Regional District of North Okanagan
Mosquito Surveillance and Control Program

Integrated Pest Management Plan
2024 – 2029

PMP # 141-Mosq-24/29

Common Blue Damsel fly (*Enallagma cyathigerum*) resting

Prepared by
Duka Environmental Services Ltd.
Langley, BC

Prepared for
The Regional District of North Okanagan
9848 Aberdeen Road
Coldstream, BC
V1B 2K9

DRAFT – 05 September 2023

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1.0 PEST MANAGEMENT PLAN SUMMARY

The RDNO contains an abundance of natural features and resources which enhance the outdoor enjoyment of residents and visitors to the area. Lakes, rivers, forested and undeveloped areas make the Regional District a major stopping point for tourists travelling through to other parts of BC and is the base of operations for cattle ranches, farming, orchards, forestry, utilities, transportation and tourism related industries. Expanding residential and commercial businesses, hospitality, recreational and agricultural activities which are all impacted by adult mosquito annoyance. The goal of the mosquito surveillance and control program is to provide residents, workers and visitors to the RDNO with the prevention of widespread, extreme, or persistent adult mosquito nuisance and reduction of potential disease vectors.

The mosquito control program proposed for select communities and areas of the RDNO Electoral Areas D+ F are intended to benefit residents, businesses and visitors by using a comprehensive and sustainable, Integrated Pest Management (IPM) approach to control. This approach focuses on the timely detection and treatment of larval mosquito populations using biological products and methodologies. Where possible, and appropriate, physical or cultural controls are recommended, and implemented, that reduce larval habitat and enhance, or conserve natural mosquito predators and their environments. Where required, larval mosquito populations would be controlled using the bio-rational larvicide product VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis,* PCP #18158), or equivalent, and VectoLex (*Bacillus sphaericus,* PCP # 28008, 28009). All treatments would be completed in accordance with the *Integrated Pest Management Act and Regulations* and the methodologies and procedures prescribed in the BC Ministry of Environment-accepted Pest Management Plan (PMP) for Mosquito Surveillance and Control, (this document), and on behalf of the Regional District of North Okanagan for 2024-2029.

Mosquito control services would be provided to residential and rural property owners, businesses, municipal and regional parks, sports fields, golf courses and other outdoor recreational and tourist facilities located within the specified areas of the RDNO. The goal of the annual mosquito control program is to reduce the potential for widespread adult mosquito annoyance for the benefit of residents, workers and visitors to the area.

This Pest Management Plan (PMP) reviews mosquito biology, the types of larval mosquito habitats affecting the program area and the local mosquito species complex. An integrated approach to mosquito population management and control using education, prevention and biological controls can reduce overall adult mosquito annoyance. This PMP outlines the procedures and methodologies of an Integrated Pest Management (IPM) approach which will suppress local mosquito populations. Important biological concepts, operational procedures and protocols are proposedly repeated throughout the document.

1.1 Geographic Boundaries of this Pest Management Plan

The Regional District of North Okanagan (RDNO) is comprised of approximately 787,000 hectares of land, divided into six (A - F) Electoral Areas. Of this total area, 608,000 hectares are crown lands, 167,500 hectares are privately-owned lands, 11,500 hectares are First Nation lands and approximately 70,000 hectares are contained within the Agricultural Land Reserve.

Located in the south central part of the Province, the RDNO is bi-sected by two principal travel routes, the Okanagan Highway (Hwy # 97 / 97A) along its western border and the Vernon-Slocan Highway (Hwy # 6) through the southern boundary. Mosquito surveillance and control program operations will be focused in the RDNO Electoral Areas F, and specifically around the communities of Grindrod, Mara Lake and Kingfisher (Mabel Lake) to Ashton Creek. Additional control program operations would be in the Lumby to south Mabel Lake (RDNO Electoral Area D) corridor.

The Okanagan area has a warm growth season and relatively mild winters and springs that have long frost-free periods. The areas hot, sunny, dry climate is classified as semi-arid, with the lowest average annual precipitation in southern Canada. The area's mountains and numerous lakes and rivers offer a variety of easily accessible summer recreational activities including fishing, hiking, mountain and dirt bike riding, horseback riding and camping.

The geographical area covered under the PMP is centred on five communities and adjacent agricultural and undeveloped lands from Grindrod to Mara Lake, Kingfisher (Mabel Lake) to Ashton Creek and Lumby to south Mabel Lake. This includes both public and private properties and low-lying, flood and seepage water-influenced habitats and impoundments in farm fields, ranch lands, First Nations lands, undeveloped forest, and at commercial and industrial properties, with permission, of the applicable owner, agency or authority. A map of treatment area (service) boundaries is presented in the Figures section of this document.

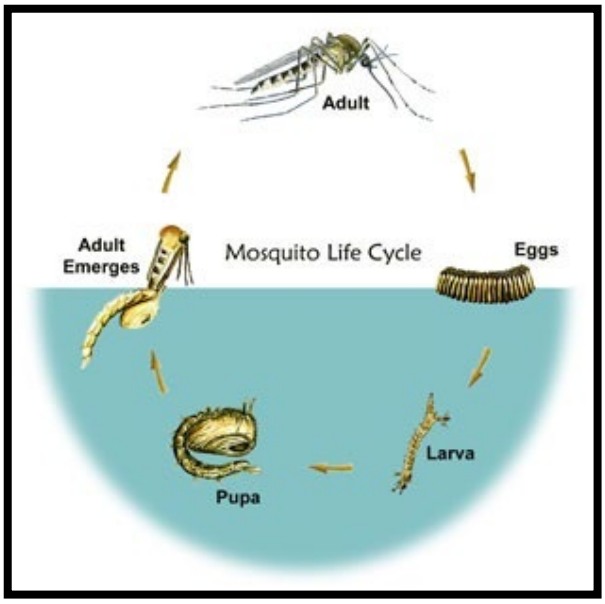
1.2 Mosquito Biology

Mosquitos are found world-wide in standing water of all possible descriptions. Mosquitos belong to the order Diptera, along with other pests such as the common house fly and the black fly. There are four genera of mosquitos common to British Columbia. These are *Aedes*, *Culex*, *Culiseta* and *Anpoheles.* They have differences in life cycles, habitat preferences and the time of the year when they predominate as larvae and adults. There are over sixty species common to Canada and over thirty are found in British Columbia.

