel used the appropriate, recommended personal protective equipment (PPE) and distancing. Any protocols set in place by businesses such as golf courses, greenhouses, horse boarding facilities etc., (i.e. check-in procedures, disinfecting equipment or gate handles etc. after use) were followed when accessing properties.

All public education materials provided interested individuals with telephone, email (duka@telus.net) and website contact addresses for *Duka Ltd*. (www.duka.consulting) and the RDCO (www.rdco.com). Information on mosquito development and control, or for links to other informative websites and contact information for Provincial, Federal and Environment, or Health offices were available through *Duka Ltd.* Property owners are encouraged to reduce or eliminate standing water on their properties and to support natural predators by installing bird and bat houses. Window screens, repellents, and adult mosquito collection devices such as Mosquito Magnets™ can contribute to reduced adult mosquito annoyance.

- ***Public Information Booths***

For the first time since 2019, *Duka Ltd.* program technicians and biologists were able to staff an informational booth for public outreach at the Canada Day celebrations this year due to the relaxation of many Covid-19 restrictions. Many members of the public approached the booth to learn about mosquito biology, how the RDCO Mosquito Surveillance and

Control Program operates and actions they could undertake around their properties to reduce larval development and adult mosquito nuisance. The annual used-tire drop-off was also offered to the public again this year, and through the program's partnership with the Tire Stewardship B.C., it removed approximately 1700 tires as potential mosquito development habitat.

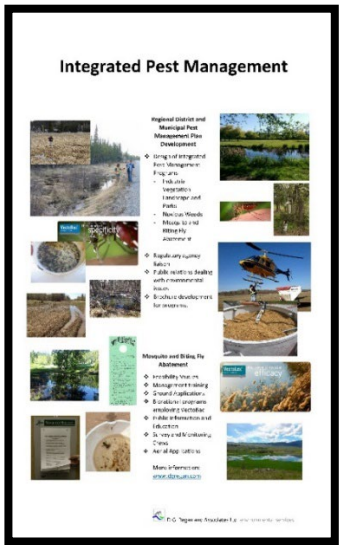
- ***Council, Committee Reports and Meetings***

The RDCO Environmental Services Department, Engineering Technologist, the RDCO Communications and Intergovernmental Affairs Coordinator, and Supervisor of Utility Services were each provided with regular, monthly, written (email) program updates throughout the 2022 operational season. Quarterly summaries of program operations were also provided throughout the year.

In addition to written reports and program updates, regular contact was maintained with these individuals through on-site personal meetings and regular telephone, text message and e-mail communications. *Duka Ltd.* office staff also maintained regular contact with RDCO office reception personnel during the season to receive any service requests or reports of adult mosquito annoyance from the general public. All interactions with the general public, RDCO staff, and contractors were accomplished while adhering to the BCCDC and BC Provincial Health Officer recommended physical distancing, hygiene and masking protocols.

- ***Informational Posters***

Laminated, informational posters (11" x 17") were again available to local golf courses and interested businesses for posting in locker, change rooms, lunchrooms or on bulletin boards. These posters contained information on mosquito life cycles, program operations and practical suggestions for how the reader could reduce, or eliminate, larval development habitat around their property and the potential for adult mosquito annoyance.



- ***Newspaper and Radio Interviews***

The RDCO Communications and Intergovernmental Affairs Officer coordinated all print, radio, social media (Facebook, Twitter) and web-based public education outreach for the 2022 Nuisance and Vector Mosquito Surveillance and Control Program. Regular, and frequent, advertisements were placed on Castanet.net, in several local newspapers and radio stations. Media releases and Public Service Announcements were also routinely aired on SHAW Central Okanagan and cable TV channels. *Duka Ltd.* managers and field personnel also provided local newspapers and several television stations with interviews in May, June and July.

News media articles and advertisements provided updates on the status of local mosquito populations and provided useful information on program operations, product safety and actions residents could undertake to reduce mosquito habitat and annoyance around their properties. Program access and contact information (telephone, email, website addresses for *Duka Ltd*.) were also provided as part of every interview and article.

- ***Doorknob message hangers***

"*Sorry We Missed You!"* doorknob message hangers were left by *Duka Ltd.* technicians and biologists at homes and properties when residents weren't available during initial site visits or when responding to a request for service. These cards contained a brief summary of the property inspection, field staff observations or actions, and contact information for further follow-up.

These hangers provided a "closed-loop communication" with residents and business operators about what was done, or what needed to be done, in response to a service request or as a result of field staff observations. These hangers typically result in some 5-10 return telephone calls by property residents to confirm their desire for program participation and to provide property access procedures, including gate keys, codes, or dog names, if required.

- ***Informational Brochures***

Informational brochures provided by the RDCO were distributed by *Duka Ltd.* personnel to interested members of the public, residents and business or facility operators during property inspections and while staffing public education booths. These brochures summarized program operations, mosquito biology, tips for reducing larval mosquito habitat and adult annoyance. They also provided telephone, email, website, Facebook, and Twitter contact information for the RDCO.

Duka Ltd. also supplied field personnel with "*Your Mosquito Surveillance and Control Program*" informational pamphlets. This pamphlet explains basic mosquito biology, facts about control, and

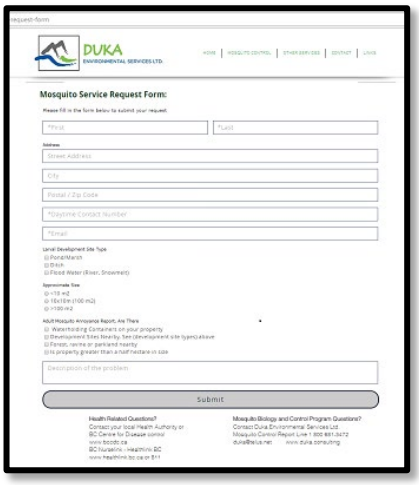
practical steps individuals can take to eliminate or reduce larval development habitat and annoyance around their properties. Often left with doorknob hangers these also provided contact information (email, telephone) and website address for *Duka Ltd.* Additional, public health information and VectoBac 200G (*Bacillus thuringiensis* var. *israelensis*) and VectoLex (*Bacillus sphaericus*) product specific brochures and pamphlets were also available through *Duka Ltd.* and on-line through *www.valentbiosciences.com.*

- ***Facebook and Twitter***

Duka Ltd. maintains a Facebook page (@DukaEnvironmentalServices) allowing us to further engage with the public by the posting of service announcements or observations, friendly reminders to empty containers of standing water, interesting news items and articles, and public health announcements as it relates to mosquitos and disease (i.e. West Nile virus, Zika).

The RDCO also maintains a presence on social media and provides routine updates on mosquito control operations. The RDCO also maintains a presence on social media and a Facebook page which was regularly updated with information on program status and how to access services

- ***Websites and email***



All public education materials (advertisements, pamphlets, etc.) provided email (duka@telus.net) and website contact addresses for Duka Ltd. (www.duka.consulting) and the RDCO (rdco.com) Detailed information on mosquito development and control, and links to other websites and contact information for Provincial, Federal and Environment, or Health offices were also available.

The public could also report adult mosquito annoyance and potential larval development sites (a waterbody) directly to *Duka Ltd.* using the "*Mosquito Service Request Form*". This form allows residents and business owners to provide details on their properties, potential sites and to request a follow-up response or inspection. The form also allows for the attachment of pictures and/or maps.

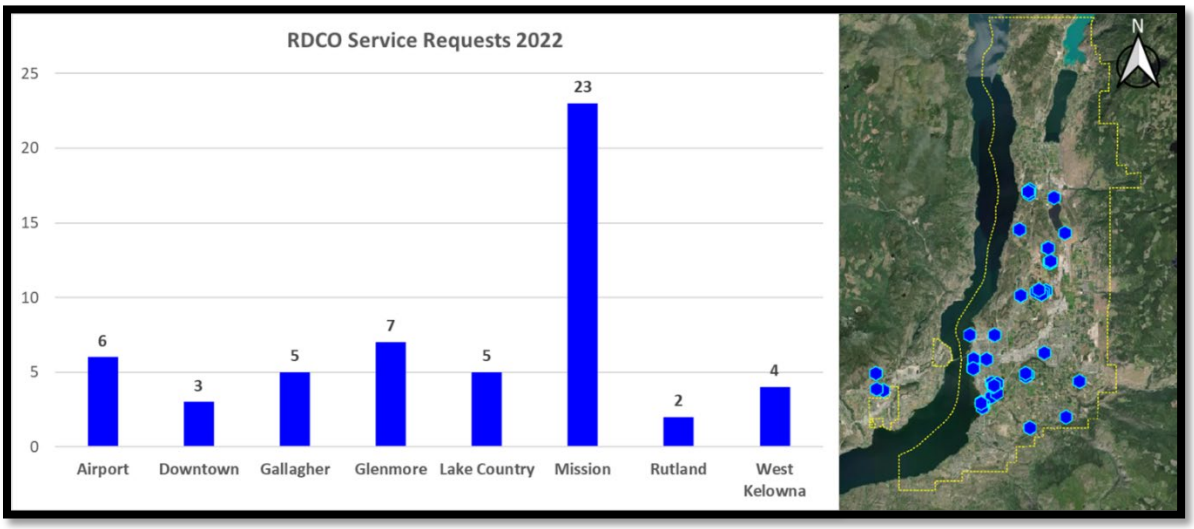
- ***Public Communications and Interaction***

In addition to encouraging the public through items such as brochures, door hangers, radio and newspaper articles, interviews, and social media to access the program through RDCO offices, *Duka Ltd*. maintains a toll free, 1-800-681-3472 twenty-four-hour phone line with voicemail. Staffed during routine office hours, the public can contact office personnel to discuss their concerns directly and/or leave a message for the program biologist/technician. Our policy is to respond to public inquiries as soon as possible, typically within hours, and unless it is a weekend, within 24-36 hours.

Typically, as part of initial program start-up or response to service requests, field personnel would knock on the doors of property owners, residents, or business operators with known development sites to introduce themselves and confirm participation in the annual control program. When personal interactions were required to access a property, equipment, or for the purpose of conversation, *Duka Ltd.* personnel used the appropriate, recommended personal protective equipment (PPE) and distancing.

This year, as in 2020 and 2021, field staff would retreat a short distance once having knocked and wait. Field staff wear hi-visibility vests, rubber boots, lanyards with their identification, carry dippers, buckets and their sampling gear making them recognizable to most individuals as the "mosquito control guy or girl". Staff would give, and receive, an "affirmative hand wave" or "thumbs up" from residents and business operators when they were encountered, and if no one was observed, or answered the door, a doorknob hanger or brief note would be left. These summarized what had been done and provided residents and businesses with follow-up contact details for *Duka Ltd.* personnel or more information.

A total of 55 service requests were received by telephone, email or through the *Duka Ltd.* website reporting from between 02 February and 25 July 2022. Twenty six (47%) of these contacts were to report of adult mosquito nuisance. Sixteen calls were to report potential larval development habitat (ponds, ditches) and seven calls were for more program information. Eight calls were a "return" phone call in response to staff leaving doorknob hangers and were made to confirm property access and program participation. A summary of service requests received, by area, is presented in Chart 1, below.



<u>Chart 1:</u> Service Request Summary, by Neighbourhood, 02 February – 25 July 2022.

Field personnel maintained regular, COVID-appropriate contact with maintenance and pro-shop staff at the various golf courses throughout the 2022 season. Regular site visits provided course operators with updates on program operations and allowed field biologists and technicians to solicit input from patrons

and staff about any observations of adult mosquitos. Similar conversations with RDCO or City of Kelowna public works personnel encountered at parks and sports fields also provided field staff with useful input and feedback on potential larval mosquito sources and observations of adult mosquito activity.

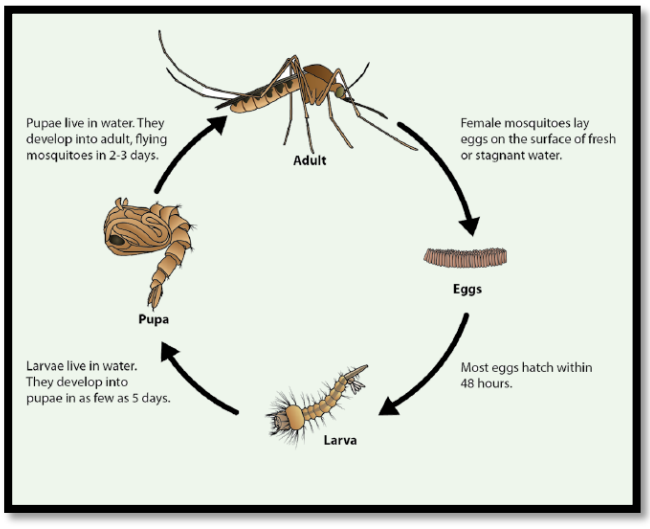
All *Duka Ltd.* personnel contacts and interactions with the general public, businesses, and local facility operators this season were very positive. Property owners and facility managers were all very helpful providing consent and unhindered access for the purposes of surveying, monitoring and control with gate keys provided for a number of properties. The large majority of residents and visitors reported little or short-lived adult mosquito annoyance this season.

3.0 ENVIRONMENTAL CONDITIONS AND MOSQUITO POPULATIONS

The key to successful mosquito control (population management) and a reduction in adult mosquito nuisance populations is through the early detection and timely control of larval development. Regular surveying and monitoring of potential mosquito development sites, typically beginning in mid to late April of each season, ensures that larval development is identified and treated.

3.1 Mosquito Biology and Public Health

All mosquitoes require water for larval development. Larvae must go through four stages or instars, (1st, 2nd, 3rd and 4th), each bigger than the previous, before developing into pupae. Pupae undergo complete metamorphosis and emerge as winged, terrestrial adults. This process can occur in as little as 5-7 days, although typically requires 7-14 days, depending on temperatures.



Adult mosquitos feed on plant juices and it is only the female that requires a blood meal to complete the development of her eggs. Adult, female mosquitoes will typically fly less than 1 – 2km in search of a blood meal although distances of +5 km are not uncommon. They have even been found 30km from their origin and at heights of 10,000 meters. While these are the extreme, and rare distances, the impact of winds on mosquito dispersal can be significant.

Mosquitos are best known as vectors of 'tropical' diseases such as malaria and yellow fever. Although these exotic afflictions are extremely rare in British Columbia, mosquitos can still pose a serious health concern. In addition to causing

nuisance, many of the species collected locally also have a potential to impact public health, comfort and well-being. Extreme allergic reactions or secondary infections from irritated mosquito bites can occasionally require hospitalization. Although locally rare, diseases such as canine heartworm, Western Equine Encephalitis (WEE) and West Nile virus (WNv) are transmitted between birds and mosquitos to family pets, humans, and livestock.

The ability of a particular species to vector disease such as WNv was established through the assignment of a competency rating by the BC Centres for Disease Control (BCCDC, 2005), based on a number of factors including mosquito life cycle, distribution, occurrence and preferred or potential blood meal hosts. Species were ranked from (0), or no potential to transmit disease, to (++++), or the ability to readily, and effectively transmit the disease. Species with a competency rating of (+++) and (++++) are the object of most vector-focused mosquito control programs.

Since mosquitos capable of vectoring diseases to man are often the source of annoyance (human-biting), the control of mosquito populations known to cause nuisance also contributes to the protection of public health by controlling mosquito species also having the potential to vector disease. A few years ago, the mosquito-associated flaviviral virus disease caused by Zika virus (ZIKV) became a prominent health concern in several areas of the world, including the southern USA. The current status of WNv and ZIKV in British Columbia, Canada and elsewhere in North America is available at www.BCCDC.ca and Health Canada at www.canada.ca/en/health-canada or www.Hc-sc.gc.ca.

The key to successful mosquito control (population management) and a reduction in adult mosquito nuisance populations is through the early detection and timely control of larval development. Regular surveying and monitoring of potential mosquito development sites (waterbodies), beginning with snowmelt and permanent habitats in early April, and for creek or lake level-influenced sites beginning in May, ensures that the onset of larval development is identified and treated. *Duka Ltd.* larval surveillance protocols ensured that larval sampling and monitoring of habitats was completed on a regular basis and typically every 6-10 days, depending on conditions.

Larval mosquito populations are sampled using a standardized, 350ml white plastic dipper. All samples were preserved and forwarded to *Duka Ltd.* corporate offices for taxonomic identification. Larval densities as low as one larvae/350ml dip sample in a roadside ditch or pond the size of backyard swimming pool (5m x 10m) has the potential to produce ~ 24,000 larvae. A one hectare site, about the size of 2 football fields would produce over 4,000,000 mosquitos. Larval

populations in much of the program area average between 10-30 larvae/dip sample. Left untreated, the resultant adult mosquito populations are capable of causing noticeable annoyance for local area residents. Depending on the species, larval mosquito populations can range upwards of 100-500+ larvae/dip sample.

3.2 Local Mosquito Species and Habitats

Mosquito development in the Central Okanagan occurs in a wide variety of larval habitats, ranging from lake and river level-influenced flood and seepage water pools and channels in farm fields and forested areas, to permanent freshwater, ponds, marshes, ditches and similar water-holding depressions. In addition, any container, or depression, either natural or manmade, which is capable of holding water for several days to weeks can provide development habitat for larval mosquitos. Bird baths, plugged rain gutters, livestock watering troughs, stored equipment, irrigation and surface water run-off collection ponds, ditches, tire ruts and catch basins are just a few examples of possible larval mosquito habitats.

Larval and adult mosquito surveys and sample collection over the past several years has resulted in the identification of over 25 different species of mosquitos occurring within the RDCO, City of Kelowna, District of Peachland, WestBank First Nations and adjacent areas. *Aedes* mosquitos are the most diverse and typically account for about 2/3 of all mosquito species collected. The balance of species collected are comprised of *Culiseta, Culex* and *Anopheles*. The diverse complex of mosquitos collected locally reflects the great variety of habitats and the impacts of local lake and river/creek levels, snowpack, and annual weather conditions on mosquito species occurrence and distribution.

Aedes mosquitos lay their eggs on the soil where they overwinter and can remain viable, and able to hatch, for upwards of twenty years. Egg hatching is dependent on flooding, and is typically synchronous, with larval development occurring within hours of inundation. Larval population densities averaging 50-100 larvae/dip are not uncommon. These mosquitos are aggressive biting pests and prefer habitats such as fluctuating ditches and marshes and temporary habitats (*Aedes vexans*, *Aedes sticticus)* including surface water run-off, river seepage, floodwater and precipitation accumulations in low-lying fields and deciduous forest areas. *Aedes* mosquitos are most common early in the season, developing in response to fluctuating river levels and floodwater accumulations in farm fields, old oxbows, sloughs, and various ponds, depressions, and ditches. Since rainfall accumulations may immerse eggs several times a season, each initiating a further hatch, regular surveillance for *Aedes* mosquitos is required. Common *Aedes* species collected locally, and which can also transmit disease, include *Aedes* melanimon (+++)*, Aedes vexans* (++) and *Aedes sticticus* (+).

Anopheles, Culex and *Culiseta* mosquitos require a different set of cues to initiate the onset of larval development, including increasing day length and warmer temperatures. They are at their most numerous and widely distributed during mid to late summer when these conditions typically exist. Although populations and individual development sites are not usually as large, and hatching is not as synchronous as *Aedes* mosquitos, *Culex*, *Culiseta* and *Anopheles* mosquitos are capable of causing

extended nuisance by producing several generations in a typical season. They prefer permanent and slow-draining, or frequently refilled sites including natural and man-made irrigation and display ponds, ditches, tire and tractor ruts, and containers such as stored tires, boats and buckets or livestock watering troughs.

Species such as *Culex tarsalis* (++++) are able to withstand a high degree of pollution and can inhabit areas with high organic content, including septic field seepage, sewage lagoons and livestock hoof prints around barns, feed lots and along creeks. Other species like *Culex pipiens* (+++), *Culiseta 13ornate* (+++) and *Culiseta incidens* (++) are common mosquitos of freshwater habitats and in addition to causing recurring adult mosquito annoyance, several species also have the capacity to vector disease including WNv and Western Equine Encephalitis (WEE), also known as sleeping sickness in horses. They can be a source of reportable annoyance by residents and visitors since preferred habitats include permanent, natural, and man-made waterbodies, temporary habitats and containers common to residential, commercial, recreational and agricultural properties.

3.3 Weather, Winter Snowpack, and Mission Creek Levels

Numerous cues interact to affect the timing and magnitude of mosquito development in the Central Okanagan and Kelowna areas. The amount of winter snowfall accumulations in local mountains and their subsequent melt in late spring and early summer have a direct impact on water levels and the extent of flooding observed in low-lying fields, forests, and undeveloped areas adjacent to local lakes, rivers, and creeks.

Temperature and precipitation (weather) impacts on mosquito development and survival can vary depending on mosquito species and habitat. Weather conditions during April, May and June can either amplify, or reduce, the extent of flood and seepage water accumulations and resultant river levels from snowpack melt. Later in the season, during July and August, temperatures and precipitation can impact development site size, persistence, and larval distributions. Adult mosquito activity and survival are affected by temperatures and humidity.

During February, March, April and May, *Duka Ltd.* personnel regularly reviewed (websites) local snowpack conditions and long-range weather forecasts. Local lake and Mission Creek levels were monitored (websites) on a near-daily basis beginning in late April and extending throughout July. Ongoing habitat surveillance during the season confirmed creek and lake level impacts, development site status and allowed new, or previously unidentified mosquito development habitat to be characterized. New, or changing, larval habitats were photographed, mapped, catalogued, and added to the development site database for future monitoring and treatment, as required.

- ***Winter Snowpack***

Snow pillow survey data collected by the BC Ministry of Environment (River Forecast Centre, www.bcrfc.env.gov.bc.ca/bulletins/watersupply) during the period 01 January to 01 May 2022 indicated an overall below average accumulation of snowfall in local mountains. Snowpack measurements were well above average during June and when measured on 15 June, the last date of measurements, they were 243% of normal)(Chart 2, below). Not because of accumulations, but because of delayed melt.

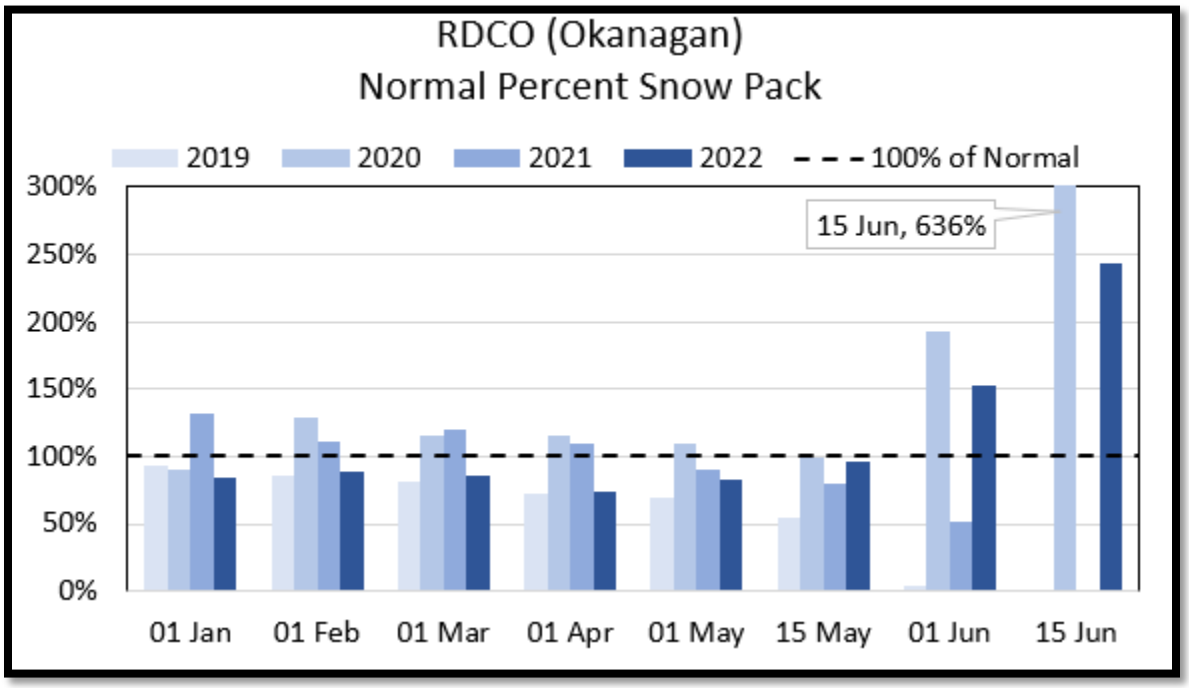


Chart 2: Snow Surveys; Percent of Normal (100%) Snowpack for 01 January – 01 June, 2019-2021, Okanagan Snow Basin (www.bcrfc.gov.bc.ca)

- ***Weather***

Overall weather conditions for Kelowna area during the 2022 spring and summer, April through August, could be summarized as cooler and significantly "wetter" when compared with 2017-2021 averages, (http://climate.weatheroffice.ec.gc.ca/climateData). Mean monthly temperatures for April through June were 1.5-3.0^{o}C below normal while July and August were 0.6^{o}C and 2.4^{o}C, respectively above normal, (Chart 3 below).

Monthly precipitation totals for April totaled 39% of normal and May was 126% of normal. Precipitation totaling 68.3mm for June was 4X (399%) normal (17.1mm), and August precipitation totals were 226% of normal. July precipitation totaled 88% of normal. Overall, during the period 01 April to 31 August 2022, a total of 134.1mm of precipitation was recorded at UBCO Kelowna, or almost twice (174%) the recent five-year average of 76.8mm, (Chart 3, below).