Mosquitos undergo four distinct development stages; egg, larvae, pupae and adult. Larvae and pupae are aquatic. Eggs are laid on the water surface or on soil and vegetation adjacent to water. The eggs of some species of mosquitos, such as *Aedes*, can survive for upwards of 20 years and will hatch after a period of winter freezing and upon being wetted. Mosquito larvae undergo four stages or instars (1st, 2nd, 3rd and 4th), each time emerging larger, but virtually unchanged from the previous instar. This is the active feeding stage of the aquatic mosquito. The mosquito pupa, like a butterfly chrysalis, is a non-feeding stage and is where the once aquatic, larval mosquito undergoes metamorphosis to emerge as the winged, terrestrial adult mosquito. 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 which requires a blood meal to complete the development of her eggs. Female mosquitoes will typically fly less than 0.5-1km in search of a blood meal, although distances of 5 km are not uncommon. Mosquitos have been found 30 km 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.

Mosquito development occurs in a wide range of larval habitats ranging from snowmelt and precipitation-influenced flood and seepage water pools and channels along rivers and lakes to permanent freshwater, ponds, marshes, ditches and similar water-holding depressions. Bird baths, plugged rain gutters, livestock watering troughs, stored equipment, irrigation and surface water run-off collection ponds, ditches and any man-made container capable of holding water for a period of 7 to 21 days can provide suitable larval mosquito habitat.



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. Extreme allergic reactions or secondary infections from mosquito bites can occasionally require hospitalization. Diseases such as canine heartworm, Western Equine Encephalitis (WEE) and West Nile virus (WNv) are transmitted from some mosquito species to family pets, humans, and livestock.

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 BC Centre for Disease Control (Vancouver) and local health authorities are responsible to coordinate the surveillance, identification and reporting of these diseases and their mosquito vectors. As part of this planning the BCCDC has developed the *Arbovirus Surveillance and Response Guidelines for British Columbia* (2005), and the BCCDC has a provincial database containing mosquito, bird and human health surveillance data relating to WNv and vector mosquito species.

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. Specific details on the response guidelines, surveillance, permitting, and other related information is available online through www.BCCDC.org

1.3 Need for Mosquito Control

In addition to negative impacts on the lifestyle and general health of residents, a large population of mosquitos can have a negative economic impact on local businesses. Worker safety, comfort and efficiency can be compromised by adult mosquito annoyance and distraction. Milk, beef, and egg production in farming or ranching communities can be reduced when animals are unable to feed or rest because of extreme mosquito annoyance or through a reaction to mosquito saliva-borne toxins or disease. Reduced use and enjoyment of hotel and restaurant outdoor patios, sports fields, golf courses, campgrounds and cycling or hiking trails by residents and area visitors directly affects business operations and revenues.

The purpose of an annual mosquito surveillance and control program is to provide residents, workers and visitors in the defined (PMP) areas of the RDNO with relief from extreme and / or persistent adult mosquito annoyance. The control program is not intended to, nor is it possible to eradicate local mosquito populations. Despite the best of efforts, some adult mosquito annoyance may still occur during the summer months. Residents are encouraged to avoid areas of mosquito harbourage (typically treed, forested or landscaped areas) during certain times of day and to use approved adult mosquito control devices, products and repellents, as per label directions.

Although not a common occurrence in most areas of British Columbia, mosquitos are capable of transmitting (vectoring) diseases. An effective, pro-active mosquito control program which focuses on the identification, prevention and timely control of larval mosquito populations is

important to limit the potential for both disease transmission and widespread adult mosquito annoyance. Uncontrolled larval mosquito development in the flood and seepage water accumulations adjacent the Shuswap River and its tributaries can produce an enormous number of adult mosquitos and cause reportable nuisance for residents. While the absence of adult mosquitos may go unnoticed, adult mosquito annoyance does not, and return visits to a particular area are governed accordingly.

The Regional District of North Okanagan Mosquito Surveillance and Control Program Pest Management Plan, described in detail below, is presented in a format which adheres to the requirements of *Integrated Pest Management Act and Regulation,* including amendments, and the *Mosquito Management Sector Review Paper*. Copies of these documents are available through the BC Ministry of Environment at www.env.gov.bc.ca/epd/epdpa/ipmp/pestact/index.html. Common themes of larval development prevention, identification and control necessary to achieve the program goal of reduced adult mosquito populations, while ensuring environmental conservation, are repeated throughout this document.

The Pest Management Plan is 'owned' by the Regional District of North Okanagan. It would remain in place for the purposes of mosquito population management and control for the five year period, 01 April 2024 to 31 March 2029. The goal of the annual mosquito surveillance and control program is to reduce the potential of widespread, or persistent, adult mosquito annoyance for the benefit of residents, workers and visitors to the program areas. This is achieved using an Integrated Pest Management (IPM) approach which concentrates on larval prevention and control initiatives. The methodologies and procedures described within this PMP are a hybrid of approaches adapted through collaboration with mosquito and vector control professionals worldwide. It has been carefully and specifically designed for the unique conditions of the program areas and is a model of environmental compatibility. The methodologies and operational procedures described within this Pest Management Plan are the industry standard.

A professional, experienced, environmental services firm (the consultant) is retained by the RDNO to deliver these very specialized services and to ensure adherence to the PMP. The consultants for the RDNO annual mosquito surveillance and control program would have Registered Professional Biologists (R.P.Bios.,) as program managers and senior biologists. All program personnel would be appropriately certified as pesticide applicators with the BC Ministry of Environment, Integrated Pest Management Program.