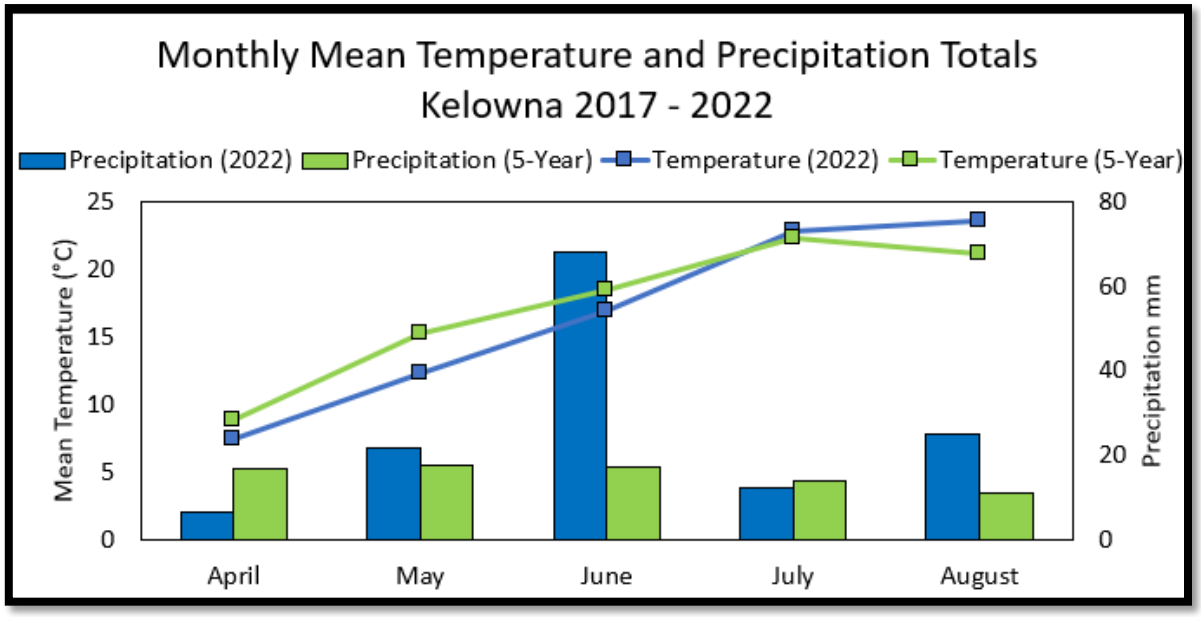


Chart 3: Monthly mean temperature and precipitation totals for April – August 2022 compared with the 2017-2021 averages. Measured at Kelowna UBCO, Station ID # 1123996

- ***Mission Creek Levels***

Increasing Mission Creek water levels flood adjacent, low-lying farm fields, forested areas and similar undeveloped lands adjacent the creek. Mission Creek levels exceeding 1.4 metres, measured at East Kelowna Station # 08NM116, (https://wateroffice.ec.gc.ca) cause local flood and seepage water accumulations sufficient for larval mosquito eclosion (egg hatching) and development. The greater the number of days with water levels above 1.4m, the greater the amount of flooding and seepage water accumulations adjacent to Mission Creek.

Year	Freshet	Days > 1.4m	Peak Level	Peak Date
2022	04 June - 04 July	16	2.040	14 June
2021	N/A	0	1.318	02 June
2020	03 May - 03 July	49	2.089	01 June
2019	N/A	0	1.265	15 May
2018	27 April - 29 May	31	2.199	09 May
2017	05 May - 09 June	31	1.886	05 May
2017 - 2021 Avg.	**01 May - 13 June**	**22**	**1.751**	**18 May**

Chart 4: Mission Creek Level Summary, measured at East Kelowna (Station # 08NM116), 2017-2022.

A cool spring, delayed snowmelt, (Chart 2above) and above average precipitation during June 2022, (Chart 3 above) combined to produce and later than usual Mission Creek freshet, (Chart 4 above, Figure 1 below). Mission Creek levels exceeding the 1.4m threshold for flooding extended from 04 June until 04 July, with a peak water level of 2.04m measured on 14 June. Typically, the Mission Creek freshet occurs during the approximate period of 01 May – 13 June, with an average maximum peak height of 1.75 measured around mid-May.

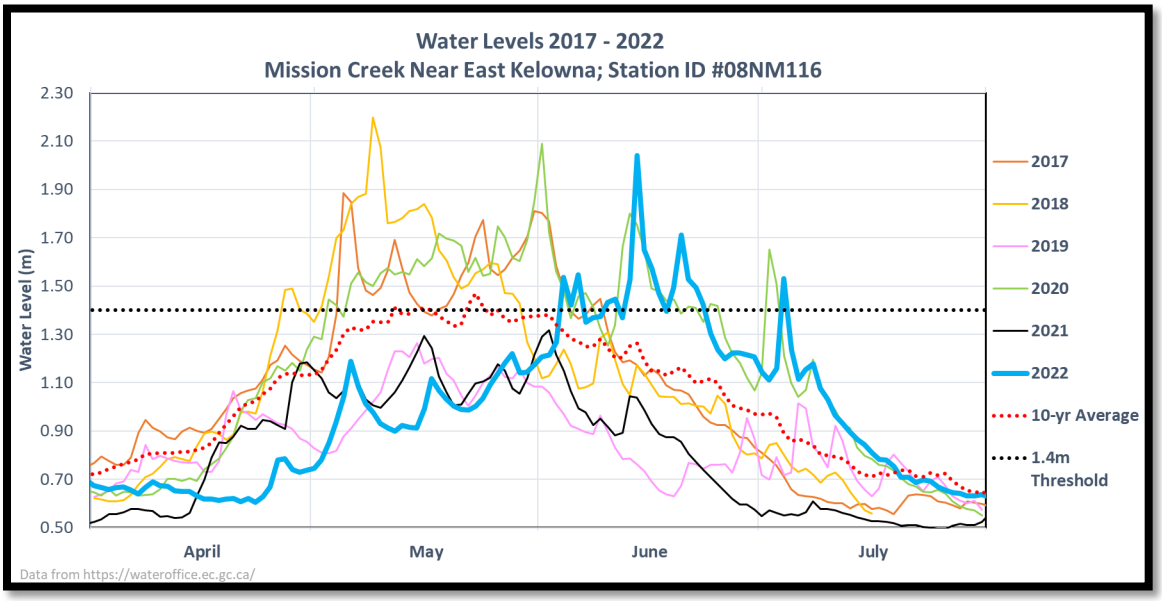


Figure 1: Mission Creek Levels, measured at East Kelowna (Station # 08NM116) 2017-2022.

Mission Creek levels exceeded the 1.4m threshold for widespread flooding and larval development for a total of 16 days in 2022 (Chart 4 and Figure 1). A delayed onset, but rapid snowmelt of snowpack accumulations beginning in early June combined with extensive precipitation, and increasing temperatures (Chart 3, above) to cause increased Mission Creek water levels beginning in early June 2022. Seepage water accumulations in low-lying forested areas and fields adjacent the creek occurred quickly, were extensive, but also short-lived with many sites beginning to drain or dry during the last week of June.

3.4 Larval Mosquito Populations

Larval mosquito development habitats occurring within the boundaries of the RDCO include permanent, and temporary marshes, ponds, and sloughs, ditches, and depressions. Both permanent and temporary habitats are affected by the impacts of creek and lake levels, flood, seepage, and precipitation.

Temporary habitats, vary in size, from month to month, and year to year, in response to variable snowpack and weather. Occurring in areas with dense underbrush and forest growth, particularly along the Mission Creek areas through the Gallagher and Mission areas, and adjacent the southern shorelines of Kalamalka, Wood and Duck Lakes, these areas can be especially difficult to survey and treat. Beginning as early as

mid-April, these sites are initially filled with local snowmelt and precipitation, and then with increasing water levels from mountain snowpack melt, flood, and seepage water accumulations. Elevated and fluctuating lake and creek levels during May and June can cause prolonged flooding in low-lying areas. Larval populations, typically *Aedes,* predominate in these sites for as long as they remain flooded.

Permanent or slow-draining ponds, small lakes, stagnant ditches provide potential season-long habitat for *Culex*, *Culiseta* and *Anopheles* mosquitos. Fluctuating in size and depth with precipitation and temperatures, larval development in these habitats often begins in late May and continues through into August, and with certain conditions into September. Cattail marshes, which are located throughout the Central Okanagan, provide ready habitat for *Culex* and *Culiseta* mosquitos but can also provide habitat for a unique, and difficult to sample mosquito. *Coquillettidae perturbans*, an uncommon mosquito, often called the cattail mosquito, has a serrated larval siphon and pupal "trumpets" allowing it to attach to young cattails (*Typha* sp.) and similar aquatic plants so that it can access the air inside these hollow plants and "breath" underwater. Because they are not free swimming like most larval, they are not generally collected in routine larval sampling. They can be aggressive biters of man during the night and in shaded areas adjacent their development habitats.

In addition to temporary and permanent waterbodies, any container or depression (tire ruts, swales), either natural or manmade, and which is capable of holding water for several days, to several weeks can also provide development habitat for *Culex* and *Culiseta* larval mosquitos. Bird-baths, plugged rain gutters, livestock watering troughs, stored equipment, tires and other man-made containers are just a few examples of other, possible *Culex* and *Culiseta* development habitats. Roadside catch basins (CBs) exist throughout the built-up areas of the City of Kelowna, Peachland, Westbank, and in several residential, rural subdivisions and industrial/commercial development areas in RDCO Electoral Areas. These CBs provide ideal habitat for *Culex pipiens* larvae as since they retain water, organic matter (leaves, grass clippings etc.) and are typically absent of mosquito predators.

- ***Open water development sites***

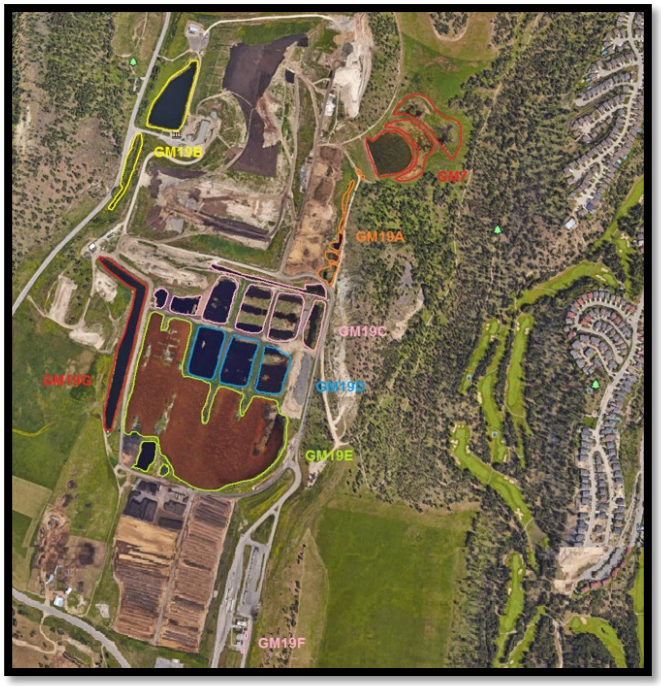
Several seasons of larval surveillance and comparison with precipitation and temperature data ensures the timely identification, and treatment, if necessary, of larval development in these sites. *Duka Ltd.* field

biologists began initial surveys on 04 April by targeting those sites expected to be active early in the season. Surveys of these sites, and the initial inspection of others verified their size, location and status. As part of these initial surveys landowners and business or recreational facility operators and managers were contacted to confirm program participation and any access procedures. These contacts provided an opportunity for field personnel to discuss control program operations, strategies and expected results with residents, managers, and property owners. Where practical, suggestions for reducing mosquito populations and annoyance on private and commercial properties were provided. For larger properties these suggestions included grading of tire ruts and field harrows, filling or ditching of depressions to drain or eliminate them and agitation of irrigation and display ponds.

Subsequent surveillance of larval development habitats was completed on a schedule of approximately every 6-10 days. With over 300 accessible development site locations and a potential +300 hectares of habitat, much of it located on private, rural, and agricultural properties, an organized, prioritized methodology has been developed to ensure timely larval surveillance and control.

Larval mosquito development habitats occurring within program boundaries included ponds, pools, and depressions located on residential, agricultural, commercial, and industrial properties. Unused swimming pools, stagnant display and irrigation ponds, surface water catchment/retention ponds, ditches and depressions provided ready sources for larval mosquito development near residents, workers and visitors.

Larval surveys and samples were first completed on 04 April, and thereafter on a regular basis until 18 August 2022. A total of 182 larval samples, containing 5784 larval specimens, were collected, preserved, and forwarded to *Duka Ltd.* offices for taxonomic identification.



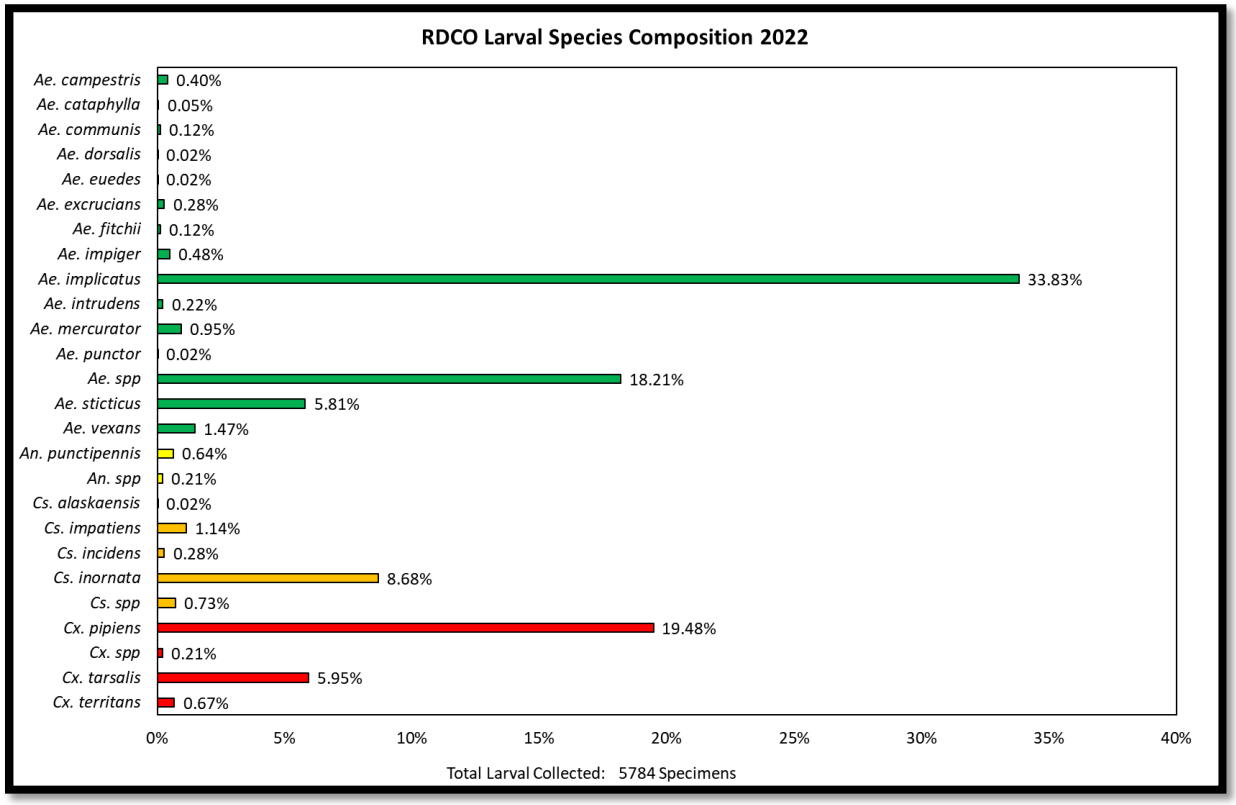
Larval populations in the permanent, but fluctuating ponds at the Glenmore Landfill were again active on a weekly basis throughout the 2022 summer, beginning with initial sampling on 05 April. Larval populations typically averaged 5-20 larvae/dip sample before peaking during late July and early August with populations of 70-100+ larvae/dip.

Ponds at local golf courses in the Lake Country, Westbank and Kelowna Airport areas, and others in the Mission/Gallagher areas were frequently active with larval mosquito development during the season. Larval populations ranged from 1-5 larvae/dip with occasional populations in excess of 40 larvae/sample.

Flood and seepage water accumulations in farm fields and forested areas along the Mission Creek area, and in particular in the Hall Road area off KLO Road in Mission/Gallagher, were extensive this season. There are also many permanent ponds in the area which provide recurrent development habitat even when not influenced by increased creek levels. Larval mosquito development in this area was observed on a weekly basis for most sites in this area, and throughout the season. Larval populations typically ranged from 5-25 larvae/dip sample with occasional populations in excess of 50-100 larvae/dip sample.

The frequent sampling protocols (6-10 days) employed for this program ensured timely larval detection and control, but also resulted in the collection of first instar larvae as part of these samples. Because of their small size and immaturity, not all 1st instar specimens could be identified to species. In these situations, larval specimens were identified to genus. This was mostly observed with *Aedes* sp.

Twenty-two species of larval mosquitos were collected during 2022 sampling; fourteen *Aedes*, three *Culex*, four *Culiseta,* and one *Anopheles* (Chart 5 below). All of these mosquitos are capable, under the right conditions, of developing multiple generations during the season and causing reportable, and occasionally extreme annoyance, especially *Aedes*, which are noted as aggressive biters of man and animals (Belton 1983). *Culex* and *Culiseta* mosquitos are also noted pests of man and animals with several species recognized as highly competent vectors of West Nile virus, (Chart 6 below).



<u>Chart 5</u>: RDCO Larval mosquito identifications. Species composition based on 5784 specimens Collected from various development site types, 04 April to 18 August 2022.

Collected from snowmelt/creek seepage and precipitation-influenced sites, marshes, and ponds with fluctuating water levels, the most numerous mosquito collected as larvae during 2022 were from the genus *Aedes*, accounting for 62.0% (3586/5784) of all samples identified. As observed in previous years, and again in 2022, over 95% of all *Aedes* larvae were collected in April and May (Chart 6 below). Laid on the soil, *Aedes* mosquito eggs hatch in response to surface water accumulations occurring early in the season with snowmelt, river seepage and precipitation. *Aedes* mosquitos are very tolerant of cold water temperatures and are typically the first mosquito larvae to emerge. In the north, they can be seen swimming under the ice which forms overnight. As the 2022 summer progressed, low-lying flood and seepage water habitats, where they existed, drained or dried, and the diversity of *Aedes* mosquito species, and their proportion of the local mosquito complex during June and July, similarly decreased.

Collected from more permanent development sites, permanent ponds, and cattail marshes, *Culex* mosquitos accounted for 26.3% (1522/5784) of all larval specimens identified this season. *Culiseta* larvae accounted for 10.8% (627/5784) all larvae collected in 2022, and *Anopheles* accounted for the balance of 0.8% (Chart 5 above, Chart 6 below). These three genera accounted for 94% of all mosquitos collected in June and July.

Species	WNv Competence	Species Occurrence # of Samples	Total # of Individuals	% Occurrence	April				May				June					July				August	
				Week # →	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Ae. campestris	0	1	23	0.40%				23															
Ae. cataphylla	0	2	3	0.05%		3																	
Ae. communis	0	4	7	0.12%	1		2			2	2												
Ae. dorsalis	+ + +	1	1	0.02%										1									
Ae. euedes	0	1	1	0.02%		1																	
Ae. excrucians	0	7	16	0.28%	10	3	2	1															
Ae. fitchii	0 ?	6	7	0.12%		2	3	1					1										
Ae. impiger	0	8	28	0.48%	18	2	6		2														
Ae. implicatus	0	87	1957	33.83%	625	425	283	300	97	56	141		29		1								
Ae. intrudens	0	3	13	0.22%		2	11																
Ae. mercurator	0	14	55	0.95%	2	10	6	20	16		1												
Ae. punctor	0	1	1	0.02%							1												
Ae. spp	N/A	40	1053	18.21%	164	259	98	42	151	159	177		3										
Ae. sticticus	+ ?	48	336	5.81%	128	34	53	71	18	14	4		14										
Ae. vexans	+ +	9	85	1.47%			1			2	6		75		1								
An. punctipennis	+ ?	9	37	0.64%								8						18	7	3			1
An. spp	N/A	2	12	0.21%								1						11					
Cs. alaskaensis	0	1	1	0.02%											1								
Cs. impatiens	0 ?	19	66	1.14%	8					3	10	1	2	5	12		3	2	3	16			1
Cs. incidens	+ + ?	3	16	0.28%							3				8					5			
Cs. inornata	+ + +	39	502	8.68%	18					9	46	26	23	38	83		13	27	101	69			49
Cs. spp	N/A	5	42	0.73%	20					7	3		8						4				
Cx. pipiens	+ + +	55	1127	19.48%							8	14	44	20	19		197	234	195	272	62	19	43
Cx. spp	N/A	4	12	0.21%							1	6							3				2
Cx. tarsalis	+ + + +	34	344	5.95%							22	63	9		3		20	58	108	27	5		29
Cx. territans	0 ?	3	39	0.67%															3	20			16
Total			**5784**	**100%**	**994**	**741**	**465**	**458**	**284**	**252**	**425**	**119**	**208**	**64**	**128**	**0**	**233**	**350**	**424**	**412**	**67**	**19**	**141**

·**Species Occurrence:** Lowest Value — Highest Value

·West Nile Virus (WNv) competency was ranked by the BC Centres for Disease Control (2005) and Belton (2015). Mosquito species were ranked from (0), or no potential to transmit the disease, to (++++), or the ability to readily, and effectively transmit the disease.

Chart 6: RDCO Larval mosquito temporal distribution, comparing species composition for the sample collection period, 04 April – 18 August 2022.

Of the fourteen *Aedes* species collected, *Aedes implicatus* was the most numerous, accounting for 33.8% of all larvae collected during 2022 sampling (Charts 5 and 6 above). It prefers temporary pools and is among one of the first larvae to appear in the spring. It was the predominant mosquito of April collections accounting for 61% of all larvae collected that month. *Aedes sticticus* (5.8%) and *Aedes vexans* (1.5%), were the next most numerous *Aedes* mosquitos collected. They develop in snowmelt, river seepage and woodland pools. *Aedes* mosquitos, as a group, are typically aggressive pests of man and animals, and species such as *Ae. Sticticus* and *Ae. Vexans* are also identified (Belton, 2005) as potential WNv vectors.

Culex pipiens, the " house mosquito" accounted for 19.5% of all larval mosquitos collected locally during 2022. It develops in freshwater habitats, utilizing ponds, ditches, marshes, and temporary sites including tire ruts, roadside catch basins and containers. It is the second highest ranked (+++) vector of West Nile virus by the BCCDC. *Culex pipiens* were most common during the month of July.

Culiseta 21nornate was the third most common (8.7%) mosquito collected as larvae this season, and although is not a significant pest to people, only biting occasionally, they can be persistent pest for livestock and other large mammals. *Culex tarsalis,* a mosquito which can use almost any waterbody for development including flood and seepage waters, polluted/sewage waters, ditches, marshes, and containers accounted for 5.9% of larvae identified, (Charts 5 and 6 above). It is an aggressive pest of man and animals and has the highest ranked (BCCDC, 2005) competency (++++) as a vector of West Nile virus.

A review of larval species distribution for the 2022 summer confirmed the expected change in diversity, population sizes and larval species occurrence over the course of the season, (Chart 6 above). As seen in previous seasons (*Duka Ltd*, 2017-2021), and elsewhere throughout BC (*Duka Ltd.*, 2022), *Aedes*, *Culex*, *Culiseta* and *Anopheles* were all collected during the first half of the season (April and May) although *Aedes* were the predominant, with *Culex* and *Culiseta* larvae being the predominant mosquitos in later summer collections (June through August).

Aedes mosquitos were the most numerous during the first half of the season, accounting for 92.6% (3461/3738) of larvae collected before the end of May 2022, and just 6.1% (125/2046) of all larvae collected during June, July, and August. As the summer progressed, many temporary, precipitation-influenced flood and seepage-influenced open water habitats drained and became reduced in size. Infrequent precipitation resulted in reduced habitat for *Aedes* mosquito species, and their proportion of the local mosquito complex, similarly decreased. These slow draining sites and permanent marshes and ponds were ideal habitat for *Culex* and *Culiseta* mosquitos which were the dominant larval mosquitos of the later, June – August, summer season (Chart 6 above).

The predominance of *Culex* and *Culiseta* larvae later in the season was not unexpected. *Aedes* mosquitos prefer temporary, flood, seepage and snowmelt habitats which typically exist during the first half of a season. *Culiseta* and *Culex* on the other hand, make use of permanent and slow-draining development sites such as natural and man-made ponds, marshes, ditches, and temporary, slow-draining, flood, or

seepage water accumulations. Responding to a more complex set of parameters including temperatures, day length and precipitation accumulations, they are most common later in a typical season.

- ***Catch basins***

The most widespread development habitat within the RDCO are roadside catch basins (CBs). With over 12,000 CBs located along public roadways and parking lots, not including those on private residential, commercial, and industrial properties, they provide a potential source of adult mosquitos throughout those areas.

Given the intent of catch basins is to collect water run-off in order to moderate flow rates and inputs into ravine and stream systems, and to also allow inorganic material (sand, gravel) and organic (leaves, twigs) to settle out, these sites often contain water for extended periods of time. Precipitation and surface water run-off from human activities including lawn watering, car and equipment washing, pool or hot tub cleaning or drainage etc. can increase the number, and extend the amount of time these sites retain water. Several years of catch basin sampling has confirmed they can produce large populations of larvae, typically *Culex pipiens* (++), an aggressive nuisance pest and very competent vector of West Nile virus (BCCDC, 2005).

Sampling for the presence of water and developing mosquito larvae was completed for 28 catch basin "clusters", comprising a total of 98 CBs. There were 23 clusters located throughout the Kelowna and Lake Country areas, 4 in Westbank and 2 in Peachland. These clusters, typically consisting of 2-5 catch basins each, were distributed throughout the control program to provide a representative sampling of larval activity onset.

Roadside catch basin clusters were sampled on a weekly basis, beginning the first week of June. Routine monitoring of CBs during the season first detected larval mosquito development in early June, and the by the third week larval development in catch basins was underway and widespread.