Public relations and ongoing program education would be accomplished through regular contacts with residents, businesses and community visitors. Information on mosquitos, their control, and prevention, may be available to the general public in a variety of forms including notice boards, informational brochures, websites, newspaper articles, websites, social media, open-houses and farmer's markets etc. Resident, business and visitor requests for service and / or information are followed up with telephone contact and site inspection, as appropriate. Physical reduction, elimination or alteration of larval mosquito development habitats is an important aspect of the control program. Wherever possible, and practical, property owners will be advised of measures they could undertake to reduce mosquito development.

1.4 Term of the Pest Management Plan

A five year period, extending from 01 April 2024 to 31 March 2029.

The designated contact for this Plan is Mr. Ian Wilson, General Manager, Strategic and Community Services, Regional District of North Okanagan, 9848 Aberdeen Road, Coldstream, BC, V1B 2K9. Telephone # 250-550-3700.

2.0 MOSQUITO CONTROL PROGRAM BACKGROUND

The geographical area covered under the PMP is coarsely defined as the communities of Grindrod, Mara Lake, Ashton Creek and Kingfisher (Mabel Lake), Lumby and adjacent areas, within the Regional District of North Okanagan Electoral Areas D+F (See Figure). Larval mosquito habitats affecting the areas include impounded waterbodies such as temporary and permanent ponds, swamps and low-lying river flood and seepage-water influenced habitats in forested areas, farm fields, ranch lands and undeveloped areas. Filling with water in response to snowmelt, precipitation run-off and increased river levels, shallow pools and ponds can form in depressions, sloughs, back channels and old river oxbows located all along the Shuswap River. Additional larval development habitats include roadside ditches and temporary sites such as water-filled tire ruts, depressions, un-used or abandoned pools or boats, canoes and containers. Many of these sites can be become active with larval development on more than one occasion during the months of April through August, depending on weather conditions. The Figure at the end of this PMP document presents an overview map of mosquito surveillance and control boundaries.

Some cursory mosquito population sampling, surveillance and limited control was completed for several North Okanagan communities (Armstrong, Coldstream, Enderby, Lumby, Vernon) as part of the Provincial West Nile virus (Wnv) Surveillance and Control Initiatives Program of 2005-2010. With funding support from the BC Provincial Government, and technical support from the BC Centres for Disease Control and local health authorities larval development sites were investigated, identified and documented, where appropriate, as potential disease vector habitats. Surveillance and pre-emptive control of WNv vector mosquitos by participating communities was suspended province-wide in 2010 with the elimination of provincial funding and support. Nuisance mosquito surveillance and control programs, such as the one described in this PMP, have been routinely, safely and effectively operated by numerous (+ 50) BC communities and regional districts, and for some, for over 35 years. The BC Centres for Disease Control (BCCDC) remains responsible for coordinating the province's response should WNv occur in BC.

The most effective means of reducing adult mosquito populations and the potential for annoyance or disease transmission is through an Integrated Pest Management (IPM) approach

focused on suppressing larval mosquito populations and development. This protocol consists of five components:

1) Public Education/outreach to explain the program and to receive input and public feedback;
2) Surveillance to identify mosquito species occurrence and their distribution;
3) Timely implementation of mosquito controls and preventative measures;
4) Adaptive management of operations during a season in response to observations; and,
5) Review of results, program evaluation and assessment to ensure sustainable, effective controls are achieved.

The annual mosquito control program provided by the RDNO will focus mosquito population surveillance and control (suppression) efforts in areas where larval development is known to occur and where past, occasionally notable, adult mosquito annoyance was documented. Mosquito control services are provided to residential and rural property owners, businesses, municipal and regional parks, sports fields, campgrounds, golf courses and other outdoor recreational and tourist facilities. Mosquito control services will be concentrated on suppressing larval mosquito development occurring in river flood and seepage water-influenced habitats occurring in low-lying farm fields, ranch lands, forest and undeveloped lands adjacent the Shuswap River. The attached Figure delineates control program boundaries and primary sources of larval mosquito development. Over 600 hectares of potential larval mosquito development habitat exist within control program boundaries. For site specific details please contact the RDNO or their control program consultants.

2.1 Primary Land Use

The majority of land, within the control program area, is comprised of residential and rural properties, small acreages, industrial, commercial and agricultural including several large cattle/ranch lands and farms. Recreational land uses include golf courses, sports and playing fields, skateboard and bike parks, pic-nic areas and campgrounds. In addition to organized sports activities, outdoor recreational activities include horseback riding, motorbike and mountain bike riding, fishing, hiking and walking.

Within the program area, permanent and temporary larval development habitats (sites) have been identified and collated. The “development site database” contains information on property ownership and access, development site type, size, and mapping, mosquito species presence, occurrence and distribution for each site.

2.2 Mosquito Species Identified within the area

The majority of mosquito control programs operated within BC are conducted for communities located along river floodplains and in northern BC and Yukon for areas surrounded by extensive muskeg swamps or perma-frost. Locally, mosquito development occurs in a wide range of larval habitats ranging from snowmelt and precipitation-influenced sites, river flood plains and seepage

sites to permanent ponds, marshes, man-made ditches, collection or display ponds and containers. Bird baths, plugged rain gutters, livestock watering troughs. tire ruts and any other container or depression capable of holding water for a period of 7–21 days can provide suitable larval mosquito habitat. Left undetected, larval mosquitos will complete their development to the adult stage within this time span.

Over thirty species of mosquitos, representing all of BC's six genera of mosquitos have been collected from within the Okanagan. All of the following species, except *Culex territans* (which feeds on amphibians) can be a nuisance and many species, particularly those which bite birds and mammals other than man, are also capable of vectoring diseases, such as Western Equine Encephalitis and West Nile virus.