3.5 Adult Mosquito Populations

Although larval population surveys and treatment activities are ongoing throughout the summer, adult mosquito annoyance may arise from untreated sites located within control program boundaries, or with wind-blown mosquitos emerging from areas outside the control program. To objectively measure the success and effectiveness of larviciding efforts for residents, adult mosquito population distributions and annoyance were monitored during the season.

Program personnel routinely assessed adult mosquito populations by measuring annoyance through biting or landing counts, observation and input from residents and property owners. A "Standard Bite/Landing Count" involves exposing the forearm for a one minute period and counting the mosquitos which land

to bite, or attempt to bite, in that time period. Using an aspirator or inverted pill bottle, this method allows for adult mosquito specimens to be collected while they are actively attempting to, or landing to, bite field personnel. These biting/landing counts and adult specimen collection were typically completed while sampling larval development habitats and when setting up and retrieving light trap sampling equipment.

Populations in excess of 3 bpm are considered as sufficient to warrant the use of mosquito repellents and/or control devices, equipment or mosquito adulticides. When undertaken at a variety of locations, this provides a relative measure of the larvicide treatment success by comparing adult mosquito nuisance populations inside control program boundaries with that occurring outside of larval treatment areas, and from one area to another within the program. These biting/landing counts were typically completed while sampling larval development habitats and during the setting up and retrieval of light trap sampling equipment.

The second method of adult mosquito population assessment employed standard CDC (Atlanta) light traps. These portable traps use 6-volt batteries to activate a fan and an incandescent light bulb to generate heat, or a black light (infrared) bulb, as an attractant to female mosquitos searching for a blood meal. Typically operated for a 10-16-hour period (overnite, dusk-dawn), these traps were set up late in the afternoon or early evening. Light traps, and their samples, were retrieved the following morning, with any captured specimens forwarded to *Duka Ltd.* offices for enumeration and identification.

This equipment effectively samples mosquitos from the local population, and from an area of some 30-50m radius from a light trap location. Because of this limitation, they do not provide a comprehensive sample, population measurement or estimate for an entire neighbourhood, subdivision or community. Benefits associated with these traps include an objective, reproducible sampling method and the collection of undamaged specimens. Since mosquito species use different habitat types, the source of localized, or reported adult mosquito annoyance, may be identified.

Adult mosquito samples were collected from a total of 40 different locations throughout the RDCO program area, either through landing/biting hand-captures or light trap equipment. Light traps were set up at 8 fixed locations for a total of 23 sampling nights between 31 May and 20 July, and mosquitos landing to bite were collected by *Duka Ltd.* field personnel on 55 separate occasions between 02 May and 11 August 2022. Landing and biting counts were typically recorded, and samples collected, while field staff were surveying, sampling and treating larval development habitats or while servicing light trap equipment.

Light trap and bite count sampling was effective in collecting a variety of adult mosquitos. A total of 52 adult mosquito specimens were collected while they were landing to bite, and 192 adult mosquitos were collected by light trap sampling activities (Chart 7 below).

A total of twelve different mosquito species were collected as adults during 2022 (Chart 7 below). Nine species of *Aedes* mosquitos accounted for 86.9% of all specimens identified from 2022 collections. The greatest majority of adult mosquitos collected this season were *Aedes vexans* and *Aedes sticticus.* This was a significant change from previous seasons (*Duka Ltd,* 2016-2020) when *Culex* and *Culiseta* specimens were the predominant adult mosquitos collected. Accounting for 17.6% of all adult mosquitos collected locally this year, *Aedes vexans* is referenced by Belton, as "probably the worst pest mosquito in southern British Columbia" as they are a very aggressive pest of man and domestic animals (Belton, 1984). Their increased occurrence in adult collections this season may be a reflection of the delayed snowmelt and the very cool summer conditions increasing their survival rates an activity as adults.

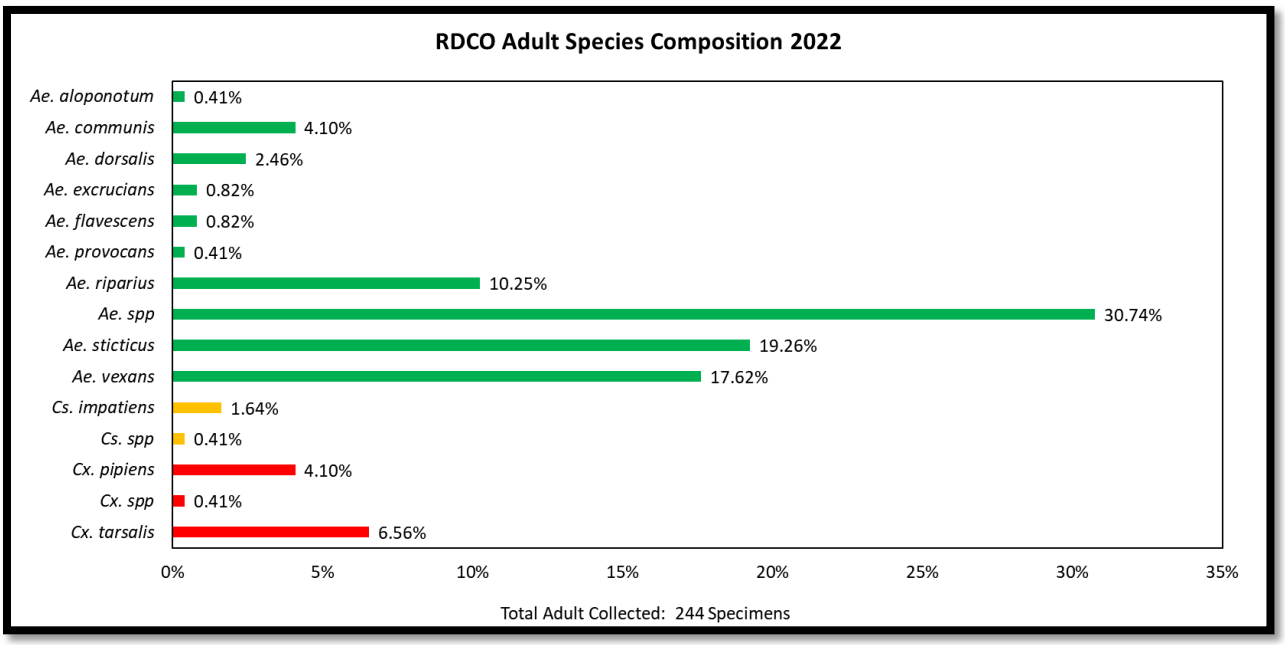


Chart 7: RDCO Adult mosquito collections. A total of 244 specimens collected while they were landing to bite and with CDC (Atlanta) light traps, 02 May – 11 August 2022.

Aedes mosquitos, because of their aggressive biting behaviour, are more likely to be collected while attempting to bite. They accounted for 100% of the adult mosquitos collected while landing to bite. Of the 192 specimens collected in light trap sampling 83% were *Aedes* and 17% were *Culex* and *Culiseta.*

Several species, including *Aedes riparius*, *Aedes communis*, *Aedes sticticus*, *Aedes vexans*, *Culex pipiens,* and *Culex tarsalis,* each accounted for between 4-10% of all adult specimens collected in 2022. All of these species can cause nuisance, and *Aedes vexans, Aedes sticticus, Culex pipiens* and *Culex tarsalis* have also been identified as West Nile virus vectors.

Adult mosquito populations and annoyance for the great majority of Kelowna and RDCO residents could be summarized as minimal, to non-existent during the 2022 season. The Mission Creek area, which has significant, difficult to access flood and seepage water habitats, ideal for *Aedes* mosquito development, and a forested and farm field landscape, also provides ideal adult mosquito harbourage. Adult mosquito annoyance where is was observed, and most frequently reported, was from the Mission and Gallagher areas. Of the 55 service request calls received this season, 26 (47%) included a mention of adult mosquitos in addition to reports of waterbodies on public land or private properties. The majority of these calls (23/26, 88%) were again (2016-2021) from the Gallagher and Mission areas, (See Chart 1 above). These areas are comprised of large rural properties with small lakes, marshes, sloughs, natural and man-made ponds, which often have difficult access because of size and vegetated shorelines or forest and brush.

Staff conversations with local golf course operators, greens keeping crews and patrons were all very positive with many commenting on the low number of adult mosquitos. Golf course operators and patrons, recreational facility operators, Glenmore landfill staff, businesses, property owners and residents were all very appreciative of the services available to them and were always helpful to program personnel often providing golf carts, combinations or keys to gate locks and site tours as required.

4.0 MOSQUITO CONTROL AND POPULATION MANAGEMENT

The Regional District of Central Okanagan (RDCO) Nuisance and Vector Mosquito Surveillance and Control Program employs a pro-active, IPM approach to control which maximizes the environmental compatibility and sustainability of the annual program. The mosquito control program reduces the potential for adult mosquito annoyance by focusing efforts on the identification and control, or prevention, of larval mosquito development. The program achieves this by using public education, physical site modifications (roadside grading, ditch maintenance, removal of containers, used tire collection) and larval control using the biological (bacterial) mosquito larvicides VectoBac 200G (*Bacillus thuringiensis* var. *israelensis* (*Bti*) *Serotype H-14, Strain 65-52*) and VectoLex WSP or CG (*Bacillus sphaericus*). Factors limiting program success are extreme, or prolonged Mission Creek or local lake levels, above average snowpack and/or rate of melt, weather conditions, larvicide treatment scope (total area treated) and frequency of surveillance and applications.

A major emphasis for effective management of mosquito populations in the program area involves the timely surveillance and control of the widespread and synchronous hatching of *Aedes* mosquitos. Given that *Aedes* mosquitos are the predominant larval species of the early season (Chart 6 above), and are aggressive pests of man, the timely identification of active larval habitats is particularly important for initial program operations, both for the purposes of program efficacy, and efficiency.

With recurrent, or extended flooding of Mission Creek or frequent precipitation during late April, May, and June there can be multiple hatches of *Aedes* larval mosquitos. As these sites slowly drain, or are

further influenced by irrigation run-off or precipitation, they can become ideal habitat for *Culex* and *Culiseta* mosquito development beginning in June and throughout the summer. In addition to being notable pests of man, several species of *Aedes, Culex* and *Culiseta* been identified by the BCCDC as potential vectors of West Nile virus have been collected locally (*Duka Ltd.* 2016-2021).

Routine sampling of flood and seepage water habitats and correlation with melting snowpack, fluctuating creek and lake levels and precipitation ensures accurate treatment timing and scope within available program resources. Permanent ponds, marshes, ditches, and containers, including catch basins, provide ideal habitat for *Culex* and *Culiseta* larval populations. Regular surveillance and actions to limit larval mosquito development in these sites is required from late May through August.

4.1 Larval Mosquito Control and Prevention

Program biologists continue to identify larval mosquito habitats which can be eliminated, reduced in size, or altered to limit their use by mosquitos. Restoring the flow through man-made ditches or ponds can reduce their suitability as mosquito development sites. Grading or filling of tire ruts and depressions or ditching of low-lying areas to facilitate draining can reduce standing water and potential larval development. The removal or regular drainage of containers such as barrels, uncovered or unused pools, toys, boats or canoes and regular changes of water in livestock watering troughs and bird baths is easily done and eliminates their potential to produce mosquitoes.

When encountered by program personnel, containers are typically emptied or drained. Where appropriate, property owners, facility managers and public works personnel are provided with site specific recommendations for reducing larval development habitat and adult mosquito annoyance.

Unable to operate for the past two seasons due to Covid-19 restrictions, the annual Used Tire Roundup was once again offered to RDCO residents and property owners. Typically held every September, unused, old, and damaged tires (cars, trucks, tractor, and bike tires) can be dropped off to be taken away and recycled into products such as athletic track and playground surfaces. This season, in partnership with Tire Stewardship BC, the equivalent of 1700 passenger vehicle tires were collected (17 tons) and removed as potential larval mosquito development habitat. Tires stored outdoors or left to lie in fields and behind sheds can capture and hold rainwater and leaves blown by the wind, heat up quickly in the sun, and provide perfect habitat for mosquitos to develop, particularly mosquitos of the genus *Culex* which prefer warm water and can utilize containers. Community "clean-ups" further contribute to reduced mosquito development and annoyance by removing old tires, buckets and containers from ravines and forest areas where they may have been discarded and can be overlooked.

Removal or alteration of mosquito producing habitat does not necessarily mean drainage resulting in habitat destruction for other organisms and natural predators. Increasing the depths of ponds to over 30 cm or encouraging water movement reduces larval mosquito use. It is best accomplished with smaller, temporary, or defined development sites located on private and commercial properties. Several private properties and golf courses have installed new, or additional fountains, and/or water pumps, in the past few seasons with a resultant exclusion of larval development in these ponds. Public works personnel maintenance of flow in ditches, grading of tire ruts and depressions along roadsides and in vacant areas, removes potential larval development habitats.

The preservation or enhancement of balanced wetland habitats has the best opportunity for a meaningful long-term contribution to overall mosquito control program success through reduction of mosquito populations and enhancement of natural controls including insect, fish, and birds.