Mosquito pest species collected locally in the Okanagan include:

Aedes canadensis
Aedes cataphylla
Aedes cinereus
Aedes communis
Aedes dorsalis
Aedes euedes
Aedes excrucians
Aedes fitchii
Aedes flavescens
Aedes hendersoni
Aedes increpitus
Aedes intrudens
Aedes mercurator
Aedes provocans
Aedes punctipennis
Aedes punctor
Aedes stirriensis
Aedes sticticus
Aedes vexans
Anopheles earlei
Anopheles freeborni
Coquillettidia perturbans
Culex pipiens
Culex tarsalis
Culex territans
Culiseta alaskaensis
Culiseta incidens
Culiseta inornata
Culiseta impatiens
Culiseta minnesotae

Mosquito development habitats are monitored throughout the season, typically from mid-April through August, to assess the abundance and species of mosquitos developing in them. Larval populations are sampled, measured and recorded as the # larvae/350 ml dip sample and by their age class, 1st, 2nd, 3rd, 4rth instars or pupae. New Jersey or CDC (Atlanta) light traps and standardized mosquito biting and landing counts are used to sample and monitor adult mosquito populations and distribution.

The majority of mosquito species occurring along river floodplains and vegetated lake shorelines are predominantly (+90%) *Aedes* mosquitos, and overall they account for between 70-80% of all mosquitos occurring in the Okanagan. These mosquitos are aggressive biting pests of mammals (including man, livestock and pets) and prefer flooded, temporary or recurring habitats such as over-irrigated fields, low-lying stream and riverbanks, ditches, snowmelt pools in woodlands, meadows and fields, and flooding from rising lake, river and marsh water levels. *Aedes* females will bite once and then lay their eggs in moist soil along the edges of recently flooded areas where the eggs can lay dormant for upwards of twenty years. Snowmelt species rely on increasing water temperatures to hatch. Following a period of wetting, and drying, eggs become "primed" to hatch. Larvae, once inundated, particularly with flood and snowmelt species, can hatch out in large

numbers, with populations typically ranging from 50-100 larvae/350ml dip sample, although +200 larvae/dip sample isn't uncommon. Developing in response to fluctuating water levels and river freshet flooding occurring with snowmelt and precipitation run-off, *Aedes* mosquitos are typically the most numerous during the first half of the season, from mid-April through July. Receding water levels, increasing temperatures, evaporation and decreased precipitation causes many of these habitats to dry, drain and disappear.

Culex and *Culiseta* comprise the balance (20-30%) of mosquito pest species for the area. Larval populations normally range from 1-20 larvae/dip sample and multiple, or recurring hatches each season are possible with additional egg laying by adult females. They typically develop later in the season, from June through August, and require a different set of cues to initiate the onset of larval development, including increasing day length and temperatures. *Culex* and *Culiseta* prefer permanent and slow-draining, or frequently-refilled sites including natural and man-made ponds, ditches and containers such as stored tires, boats and buckets or livestock watering troughs. They overwinter as adults and females and can bite multiple times, a variety of hosts (mammals, birds) and lay eggs several times in a season.

Anopheles are large mosquitos which prefer permanent sites or slow draining and flowing ditches or stream margins. They are not very common and are often the least numerous of the mosquito species occurring in the area. Although their populations and individual development sites are not usually as large as the synchronous hatching *Aedes* mosquitos, they can be a source of reportable annoyance since their preferred habitats are common to residential, commercial, recreational and agricultural properties.

Cattail marshes, which are located throughout the 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 "breathe" underwater. Because they are not free swimming like most larvae, 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.

Species such as *Culex tarsalis* are able to withstand brackish waters and a high degree of pollution. They can inhabit areas with high organic content, including septic field seepage, sewage lagoons and livestock hoof prints around barns, feed lots and along creeks. *Culex pipiens*, the "house mosquito", can use a large variety of natural and man-made freshwater habitats including containers and they are the predominant (+99%) mosquito developing in roadside catch basins.

All of the species collected locally are able to develop as multiple hatches during a typical season. They are all capable of causing reportable and often extreme annoyance, particularly *Aedes,* and *Ae. vexans* and *Ae. sticticus* are potential West Nile virus (WNv) vectors. *Culex* and *Culiseta* mosquitos are not only a source of annoyance, but they too are also recognized as vectors of several diseases, including WNv. *Culex tarsalis, Culex pipiens* and *Culiseta incidens* are identified by the BC Centre for Disease Control (BCCDC) and the Center for Disease Control (Atlanta, USA) as three of the primary vector vectors of WNv in North America. Control of locally occurring *Aedes*, *Culex* and *Culiseta* mosquitos not only prevents widespread nuisance for the benefit of residents, workers and visitors, but also contributes to the protection of public health.

Mosquito surveillance, collection and identification are components of an ongoing operational and effective control program. The mosquito species listing and development site database would be updated as required.

2.3 Mosquito Surveillance and Control Program Summary

In response to resident, workers and visitor reports of recurring adult mosquito annoyance, the RDNO intends to provide residents, workers and visitors (through its consultants/contractor) with environmentally-sound and sustainable, mosquito control using an IPM approach. This methodology incorporates public education, development site identification and categorization, surveillance, site alteration or modification, the conservation or enhancement of natural predators and controls, and where required, larval mosquito control using the safest, most effective biological control agents available.

Approximately 600-1,000 hectares of natural and man-made larval mosquito development habitat has been tentatively identified within the identified project areas. Ranging in size from less than $10m^2$ to several hectares in total treatment area, these sites vary in description from a single, roadside ditch or pond to low-lying farm field, forest and snowmelt habitats which may - contain 50 or more individual, temporarily-filled ponds and depressions and total several hectares in size. These flooded areas can persist and fluctuate in depths for as long as river levels are elevated and until drainage and evaporation eliminate them, often weeks later.

Stagnant and non-flowing ponds, ditches, tire ruts and depressions, most of them man-made or influenced, provide ideal larval mosquito development habitat and by their nature are often located in close proximity to residences and recreational areas. Other habitats such as bird baths, buckets, stored boats, livestock watering troughs and tires are not treated as part of routine control program operations. When discovered, physical control of these habitats can be easily accomplished by removal of the container or for bird baths or watering troughs, regular drainage and refilling. Tire ruts and depressions can be filled or graded to eliminate their ability to hold water. This prevents larval mosquito development

and subsequent adult mosquito annoyance. Public education activities encourage property owners to survey their properties and identify these types of habitat for removal, elimination or regular attention.

Adult and larval mosquito population monitoring is conducted as part of ongoing operational mosquito population management and control programs. This allows for an assessment of larval control effectiveness in reducing nuisance mosquito populations, updates the local species record and the larval mosquito development site database.

2.4 Control Products (Larvicides) Proposed for Use

The Regional District of North Okanagan Mosquito Surveillance and Control Program reduces adult mosquito populations, and potential for annoyance, by focusing on the identification and suppression of larval mosquito development using an IPM approach. This approach includes site modification or elimination, the conservation and enhancement of natural predators, and when these are ineffective, or inefficient, the use of only biological and bio-rational control products.

Given that the majority of larval development habitats occurring within the program areas are temporary, flood and seepage water influenced accumulations in low-lying farm fields and ranch lands, physical control/prevention of larval mosquito development through grading, filling, ditching or dyking of habitats isn't feasible or fiscally achievable.

Effective mosquito control operations and population suppression have been developed using bio-rational, *Bacillus* sp.-containing larvicides, including VectoBac 200G (PCP # 18158) and VectoLex CG (PCP # 28008). Extensive product information, including product labels and Material Safety Data Sheets (MSDS) can be found at the manufacturer's website www.valentbiosciences.com or through the Health Canada, Pest Management Regulatory Agency (PRMA) website www.pmra-arlc.gc/ca. and the Pesticide Label Search www.hc-sc.gc.ca. Section 3.4.3 Bio-rational Control (below) discusses the larvicide products VectoBac 200G and VectoLex CG in further detail.

Property owners would be consulted with prior to any larvicide applications and for any recommended physical or biological/natural methods. Product brochures, labels, MSDS sheets and website addresses would be supplied and reviewed to ensure residents, business, and facility operators understand, are comfortable with, and approve, proposed treatments. In the event that a property owner wishes exclusion from the control program this request would be honoured and noted in the development site database.

3.0 MOSQUITO CONTROL PROGRAM METHODOLOGIES

The objective of the annual control program is to reduce the potential for widespread adult mosquito annoyance for residents, workers and visitors to the program areas. A program of this

scope is not intended to eradicate the mosquito population. The total eradication of a widespread, fecund insect pest is not feasible.

The prevention or control of larval development is preferred over control of the often widely dispersed and mobile adult mosquito since larvae are concentrated in one place, they must remain there for 5-21 days, and they are very susceptible to the bio-rational control products VectoBac 200G and VectoLex CG. Regular monitoring of established mosquito development habitats, and surveying for new or previously undetected sites, ensures that larvae are controlled before they complete their development and cause adult mosquito annoyance.

The need to coexist with a dynamic aquatic habitat necessitates that an integrated approach to mosquito control be undertaken. This approach requires an assessment of the problem, an in-depth understanding of factors influencing the situation, followed by the use of appropriate control. Measures employed in an IPM approach to mosquito control typically include a combination of elements directed at the elimination or modification of mosquito-producing habitat and control of larvae (larviciding) through predators, parasites or other bio-rational means.

Drainage or other physical alterations to larval mosquito development sites is the preferred and permanent control method. Once done it often requires no further attention. Physical control can be integrated into routine, local public works activities such as roadside grading and ditch or culvert maintenance and cleaning. Private and business property owners can contribute to mosquito control efforts by eliminating, reducing or modifying sources of mosquito development. Removal of buckets, draining of plugged eaves troughs or unused bird baths and regular changes of water in livestock watering troughs reduces local mosquito populations. Wherever practical, during the course of monitoring, residents and businesses were advised of options for physical control of mosquito development habitats located on their property.

Adult mosquito populations are monitored at select locations within the control program and in response to resident requests for service. When adult mosquito annoyance is identified, surveillance for potential, and unknown development sites can be undertaken, and controls completed, to reduce mosquito populations before they can disperse to cause increased annoyance. Since different species of mosquitos use different habitats for development, adult mosquito sampling and identification can help determine, or confirm, the source of localized mosquito nuisance. Routine adult mosquito control applications (adulticiding) for the purposes of nuisance mosquito control **are not** a component of the annual RDNO Mosquito Surveillance and Control Program, or this Pest Management Plan.

The mosquito control program and methodologies developed for the RDNO are a hybrid of approaches developed through collaboration with mosquito and vector control professionals worldwide. It has been carefully and specifically adapted for the unique conditions of the program area and is a model of environmental compatibility. The components of this successful control program may include the following activities, as detailed in Sections 3.1, through to Section 4.5 of this document.

3.1 Public Information and Education

The general public is regularly advised of control efforts in their area and provided with the opportunity to have input to their mosquito control program. This is essential since, in the final analysis, it is the general public which must be satisfied with control program efforts.

The *Integrated Pest Management Act and Regulation* requires public notification of Pest Management Plan preparation through newspaper notices. These must be published once each week, for two weeks in row, starting at least 45 days before submission of a notice to the BCMOE confirming that a Pest Management Plan has been prepared according to the legislation. The general public, first nations and other stakeholders are invited through these advertisements, or direct contact (First Nations) to provide comments on the PMP and to consult with the PMP holder or their designate, on PMP contents and the proposed mosquito population management and control program. In addition, those individuals or groups which had requested information, or who have supplied input when the local mosquito control program was last advertised and approved, are contacted directly each time the PMP is renewed.

The annual mosquito surveillance and control program will have a highly visible nature using helicopters and field biologists working along roadsides, in parks, golf courses, cycling and hiking trails and private properties. Newspaper, television and radio articles, interviews and advertisements, brochures, posters and interactions with field personnel are completed as part of routine program operations. Combined with web site and social media posts, these provide the general public with regular and frequent information on mosquitos and program service access.

Considerable value can be obtained through exposure of the control program and interactions with the public. Residents are encouraged to contact RDNO offices, or those of its program consultants, to report potential sources of larval mosquitos (a waterbody) or adult mosquito annoyance which can result in the locating of new development sites. Field biologist and technician follow-up provides opportunities to discuss suggestions for physical removal or source reduction on private property which allows the owner to participate on a smaller scale. Once accomplished, physical source reduction, especially of artificial containers, eliminates the need for further attention.