Large-scale, physical alterations of the low-lying areas adjacent Mission Creek and the filling, drainage or alteration of most natural and man-made marshes, ponds and ditch systems is impractical, undesirable, or fiscally prohibitive. The nature, purpose, and intent of many of these permanent ponds and marshes requires that they not be eliminated, and as such, routine surveillance and treatment of developing larval populations is required. For these sites, the only practical solution for reducing mosquito populations is through the use of the granular, biological mosquito larvicides such as VectoBac 200G (PCP # 18158) or VectoLex CG and WSP (PCP # 28008, 28009).

VectoBac 200G contains bacterial spores of the bacterium *Bacillus thuringiensis* var. *israelensis*, (*Bti*) *Serotype H-14, Strain AM65-52*. Its mode of action is on the larval mosquito stomach. It is very specific, producing rapid lethal effects in larval mosquitoes within hours. It has no residual activity, does not bio-accumulate, and has no impact on beneficial organisms found in mosquito development habitats. The timing of all VectoBac 200G applications ensured they were directed at the most susceptible 1st through 3rd larval instar stages.

VectoBac 200G and VectoLex CG are formulated on corn cob granules for ease of application and are recommended by the manufacturer for use in standing water habitats including temporary and permanent pools, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons. Similar to VectoBac 200G, VectoLex CG also contains a naturally occurring, spore-forming soil bacterium. VectoLex CG contains spores and crystals produced by *Bacillus sphaericus.* It also is classed as a bio-rational, rather than conventional, pesticide. Like VectoBac, VectoLex acts on the larval mosquito stomach and must be eaten to be effective. VectoLex is very specific and produces lethal effects in a narrow range of mosquito species, including *Coquillettidia perturbans* and most *Culex* mosquito species. As with VectoBac, It does not have any effects on man or animals, fish and other insects which may use these aquatic habitats.

Operationally, the important differences between VectoLex and VectoBac are speed of action and persistence in the larval habitat. Larval mortality can take several days for VectoLex versus several hours with VectoBac 200G. This occurs because *B. sphaericus* is more stable, has a slower settling rate in the water column and the unique ability for its spores to germinate, grow and reproduce in dead mosquito larvae. This is known as recycling and is the mechanism which allows VectoLex to provide long-term, extended control (+28 days in many jurisdictions) of recurring larval mosquito development. VectoLex CG is recommended by the manufacturer for use in standing water habitats including temporary and permanent pools in pastures and woodlots, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons.

The Glenmore Landfill, comprised of several ponds (Sites GM 19A-H), is one of the largest and most prolific larval development habitats. These sites are typically the first to become active, as early as mid-March when ice can still be found on some ponds, and the edges of larger, deeper ponds. Requiring treatment on a near-weekly basis, and depending on the pond, between 5 and 13 times a season, this area required 133.65 kg of VectoBac 200G during 2022. Several shallow ponds in Glenmore (Tutt Ranch/UBCO), Site # GM07A-D, were also repeatedly active and treated on 10 occasions with a total of 55.0 kg of VectoBac 200G during 2022.

Precipitation-filled depressions in a flooded field off Curtis Road in Glenmore (Site GM10) and tire ruts and depressions filled with rainfall, irrigation run-off, and Mission Creek seepage in farm fields at 3885 Gordon Drive (Sites # MIS13B&C) were active with larval development on at least 8 occasions in 2022. Three stagnant ponds located just outside The Okanagan Golf Club -Bear and Quail (Sites # AP21A&B, AP22) and Site # AP25, a slough west of the and Quail Ridge subdivision, were each treated between 6-8 occasions. Permanent and seepage water sites in forested areas and rural properties in Gallagher along Hall Road, including Sites # GG25, GG26 and GG29 were each treated between 5 and 6 occasions during 2022.

A total of 1150.35 kilograms of VectoBac 200G were applied to a total area of 153.38 hectares of active larval mosquito development habitat within the RDCO, Kelowna area (Table 1). Some 194 sites were treated on a total of 888 separate occasions. Although many sites required only 1 or 2 treatments during 2022, numerous sites were treated 3 or 4 times and several sites were treated 10 or more times. A further 15 sites located within the boundaries of the Westbank First Nations were treated on 33 occasions with 18.05kg of VectoBac 200G were applied to 2.41 ha of active development habitat (Table 2.)

In an attempt to reduce mosquito populations in areas with difficult access, because of thick, overgrown, or dense vegetation (i.e. blackberries, brush or *Typha* sp. cattails), and a history of adult mosquito nuisance reports, the long-acting VectoLex WSP (Water-Soluble Pouch) was used for treatments. Already used throughout the program for catch basin treatments, these 10gm satchels (2cm X 2cm) can be readily thrown into sites where the bio-degradable, glucose-based bag quickly dissolves, and the granules disperse across the water surface. VectoLex WSP was used again in this annual program in select,

permanent waterbodies such as Sites MIS15A and MIS15B near K.L.O. Road. Other difficult to access sites with a history adult mosquito nuisance complaints include Sites # GG26, GG36 and RT19. Its use in other programs for several years has shown a reduction adult mosquito nuisance occurring near cattail swamps and has suggested, at least anecdotally , that it is providing control of difficult to sample species such as *Coquillettidia perturbans.* A total of 1.69 kg (169 pouches) of VectoLex WSP was used for this purpose during 32 treatments in 2022 (Table 3).

Catch basins can provide season-long larval development habitat and are best treated with VectoLex WSP (PCP #28009). Alternative larval control products such as juvenile growth hormone mimics (Altosid/methoprene) can have negative impacts on other aquatic insects, arthropods and amphibians and are not used in the program developed for the RDCO by *Duka Ltd.*

Duka Ltd. personnel surveyed some 98 catch basins (CBs), divided into 29 "clusters" of 2-5 catch basins, distributed throughout the control program, on a regular, weekly basis beginning the first week of June. Once widespread larval development was underway, *Duka Ltd.* personnel surveyed over 12,000 roadside catch basins for the presence, or absence of water, as part of each treatment campaign. All catch basins holding water at the time of inspection were treated with VectoLex WSP (*Bacillus sphaericus*) 10gm water soluble pouches.

A total of 11,373 roadside catch basins were treated the third week of June 2022, and a further 11,766 roadside catch basins were treated the last week of July 2022. Catch basin treatments completed between 20-23 June, included 9,856 CBs located throughout RDCO/Kelowna and Lake Country, 394 CBs in Peachland, 1,055 CBs within in the Westbank First Nation, and 68 catch basins located in RDCO West Kelowna. During the period 25-28 July, 10,087 CBs located throughout RDCO/Kelowna and Lake Country, 462 CBs in Peachland, 1,129 CBs within the Westbank First Nation, and 88 in West Kelowna were treated to control larval development.

Post-application monitoring of all VectoBac 200G and VectoLex WSP applications indicated excellent results had been achieved, with observed mortalities within the first 1-2 hours post-treatment typically greater than 95%. Adult mosquito monitoring and anecdotal reports from residents, businesses, golf course operators and visitors confirmed that adult mosquito annoyance for the great majority of RDCO residents, workers and visitors was minimal during 2022. Adult mosquitos and annoyance, where it was reported, was typically from areas with large and/or numerous and difficult to access development sites.

4.2 Adult Mosquito Control and Nuisance Reduction

Adult mosquito control (adulticiding) using truck mounted or backpack ULV (ultra-low volume) sprayers has not been a component of routine nuisance mosquito control programs in BC and Yukon for over twenty years.

Adulticide provides temporary relief from adult mosquito annoyance and repeated applications, along an approved route, are required to provide extended relief. The application method, a mist applied to the air, and the non-target specificity of adulticide products, are such that the potential for impacts on insects other than mosquitos makes this the least desired method for routine mosquito population management. When deployed, the natural chrysanthemum derived pyrethrins, or synthetic equivalents are preferred. These products have a low persistence in the environment and quickly degrade within hours of exposure to sunlight.

Adulticiding **IS NOT** a component of the RDCO nuisance and vector mosquito surveillance and control program.

- ***Devices, pesticides, and repellants***

Adult mosquito collection devices such as Mosquito Magnets™, which use propane to generate CO_2 will collect adult mosquitos and are marketed by several companies for use by property owners. Although they do collect adult mosquitos, with a collection range of about ½ hectare (one acre), their ability to reduce mosquito populations sufficiently to provide relief from annoyance on a community level is unlikely without the deployment of numerous units. Their use at a single property/residence though, can have a noticeable impact by collecting adult mosquitos and reducing annoyance.

Citronella candles, mosquito coils, Konk™ Automatic Aerosol Sprayers and other such products are marketed as mosquito repellants, or for adult mosquito or biting insect control. These are readily available to residents, campers, and property owners.

- ***Natural predators***

Although flying insects can form a large component of the diet for flying insectivores (*e.g.* bats, swallows, Purple Martins), there is no scientific evidence which suggests that birds or bats provide a detectable level of mosquito control. Both birds and bats are opportunistic feeders and adult mosquitos have been identified as a very small component (<2%) of their diet (Fang 2010, Gonsalves *et al*, 2013). They are not however, scientifically recognized as able to provide any real impact on mosquito

populations when used solely as a mosquito population control option. Reported to eat up to 300 mosquitos a day, a total of some 13,000 birds and/or bats would be required to consume the mosquitos emerging from a single hectare of habitat where upwards of 4,000,000 mosquitos can emerge.

Interested residents are, however, still encouraged to install bird nesting boxes or bat houses if they wish. It allows individuals to contribute to a comprehensive, integrated mosquito control program, to enhance the natural control of mosquito populations and it may provide residents with a sense of reduced adult mosquito annoyance. Additional predators for adult mosquitos include frogs and insects such as wasps, deer flies, dragonflies, damsel flies, etc. and spiders.

The key to successful mosquito control (population management) and a reduction in adult mosquito nuisance populations is through the early detection and timely control, or prevention, of larval development.

Preserving and enhancing natural predator populations, including aquatic larval predators (diving beetles, dragon flies, stickleback fish etc.), and reducing, or eliminating larval mosquito habitats including temporary, water-holding, tire ruts and depressions, containers or unused swimming pools, tarped equipment or bird baths contributes to sustainable control operations and supports a natural contribution to the suppression of local adult mosquito populations.

As mentioned previously, and above, a one-hectare site, about the size of 2 football fields, with a larval population density of just 1 larvae/dip sample can produce 4,285,714 mosquitos. Larval populations in much of the program area average between 10-30 larvae/dip sample. With over 150 hectares of potential habitat, and much of it located within 100-200m of residents and businesses, the sheer potential for adult mosquito populations, likely in the 100s of millions, would make a reliance on solely natural controls unlikely to have a noticeable impact on annoyance levels for area residents.

In a typical or average season of snowpack, temperatures and precipitation, adult mosquito annoyance, should it occur, is usually localized and short-lived. Snowpack accumulations during late May and June were well above (240%, 15 June 2022) normal, before melting quickly. Weather conditions were predominantly “wet and warm” during the June, July and August 2022, conditions which combined with the delayed snowmelt to generate protracted larval development and adult mosquito populations.

5.0 CONTROL PROGRAM EVALUATION AND RECOMMENDATIONS

Larval development site identification, sampling and targeted, timely treatments with analysis of results, are primary components of successful, ongoing IPM-focused mosquito control programs. A review of winter snowpack, water levels and local weather conditions, in conjunction with a sound knowledge of mosquito biology, local species and development sites, are required to ensure timely surveying and monitoring. Left untreated, larval mosquitos would complete their development to become a possible source of adult mosquito annoyance. Factors limiting program success are larvicide treatment scope and frequency of surveillance and application. Increasing the scope (total area) and frequency of larval monitoring and applications reduces overall mosquito populations and improves program effectiveness.

Once underway, larval development in Kelowna, WestBank First Nation lands and adjacent RDCO areas has been observed to occur on a near-continuous, or recurrent basis in many permanent and slow draining sites. Larval development has been observed as early as the first week of April and as late as the third week of August. The forested area, farm fields and large rural properties adjacent Mission Creek, and the numerous permanent ponds scattered throughout area at golf courses, public and private lands provide ideal larval mosquito development habitat. Flood and seepage water-influenced sites typically produce larval mosquitos for as long as they contain water and permanent ponds can produce mosquitos throughout the season. Rigorous and extensive sampling of these often-expansive sites allows for individual sites, or portions of sites, to be identified for timely treatments.

Mosquito control programs should be evaluated annually, and the results achieved this year confirms that it continues to meet the needs of residents. A total of 26 of the 55 service requests (47%) received by *Duka Ltd.* in 2022 included reports of adult mosquito annoyance or observation. For the great majority of Kelowna, Westbank, Peachland and adjacent RDCO Electoral area residents, adult mosquito annoyance was non-existent, minimal, or short-lived. The many positive reports and discussions *Duka Ltd.* field personnel had with area residents confirmed the overall success of the 2022 Nuisance and Vector Mosquito Surveillance Control Program. There is strong, positive support for this safe and effective annual mosquito control program.

5.1 Public Relations and Education

Regular and routine interactions with residential and rural property owners, golf course managers, farmers, orchardists and their staff, brochures and 'doorknob hangers' provided residents and area visitors with practical, useful information and updates on control program operations. Regular and frequent newspaper articles, radio and television interviews, advertisements, website and social media posts by the RDCO Communications and Intergovernmental Affairs Coordinator and *Duka Ltd.* provided frequent, and current information about ongoing program operations. For the first time since 2019, a public information booth was set up at the Canada Day celebrations and the annual Tire Roundup was offered again in September 2022. Over 1700 tires were collected for recycling.