Movement of adult mosquitos, either by active flight or passively by wind, from outside of treated areas is always a possibility given the nature of local geography. Public education further encourages residents and businesses to undertake actions for excluding adult mosquitos and modification of personal behaviours which will reduce the potential for annoyance. Through eliminating development sites on their property and learning to reduce adult mosquito annoyance through preventative actions, residents can actively participate in their program. 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 adult mosquito annoyance may be anticipated at certain locations, times of day and during some years.

Examples of some various public education and information initiatives which have been successfully employed in other programs and which are available, or which could be deployed for this annual program include:

- *Informational Brochures* – these review mosquito biology and control, mosquito "myths", program operations and contact information for program biologists.
- Web-based program information and service contact details
- Social media (Facebook/twitter/instagram) accounts – public access and information
- *Laminated posters* – durable. Can provide basic information on protection from annoyance. Installation along walking trails, picnic and camping areas is possible.
- Newspaper Display Advertisements – placement in local newspapers from April–August provides program contact and access information.
- *Presentations at Council meetings - (Power Point™).*
- *Public information booth @ Open houses, farmers markets*
- *Radio, television and newspaper interviews and /or articles*

As part of annual control program start-up in early April and May, program field personnel would contact property owners, residents and facility operators listed in the program database to determine site status and confirm program participation and property access. Ongoing interactions and conversations with property owners, residents and general public provides opportunities to discuss program operations, goals and allow for the distribution of public education and outreach materials. Office and field personnel response to service requests received from the general public provides additional opportunities for public education and information sharing of program operations.

Occasionally individuals may wish to be excluded from the mosquito control program for personal reasons. A record of "AVOID" areas is maintained, and updated as required. Meetings and input with concerned residents and special interest groups ensures that activities of control personnel do not conflict with those of residents. By staying informed of community events such as baseball games, tournaments, rodeos and the like, control personnel can increase efforts prior to an event to reduce potential adult mosquito annoyance.

The cooperation and support of local businesses, farmers, business, facility operators and other property owners is indicative of true community spirit and support for a successful program which benefits workers, residents and visitors to the RDNO. Prevention of adult mosquito annoyance through pro-active, larval mosquito surveillance and control provides significant benefit to residents, outdoor workers and recreational users.

3.2 Protection of Archaeological Sites

Archaeological sites on both public, or private land are protected under the Heritage Conservation Act (HCA) and must not be altered without a permit. Archaeological sites are non-renewable and have cultural, historical, scientific and educational value. The HCA automatically protects all

archaeological sites that predate AD 1846, with exception of burial sites and rock art sites which are protected regardless of age.

Any individuals working in the annual RDNO Mosquito Surveillance and Control Program that believe they may have encountered materials or items of archaeological importance will follow the procedures below:

- all work in the vicinity of the items/objects will cease immediately and any archaeological and/or human remains will not be disturbed.
- will contact their supervisor/program manager.
- no excavation or removal of soil from the area will occur.
- will isolate, mark and protect the area from disturbance.
- take pictures of the artifact, the immediate and adjacent areas.
- note location (GPS coordinates, location description) and leave all discoveries in place.
- the RDNO and provincial Archaeology Branch (email: Archaeology@gov.bc.ca, or 250-953-3334) will be contacted.

3.3 Mosquito Control Program Data Collection and Reporting

The environmental consultant (contractor) managing the annual mosquito surveillance and control program for the RDNO is responsible to follow the data collection and reporting requirements of the PMP and the *Integrated Pest Management Act.*

The RDNO would be kept regularly informed of control program activities through personal contact, telephone, facsimile or e-mail by their consultant's program managers and field personnel. In addition, monthly, written progress reports summarizing weather conditions, surveying and monitoring results, treatment areas and interactions with the public are supplied to the RDNO by the consultant during operational phases of the control program.

At the conclusion of each annual mosquito control program season the consultant would provide the RDNO with a summary report detailing all activities and pesticide treatments completed under the PMP. All necessary pesticide use reporting required under the *Integrated Pest Management Act*, the approved PMP, and as requested during the season by government regulatory agencies including the BC Ministry of Environment would be completed by the consultant (as agents for the Regional District), as requested and necessary.

At a minimum, the consultant would maintain the following information for their use in managing the program and to complete the reporting and information requirements of the RDNO, the PMP, the *IPM Act and Regulations*, and the BC Ministry of Environment:

- a mosquito development site database with information including property ownership, address, contact telephone number, development site maps and or photographs, GPS identification, public access information (paths, trails, roadways), records of past and current monitoring and

treatment activities, pesticide use daily operation records and other relevant information related to the control program.

- a record of properties identified as 'AVOID' areas, where the owner or residents have indicated through telephone, written, verbal (in person conversation) or electronic (e-mail, facsimile) communication with the contractor, or the RDNO, their wish to be excluded from the mosquito control program.

- a list and/or maps identifying, where necessary, areas such as fish-bearing waters, potable surface water intakes or areas of environmental sensitivity, including provincial or regional parks, habitat conservation areas, archaeological sites, and other identified or designated speciality management areas. When the status of a waterbody or other area of potential environmental concern (eg. bird nesting sites) is unknown, a local representative of the Department of Fisheries and Oceans (DFO) Canada or the BC Ministry of Environment (BCMOE), or other agencies where appropriate, may be consulted, as appropriate.

The development site database is updated during each field season when control program personnel meet with residents, owners and operators of the farms, businesses and recreational facilities. Property ownership, access, development site status, avoid areas and control program operations are reviewed at this time. Regular contact is maintained with these individuals throughout the season to provide updates on program operations and opportunities for input and comment. Ongoing activities related to surveying, monitoring and mosquito control operations are recorded in the historical data section of the database as they occur.

3.3.1 Environmental Conditions Affecting Mosquito Development

Review of weather conditions and long-range forecasts, winter snowpack accumulations and river levels are essential for successful program operation. Combined with a sound knowledge of mosquito biology and local development site types this information ensures timely surveying and monitoring activities are scheduled and completed to detect the onset of mosquito development.

The amount of winter snowfall accumulations in local mountains and its subsequent melt in late spring and early summer have a direct impact on river and lake levels and the extent of flooding observed in adjacent, low-lying fields, undeveloped lands, forested areas and islands. During January through to early June, local (mountain) snowpack conditions and long-range weather forecasts (websites) are regularly reviewed.

Precipitation, temperatures and weather patterns are regularly reviewed (websites) throughout the operational season, late April – late August. This ensures timely surveillance and treatment of larval development occurring in response weather fluctuations, which depending on intensity or amount, can rapidly increase, or decrease water levels, as appropriate, in development sites.

Increasing river and lake levels (freshet) in response to snowmelt and precipitation in April, May and June will cause flood and seepage waters to accumulation in low-lying areas with resultant larval eclosion (egg hatching) and development. Several seasons of correlating river and lake levels with larval mosquito development onset and distribution data allows for a predictive '*larval development threshold*' to be determined. River and levels in excess of this threshold are sufficient to cause widespread larval development. Correlating snowpack measurements, and their melt rates with local river and lake levels (thresholds) allows for the occurrence and distribution of larval development to be forecasted and subsequent treatment of larval populations to be completed in a timely fashion.

Temperature and precipitation (weather) impacts on mosquito development and survival can vary. 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 snow pack melt. Later in the season, during July and August, daily temperatures and precipitation can impact development site size, persistence and larval activity in open water sites, and catch basins. Simply put, the greater the amount of precipitation, the greater the potential for standing water in depressions and ponds, catch basins and containers with may result in increased larval development.

3.4 Surveying and Monitoring of Mosquito Populations

As part of the annual program start-up, and throughout the season, field biologists conduct regular, comprehensive surveys of program areas by air and ground. The goal of these surveys is to confirm the extent and locations of existing, known mosquito development sites and to identify any new, unknown, potential larval habitats.

Surveying and monitoring of larval development sites determines the presence of larval mosquitos and the need for control. Ground-based monitoring confirms observations made during aerial surveys and allows an accurate update of records from previous seasons. Where observed, larvae are collected and enumerated using a standard 350 ml white larval mosquito dipper. Preserved larval specimens are identified to species wherever possible.

Mosquito development varies from year to year and throughout the season depending on environmental conditions and habitat availability. Environmental cues interact to affect both the timing and magnitude of mosquito development, and adult mosquito survival. These factors include winter snow pack accumulations and rate of melt, river and lake levels, temperatures, humidity, and precipitation.

Monitoring and correlation of meteorological and hydrological data with larval sampling information collected over several seasons allows for the determination of 'thresholds' which aid in the prediction of larval development and distributions. Review of weather conditions, winter snowpack, river and lake levels combined with a sound knowledge of mosquito biology and local development site types is necessary to ensure surveying and monitoring activities occur to detect

mosquito development. Failure to timely survey and monitor could allow unchecked development of larvae which will result in adult mosquito annoyance. Larval habitats would be monitored throughout the season to assess the relative abundance and species of larval mosquitos found in these habitats. When investigating reports of adult mosquito annoyance or potential larval development sites, a thorough survey of each area would be performed to locate the source of annoyance, and any previously unidentified larval habitat.

3.4.1 Larval Mosquito Populations

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos and the need for control. Routine sampling of development habitats is completed on a 6-10 day basis, depending on conditions and observations, throughout the operational season, typically mid-April to late August.

Larval mosquito populations as small as one larvae per 350ml dip sample in an area as small as a backyard swimming pool (5m x 10m) can produce thousands of adult mosquitos over the course of a season. Located adjacent to established outdoor recreational facilities including golf courses, municipal parks, sports fields, picnic areas, campgrounds and nearby residential and commercial areas can be a major source of mosquito annoyance and a primary focus of the mosquito control program.

Pre-treatment surveys determine the extent of larval development which ensures that control measures are directed only to those areas containing larvae. In addition to providing pre-application information essential to timely control applications, surveying and monitoring following treatment, 'post-treatment monitoring' allows for an evaluation of the degree of control achieved from a particular larvicide application or site modification procedure. Environmental compatibility and cost effectiveness of a control program is dependent on the effective application of control or larval preventative measures directed only to those areas requiring, or appropriate for them. Post-treatment monitoring to confirm larval mortalities from larvicide (VectoBac 200G and Vectolex CG) application is typically completed within 2-96 hours of site treatment.

3.4.2 Adult Mosquito Populations

Adult mosquito populations and annoyance are routinely monitored during the season by field personnel as they go about their larval surveying and monitoring activities. Monitoring at select locations may also be completed where indicated by a reports of mosquito annoyance.

Monitoring of harbourage (forest, landscaped) areas adjacent larval development sites and near population centres is conducted on a routine basis throughout the season. This pro-active approach performs two important functions; firstly, it complements larvicide applications, since it is impossible under even the best conditions, to achieve 100% larval mortalities. And secondly, it allows for an objective measurement of the success and effectiveness of larviciding efforts in reducing adult mosquito populations.

Two internationally accepted sampling methods are employed to sample adult mosquito populations and annoyance. The first, a standard biting/landing count, measures the number of mosquitos which land, to bite, on the exposed forearm (from wrist to elbow) in a one minute period. Adult biting counts of three or more per minute, measured between the wrist and exposed forearm, is intolerable for most people. Beyond three bites per minute, outdoor enjoyment and worker performance and safety are affected, and negative economic impacts on recreation and tourism can be expected. Although it is the accepted world-wide standard, it must be noted that bite counts are not without bias. Clothing and body physiology make some people more or less attractive than others. Also, daily timing for collection is crucial as mosquitos are most active at dusk and dawn, when temperatures are lower and humidity generally higher. For these reasons, collection timing, locations and clothing worn by the observer are standardized as much as possible. When reviewed in conjunction with anecdotal reports from residents, this data is a useful measure of mosquito annoyance levels and facilitates the collection of mosquito species that actively seek a human blood meal.