Responding to resident requests for service allows program personnel to locate new or previously undetected development habitat and provides an opportunity to discuss mosquito control program operations and goals. Wherever practical, residents are advised of options for physical control or maintenance to limit mosquito development and adult mosquito annoyance on their property. A total of 29 telephone calls and emails were received from residents wishing to confirm participation in the program and property access for field staff, to report observations of stagnant water and potential larval habitat, or for more information about the program.

All private property owners, and outdoor facility operators, golf course, campground and landfill managers were very helpful to *Duka Ltd.* field personnel providing ready access to their lands and businesses for larval mosquito surveillance and control. All *Duka Ltd.* office, field and management staff contacts with the general public, business operators, visitors and residents were very positive.

5.2 Surveying, Monitoring and Environmental Effects

The goal of the annual RDCO Nuisance and Vector Mosquito Surveillance and Control Program is to identify and prevent, or control, the widespread development of larval populations. This will suppress overall mosquito populations and reduce the potential for adult mosquito occurrence and nuisance. Surveying and monitoring of larval habitats (water bodies) and adult harbourage (treed, woodland) areas for the presence of mosquitos determines the need for control and treatment decisions. Regular, and frequent development site surveillance is essential to this successful annual larval mosquito control program.

A review of winter snowpack accumulations, seasonal precipitation, and temperatures, in conjunction with a sound knowledge of mosquito biology, local development habitats, species complex and their interactions are necessary to ensure effective and timely control. Program data collected over the past few years confirms that extended periods of Mission Creek levels, measured in excess 1.4m, will give rise to seepage water accumulations in adjacent farm fields and forested areas resulting in recurring larval mosquito development. Weather and water level information allows the onset of larval mosquito development to be forecast and surveillance focused on larval species occurrence and distributions.

Twenty-two different species of larval mosquitos were collected during the 2022 season. Collected from flood and seepage water-influenced sites, marshes, and permanent ponds with fluctuating water levels, 14 species of *Aedes* mosquitos accounted for some 62.0% of all larval samples identified. *Culex* mosquitos (3 species) were the most common larvae collected in 2022 and accounted for 26.3% of all larvae collected and identified. *Culiseta* mosquitos accounted for 10.8% of all larvae collected, and *Anopheles* for 0.8% (Charts 5 and 6, above).

Adult mosquito species composition wasn't as diverse as that of larvae, but the sampling was also not as extensive or season long. A total of 9 species of *Aedes*, 1 *Culiseta* and 2 *Culex* were collected. *Aedes sticticus* was the predominant species collected as an adult in 2022. Its aggressive biting behaviour

likely contributed to its disproportionate collection, representing 19.46% (47/244) of all adults caught this season. Other species collected in light traps and as part of biting/landing counts included *Aedes riparius*, *Aedes vexans*, *Culex pipiens*, and *Culex tarsalis,* each accounting for at least 4% of all adult specimens collected in 2022 (Chart 7 above).

Light trap sampling of adult mosquitos at fixed locations provides information on localized populations, and specifically those occurring within 30-50m of its position. To provide an effective measure of overall program efficacy, traps would need to be much more numerous, set up in more places and more frequently. Their best use is as a means to measure populations and collect samples in areas with where repeated reports of annoyance are received. Mosquito species identification from collections in traps deployed under this protocol would help to identify potential development habitats affecting an area, allowing them to be targeted for larval surveillance and control.

Ground-based treatment to accessible habitats controlled recurrent larval mosquito development in areas located adjacent to numerous private residences, commercial and recreational operations, campgrounds and golf course areas. Weekly surveying of known development sites is necessary until they drain or are no longer producing larval mosquitos. This ensures that larvae are identified and controlled at their source, and in a timely fashion. The annual magnitude of treatments, and larvicide used, is determined by a variety of factors, not limited to, but including, habitat type (permanent or temporary), larval species, winter snowpack accumulations, summer precipitation, temperatures and local lake, river and creek water levels.

Capable of vectoring diseases such as West Nile virus (WNv), the control of *Aedes* vexans (+), *Ae. sticticus* (+), and the highly competent vectors, *Culex tarsalis* (++++), *Culex pipiens* (+++) and *Culiseta inornata* (+++) as part of the annual Nuisance and Vector Mosquito Surveillance and Control Program not only suppresses adult mosquito populations to reduce potential annoyance, but also contributes to the protection of public health and potential risks from WNv.

Catch basins provide the most widespread type of larval mosquito development habitat within the defined areas of the RDCO and potential source of adult mosquitos. Typically providing habitat for *Culex pipiens* mosquitos, their control is essential to limit localized annoyance and the possibility for disease transmission within “built-up” residential, industrial, and commercial areas of the Regional District, City of Kelowna, Westbank and Peachland. *Culex pipiens* mosquitos can have multiple generations in a season and adult females will enter buildings in search of blood meal. They have a WNv ranking for competency of (+++).

5.3 Mosquito Control Options

An important element for smaller scale control of mosquito populations nearest residential, commercial, and recreational areas is the reduction, modification, or elimination of temporary larval mosquito habitats. Locally, this practice should include physical mosquito control through source reduction, including the filling, and draining of depressions, tire ruts or excavations and the re-establishment of

water flow in ditches, ponds and sloughs as a preferred method of control. Once completed it requires either no further attention or minimal maintenance to exclude further larval development.

The elimination or routine draining of water holding containers excludes them as a regular source of mosquito development. The tire recycling program typically offered by the RDCO every fall collects an average of 1400 – 1600 tires annually. Tires stored outdoors or left to lie in fields and behind sheds can capture and hold rainwater and leaves blown by the wind, heat up quickly in the sun, and provide perfect habitat for mosquitos to develop, particularly *Culex* mosquitos, many species of which are vectors of WNv.

Removal or alteration of mosquito producing habitat does not necessarily mean drainage resulting in habitat destruction for other organisms and natural predators. For sloughs, water features and irrigation ponds at golf courses and private properties where site elimination is not desirable for aesthetic or practical reasons, measures include installing fountains, water baffles or pumps to increase water movement. This can reduce their suitability for larval mosquito development while conserving, and enhancing, habitat for aquatic (insect, fish, amphibian) mosquito predators. Nearly all of the local golf courses have some form of water agitation in one or more of their ponds. Development where it occurs, tends to be in vegetated (cattails, grasses, brush) sloughs, ditches or pond edges which are protected from water movement.

Given that physical elimination of most natural or purpose-designed manmade open water mosquito development habitats occurring within the area is impractical or undesirable, developing mosquito populations are best controlled using bio-rational larvicides containing *Bacillus thuringiensis* var. *israelensis* (VectoBac 200G) or *Bacillus sphaericus* (VectoLex CG or WSP). Their use supports the principles of an Integrated Pest Management (IPM) approach to mosquito control.

The procedures, methodologies, and control products employed in this annual program are described in detail in the *Regional District of Central Okanagan Mosquito Control Pest Management Plan (PMP) # 142-0030-21/26*. The PMP expires on 03 March 2026.

All government regulatory agency conditions and notifications were completed as required for program start-up and operation by *Duka Ltd*, as appropriate. BCMOE requisite reporting, the "*Pesticide Use Follow-up Report*" (due 31 December 2022) and the "*Annual Report on Pesticide Use for Confirmation Holders*" (January 2023) will be completed by *Duka Ltd*. and submitted to the BCMOE on behalf of the RDCO.

5.4 *West Nile virus* and *Zika virus* Update

- ***West Nile virus***

Due to the low and stable incidence of West Nile virus (WNv) it was decided by the BCCDC in the fall of 2014 that it was no longer necessary to conduct active surveillance of mosquitos or other indicators. The provincial decision to eliminate this surveillance was reached at the BC Communicable Disease Policy

Advisory Committee meeting in February 2015. Since 2015, WNv surveillance in BC has been conducted through testing horses, birds that are sick or dead, and humans who have symptoms compatible with WNv. Human clinical testing continues as part of routine blood and organ donor programs. Health Canada relies on the provinces and territories to report the number of West Nile virus cases.

There have been no cases reported in BC for 2022 and WNv has not been found in mosquitos, mammals, birds or humans. In 2021 two travel-related human cases were reported in BC and no animal tested positive for WNv. No humans or animals tested positive in 2020 for WNv in BC. In 2019 one-travel-related human case and one travel-related horse case were reported. Two crows were found in Kimberley in 2018.

- ***Zika (ZIKV) virus***

Zika virus disease is a mosquito-associated flaviviral disease caused by Zika virus (ZIKV). It is related to other *Flaviviridae,* including Japanese Encephalitis, West Nile, Yellow Fever, St. Louis Encephalitis and Dengue viruses. Provincial and national resources are continually being developed and compiled for health care professionals to reference. Guidance documents for health care professionals and travellers are regularly updated as information on Zika virus becomes available.

As part of West Nile virus surveillance programs, several provinces and territories continue to conduct routine mosquito surveillance activities. Provinces, Regional Districts and Municipalities are responsible for the control of mosquito populations. Health Canada advises that in the future, consideration could be given to enhancing mosquito surveillance to detect an incursion of new or invasive mosquito species in Canada. This would include those species responsible for Zika virus transmission. The mosquito species which carry Zika virus are not currently present in Canada.

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TABLES

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
AP	**Airport Kelowna**			
AP02	Unit 1 - 395 Hereron Rd	11	3.000	22.50
AP03	Hereron Rd	6	0.920	6.90
AP05	3510 Bulman Rd	1	0.067	0.50
AP06	1137 Alumni Ave	5	0.587	4.40
AP07A	3740 Bulman Rd	3	0.267	2.00
AP07B	3740 Bulman Rd	9	0.693	5.20
AP07C	3740 Bulman Rd	10	0.987	7.40
AP08	3685 Bulman Rd	4	0.313	2.35
AP10	5690 Upperbooth Rd North	2	0.933	7.00
AP12	4520 Farmers Dr	4	0.947	7.10
AP13	5816 Farmers Dr 500m past	0	0.000	0.00
AP14	5835 Sierra Dr	4	0.120	0.90
AP16A	6880 Sierra Dr	5	0.720	5.40
AP16B	6880 Sierra Dr	10	1.493	11.20
AP21A	2210 Quail Ridge Blvd	8	1.360	10.20
AP21B	2210 Quail Ridge Blvd	6	0.293	2.20
AP22	2210 Quail Ridge Blvd	9	0.827	6.20
AP23	3200 Via Centrale	3	0.227	1.70
AP24	3200 Via Centrale	5	0.427	3.20
AP25	Quail Cres (access at end)	8	0.407	3.05
AP26	Valentino Crt (end of)	1	0.013	0.10
AP29	5305 Okanagan Hwy	5	0.467	3.50
AP30	Adams Rd & Carnie Rd	8	2.147	16.10
AP31B	3330 Old Vernon Rd	3	0.033	0.25
AP33	5775 Deadpine Dr	8	1.267	9.50
AP35A	6741 Hwy 97 North	8	6.653	49.90
AP35B	6741 Hwy 97 North	6	1.227	9.20
AP37	5932 Old Vernon Rd	9	1.827	13.70
	Airport totals	**161**	**28.220 ha**	**211.65 kg**
DK	**Downtown Kelowna**			
DK01	Francis Ave off Pandosy	5	1.360	10.20
DK04	Knox Mountain Dr	4	0.507	3.80

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
DK05	Knox Mountain Dr	7	1.253	9.40
DK06	Rio Dr	3	0.253	1.90
	Downtown totals	**19**	**3.373 ha**	**25.30 kg**
GG	**Gallagher**			
GG01	4320 Gallaghers Dr West	6	0.813	6.10
GG02	4320 Gallaghers Dr West	3	0.280	2.10
GG03	3993 Eastwood Ct	1	0.007	0.05
GG04	3858 Summerside Dr	1	0.013	0.10
GG05	4075 Jean Rd	3	0.113	0.85
GG06	3295 Mathews Rd	1	0.013	0.10
GG07	4284 Jaud Rd	5	0.573	4.30
GG09	4215 Wallace Hill Rd	4	0.400	3.00
GG10A	2950 Balldock Rd	2	0.147	1.10
GG10B	2950 Balldock Rd	4	0.267	2.00
GG10C	2950 Balldock Rd	2	0.240	1.80
GG11	4485 Sallows Rd	3	0.267	2.00
GG13	3079/3081 Hall Rd	3	0.267	2.00
GG17	3145 Hall Rd, 2550 & 2570 Maquinna Rd	4	0.493	3.70
GG20A	3130 Hall Rd	2	0.080	0.60
GG20B	3130 Hall Rd	3	0.253	1.90
GG21	2455 Maquinna Rd & 2475 Maquinna Rd	1	0.107	0.80
GG22B	3150 Hall Rd	2	0.133	1.00
GG23	3190 Hall Rd	2	0.040	0.30
GG24	3215 Hall Rd	4	0.153	1.15
GG25A	3236 Hall Rd	4	0.453	3.40
GG25B	3236 Hall Rd	6	1.147	8.60
GG26	2415 Dunsmuir Rd	5	0.520	3.90
GG27	3205 Wildwood Rd	2	0.120	0.90
GG29A	2130 K.L.O. Rd	2	0.060	0.45
GG29B	2130 K.L.O. Rd	5	1.000	7.50
GG30A	1979 K.L.O. Rd	1	0.013	0.10
GG30B	1979 K.L.O. Rd	3	0.200	1.50
GG32	3270 Wildwood Dr	2	0.107	0.80

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
GG33	3280 Wildwood Dr	2	0.160	1.20
GG34A	3281 Hall Rd	1	0.107	0.80
GG34B	3281 Hall Rd	1	0.040	0.30
GG34C	3281 Hall Rd	1	0.267	2.00
GG36	3236 Hall Rd	4	0.200	1.50
GG38	3314 Wildwood Rd.	1	0.133	1.00
GG39B	1959 KLO Rd	2	0.027	0.20
GG39C	1959 KLO Rd	2	0.107	0.80
GG39D	1959 KLO Rd	1	0.027	0.20
GG39E	1959 KLO Rd	1	0.067	0.50
GG39F	1959 KLO Rd	1	0.027	0.20
GG43	4069 Miller Rd	7	0.653	4.90
GG44	4154 Gallagher's Forest South	4	0.307	2.30
GG45	2450 Maquinna Rd	1	0.133	1.00
	Gallagher totals	**115**	**10.533 ha**	**79.00 kg**
GM	**Glenmore**			
GM01	4055 North Glenmore Rd	8	0.947	7.10
GM02	3550 North Glenmore Rd	6	1.067	8.00
GM03	3550 North Glenmore Rd	7	0.400	3.00
GM04	2248 McKinley Rd	4	0.240	1.80
GM06	2245 McKinley Rd	4	0.200	1.50
GM07A	2105 North Glenmore Rd	10	1.880	14.10
GM07B	2105 North Glenmore Rd	13	2.907	21.80
GM07C	2105 North Glenmore Rd	9	2.187	16.40
GM07D	2105 North Glenmore Rd	6	0.360	2.70
GM08A	Millard Crt West	9	0.507	3.80
GM08C	Millard Crt West	5	0.067	0.50
GM09	745 Rifle Rd	1	0.040	0.30
GM10	John Hindle Dr & Landfill Entrance Rd	11	2.733	20.50
GM13	Glenmore Rd, South of Begbie Rd	10	1.907	14.30
GM19A	2105 North Glenmore Rd	13	7.027	52.70
GM19B	2105 North Glenmore Rd	12	1.627	12.20
GM19C	2105 North Glenmore Rd	13	4.640	34.80

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
GM19D	2105 North Glenmore Rd	11	1.600	12.00
GM19E	2105 North Glenmore Rd	5	0.533	4.00
GM19F	2105 North Glenmore Rd	2	0.093	0.70
GM19H	2105 North Glenmore Rd	10	1.527	11.45
GM19I	2105 North Glenmore Rd	9	0.773	5.80
GM22A	Curtis Rd & Sexsmith Rd	2	0.027	0.20
GM22B	649 Curtis Rd across street	12	3.813	28.60
GM22D	899 Curtis Rd	10	2.267	17.00
GM22E	John Hindle Dr & Landfill Entrance Rd	13	6.973	52.30
GM22G	989 Curtis Rd	8	0.867	6.50
GM22H	995 Curtis Rd	5	0.613	4.60
GM22I	1019 Curtis Rd	9	0.907	6.80
GM25	840 Curtis Rd	2	0.307	2.30
GM26	Hilltown Dr, McKinley Beach pond	4	1.787	13.40
	Glenmore totals	**243**	**50.820 ha**	**381.150 kg**
GMHL	**Glenmore Highlands**			
GMHL02	Upper Canyon Dr & Union Rd	4	0.680	5.10
GMHL03A	Longridge Dr & Hidden Lake Pl	3	1.400	10.50
GMHL03B	Longridge Dr & Hidden Lake Pl	2	0.373	2.80
	Glenmore Highlands totals	**9**	**2.453 ha**	**18.40 kg**
MIS	**Mission**			
MIS03	3687 Benvoulin	4	0.413	3.10
MIS07	3805 Lakeshore Rd	6	0.720	5.40
MIS08A	4105 Gordon Dr	3	0.973	7.30
MIS08B	4106 Gordon Dr	2	0.280	2.10
MIS10A	1085 Lexington Ave	4	0.320	2.40
MIS10C	1085 Lexington Ave	5	0.320	2.40
MIS10E	1085 Lexington Ave	2	0.093	0.70
MIS10f	1085 Lexington Ave	2	0.093	0.70
MIS12	4444 Belmont Rd	6	0.973	7.30
MIS13A	3885 Gordon Dr	6	0.347	2.60

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
MIS13B	3885 Gordon Dr	8	3.427	25.70
MIS13C	3885 Gordon Dr	8	5.160	38.70
MIS15A	1429 K.L.O. Rd	3	0.400	3.00
MIS15B	1429 K.L.O. Rd	2	0.307	2.30
MIS17	K.L.O. Rd. bridge-southside	6	0.307	2.30
MIS18A	S. of Mission Creek Bridge, Casorso Rd.	6	1.000	7.50
MIS18B	S. of Mission Creek Bridge, Casorso Rd	5	0.187	1.40
MIS18C	S. of Mission Creek Bridge, Casorso Rd	8	2.960	22.20
MIS18D	N. of Mission Creek Bridge, Casorso Rd	4	0.547	4.10
MIS18E	N. of Mission Creek Bridge, Casorso Rd	2	0.293	2.20
MIS19	2077 Fisher Rd	1	0.040	0.30
MIS21A	Ditches on Swamp Rd	4	0.560	4.20
MIS22	3695 Benvoulin Rd	6	1.933	14.50
MIS23	3685 Benvoulin Rd	7	2.080	15.60
MIS26	Cavell Pl	3	0.053	0.40
MIS31A	Hill Spring Park	4	0.680	5.10
MIS31C	1625 Vincent Place	2	0.080	0.60
MIS34	2500 Enterprise Way	3	1.027	7.70
MIS35	Access Greenway from Mayer Rd	2	0.067	0.50
MIS36	1750 Munson Rd	3	0.107	0.80
MIS37	3551 Benvoulin Rd	2	0.053	0.40
MIS38	Rockview Park	5	0.753	5.65
MIS47	1524 Pioneer Rd	1	0.427	3.20
MIS49A	3830 Casorso Rd	1	0.080	0.60
MIS50B	1321 Ladner Rd	4	0.720	5.40
MIS51	Fasciux Wetlands	2	0.053	0.40
MIS53	3260 St Amand	4	0.107	0.80
MIS56A	1590 Pioneer Rd	5	0.400	3.00
MIS56B	1590 Pioneer Rd	3	0.627	4.70
MIS	1290 Ladner Rd	2	0.013	0.10
	Mission totals	**156**	**28.980 ha**	**217.35 kg**
RT	**Rutland**			
RT07	1759 Hwy 33 East	3	0.360	2.70

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
RT08	2100 Garner Rd	1	0.120	0.90
RT10B	Swainson Rd & Treetop Rd	2	0.253	1.90
RT16	1164 Morrison Rd	2	0.133	1.00
RT17	350 Moyer Rd	2	0.347	2.60
RT19	250 Sumac Rd West	8	1.053	7.90
RT21	Off Hollywood Rd South	3	0.360	2.70
RT22A	Leckie Rd & Springfield	3	0.107	0.80
RT23	2725 Acl& Rd	5	0.653	4.90
RT25A	Fenwick Rd	2	0.133	1.00
RT25B	Fenwick Rd	1	0.013	0.10
RT25C	Fenwick Rd	3	0.320	2.40
RT25D	Fenwick Rd	6	0.853	6.40
RT27B	1855 Tower Ranch Blvrd	2	0.187	1.40
RT27C	1855 Tower Ranch Blvrd	3	0.040	0.30
RT28	1225 Mackenzie Rd	4	0.387	2.90
RT30	1342 Shaunna Rd	4	0.840	6.30
RT32	175 Rains Rd	2	0.173	1.30
RT36	1959 Walburn Rd	3	0.600	4.50
	Rutland totals	**59**	**6.933 ha**	**52.00 kg**
WO	**Winfield-Oyama (Lake Country)**			
WO01	2611 Stillwater Way	3	0.320	2.40
WO04	10639 Bottom Wood Lake Rd	6	0.480	3.60
WO07	10639 Bottom Wood Lake Rd	3	0.213	1.60
WO08	Lodge Rd	2	0.067	0.50
WO12	Lodge & Woodsdale Rd	3	1.507	11.30
WO13A	3687 Woodsdale Rd	3	0.040	0.30
WO17	4404 Hebbert Rd	5	0.427	3.20
WO18A	12250 Oyama Rd	1	0.013	0.10
WO20A	5574 Hayton Rd	7	0.460	3.45
WO20B	5574 Hayton Rd	5	0.307	2.30

Table 1: **Vectobac 200G Application Summary; Regional District of Central Okanagan - Kelowna; 2022 Nuisance and Vector Mosquito and Surveillance Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
WO22	Lloyd Rd & Greenhow Rd	5	3.813	28.60
WO23	16011 Greenhaw Ct	10	3.093	23.20
WO24	15800 Oyama Rd	3	0.307	2.30
WO25	15800 Oyama Rd	5	2.493	18.70
WO26	16012 Oyama Rd	4	1.013	7.60
WO27	3271 Berry Rd	1	0.040	0.30
WO31	4108 Evans Rd	6	0.573	4.30
WO32	16811 Owls Nest Rd North pond	10	1.853	13.90
WO35	1960 Camp Rd	6	0.840	6.30
WO36	1960 Camp Rd	7	1.373	10.30
WO37	Long Rd Pond	4	0.260	1.95
WO39	2975 Woodsdale Rd @ Woodsdale Ct	9	0.853	6.40
WO40	415 Commonwealth Rd	4	0.520	3.90
WO41A	12824 Oyama Rd	5	0.320	2.40
WO43	13221 Cliffstone Rd	2	0.173	1.30
WO48	McCoubrey & Okanagan Centre Rd	5	0.653	4.90
WO54	3583 Woodsdale Rd	2	0.053	0.40
	Winfield-Oyama totals	**126**	**22.067 ha**	**165.50 kg**
	Vectobac totals	**888**	**153.380 ha**	**1150.35 kg**

Table 2: **Vectobac 200G Application Summary; Regional District Central Okanagan - Westbank First Nations; 2022 Nuisance and Vector Mosquito Surveillance and Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
WFN03	Daimler Dr & Ross Rd	4	0.153	1.15
WFN04B	3509 Carrington Rd	2	0.080	0.60
WFN04C	3509 Carrington Rd	2	0.160	1.20
WFN04D	3509 Carrington Rd	1	0.027	0.20
WFN04E	3509 Carrington Rd	3	0.120	0.90
WFN04F	3509 Carrington Rd	4	0.587	4.40
WFN04G	3509 Carrington Rd	4	0.307	2.30
WFN04H	3509 Carrington Rd	3	0.173	1.30
WFN06	Bering Rd & Louie Dr	**1**	0.027	0.20
WFN07	3041 Louie Dr	1	0.107	0.80
WFN11	2095 Boucherie Rd	1	0.040	0.30
WFN12	~1860 Boucherie Rd	4	0.520	3.90
WFN13	3210 Shannon Lake Rd	1	0.067	0.50
WFN14	Grouse Rd	2	0.040	0.30
	Total Applications	**33**	**2.407 ha**	**18.05** kg

Table 3: **VectoLex WSP (10g satchels) Application Summary; Regional District Central Okanagan - Kelowna; 2022 Mosquito Control Program**

Site #	Location	Number of treatments	Area Size (ha)	Amount applied (kg)
GG07	4284 Jaud Rd	1	0.001	0.01
GG09	4215 Wallace Hill Rd	3	0.017	0.13
GG10A	2950 Balldock Rd	1	0.003	0.02
GG24	3215 Hall Rd	1	0.003	0.02
GG26	2415 Dunsmuir Rd	2	0.007	0.05
GG29B	2130 K.L.O. Rd	1	0.008	0.06
GG36	3236 Hall Rd	1	0.004	0.03
GM19G	2105 North Glenmore Rd	1	0.033	0.25
MIS07	3805 Lakeshore Rd	3	0.032	0.24
MIS13A	3885 Gordon Dr	2	0.016	0.12
MIS13B	3885 Gordon Dr	2	0.015	0.11
MIS13C	3885 Gordon Dr	4	0.016	0.12
MIS15B	1429 K.L.O. Rd	2	0.025	0.19
MIS18C	Mission Creek bridge, behind driving range	1	0.007	0.05
MIS34	2500 Enterprise Way	1	0.009	0.07
MIS50A	1321 Ladner Rd	1	0.003	0.02
MIS53	3260 St Amand	1	0.001	0.01
MIS56B	1590 Pioneer Rd	1	0.003	0.02
RT19	250 Sumac Rd West	2	0.019	0.14
WO36	1960 Camp Rd	1	0.004	0.03
	TOTAL	**32**	**0.225 ha**	**1.69 kg**