The second method of adult mosquito population assessment employs standard New Jersey or Center for Disease Control (CDC, Atlanta) light traps. Both traps use electricity (extension cord, 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. These traps can be augmented (baited) with $C0_2$, in canisters, or as dry ice, to increase capture rates since it is another key attractant for female mosquitos. Typically operated for a 10-16-hour period (overnite, dusk-dawn), these traps are typically set up late in the afternoon or early evening. Light traps, and their samples, are retrieved the following morning, and any captured specimens are enumerated and identified. Light traps are typically placed near a development site, or at a property where adult mosquito annoyance has been reported by the resident.

Light traps effectively samples mosquitos from the local population, and from an area of with an approximate radius of 30-50m from a light trap location. They do not provide a comprehensive sample, population measurement or estimate for an entire neighbourhood, subdivision or community. Multiple traps may be set up over several consecutive nights to achieve this. Benefits associated with these traps include an objective, reproducible sampling method and the collection of undamaged specimens. Since mosquitos use different habitat types depending on species, the source of localized, or reported mosquito annoyance, may be

identified. Information gathered from light trap captures can be used to give an indication of the mosquito population size, species complex and the type of development habitat.

New Jersey or CDC Light traps would be deployed to monitor adult mosquito populations in areas with a history of adult mosquito annoyance problems, or in response to reports of localized adult mosquito nuisance. Benefits associated with these traps include the collection of a much greater number of specimens than with un-baited traps, or from biting counts, and they provide an objective, reproducible sampling method. These collections complement bite count sampling for annoyance by allowing field personnel to more effectively identify the mosquito species present in a particular area. Correlation of this data over several years with larval monitoring and adult mosquito biting count data allows for continued, increased forecasting of mosquito populations.

Larval and adult mosquitos would be identified according to the taxonomic keys of Darsie and Ward (1981) and Wood, Dang and Ellis (1979), and others as appropriate.

3.4.3 Mosquito Development in the Okanagan

The largest and most prolific sources of mosquito development within the program area are several hundred hectares of floodwater-influenced habitat located adjacent the Shuswap River (see Figure). The relatively flat topography of fields adjacent this river contains numerous old oxbows and depressions which collect snowmelt and rainwater early in the season and with rising river levels, floodwater and seepage waters accumulate. Indirect flooding through seepage can lead to inundation of areas that have no direct connections to either river.

Larval development occurs in sloughs, depressions and other low-lying areas in ranch and farm land areas adjacent these rivers. Persistence of these sites is influenced by a number of factors including duration and magnitude of the river freshets, frequency and amounts of precipitation, daily temperatures and humidity. These temporary development sites provide ideal conditions for mosquito development and often persist into July before becoming completely dry.

Winter snow pack accumulations and local weather conditions, including total precipitation and frequency, humidity and winds all impact on mosquito development and survival rates. Next to snowmelt and precipitation, temperatures have the single greatest impact on the onset and rate of larval development. Depending on local weather conditions, temporary and slow-draining, or permanent ponds provide ideal conditions for mosquito development. Producing

predominantly *Aedes* mosquitos from late April through late June, they are a recognizable source of adult mosquito nuisance for area residents. Subsequent larval development, which includes *Culiseta, Culex* and *Anopheles,* also have the potential, if left untreated, to cause localized annoyance which may extend through July and into August.

Smaller depressions and non-flowing drainage ditches, tire ruts and artificial containers such as livestock watering troughs, old tires landscape, and display and irrigation ponds provide the remainder of larval mosquito habitats for the area. Although these sites may often be small, their locations and distribution near outdoor work sites, recreational areas, businesses and residential properties makes them important sources of localized adult mosquito annoyance if not effectively monitored and controlled. Notable pest and vector species collected from manmade and natural, freshwater development sites locally include: *Aedes vexans, Aedes sticticus*, *Aedes implicatus*, *Culex pipiens*, *Culex tarsalis, Culiseta incidens* and *Culiseta inornata.*

The great majority (70-80%) of mosquitos developing within the defined boundaries of the RDNO mosquito surveillance and control program are *Aedes*. They are at their most numerous early in the season, April, May and June. *Culex* and *Culiseta* species are the predominant larvae occurring during late June, July and August.

3.5 Mosquito Control Options

Simple, but established key elements of a sound integrated pest management for this, and every effective, and environmentally compatible nuisance and vector mosquito surveillance and control program are:

1.) Assessment of need for control using scientifically sound evaluations,
2.) Development and application of site-specific controls, and;
3.) An assessment of results and adaptation of approach, as required.

Mosquito development varies from year to year and throughout the season depending on environmental conditions and habitat availability. Environmental cues interact to affect both the timing and magnitude of mosquito development, and adult mosquito survival. These factors include overall development site water levels, fluctuations, water and ambient temperatures, humidity, and precipitation.

Each mosquito development site will have its own unique requirements and treatment options. The PMP for this mosquito control program uses a combination of techniques, and an IPM approach, to achieve the management and suppression of mosquito populations. The best choice for control reduces both mosquito populations, and the potential for adverse effects on people, domestic animals, livestock and natural ecosystems. Sometimes, particularly with man-made habitats such as ditches, irrigation or display ponds and containers, larval mosquito populations can be reduced, or effectively limited using physical or natural (biological) controls.

These options are discussed here as they would be considered as a potential solution prior to any larvicide applications.

Many of the possible physical and biological control options suggested below may be supported and possibly implemented by local public works personnel and landowners. Private property owners with mosquito development habitat are best motivated to become involved in their control program through public education initiatives and through consultations with program personnel. Once educated about mosquitos and their requirements, property owners can undertake steps to reduce, or eliminate, larval mosquito habitat and adult mosquito annoyance on their property. A reduction in larval populations contributes to the overall decrease in adult mosquito annoyance.

The preservation or enhancement of balanced wetland and riparian habitats has the best opportunity for a meaningful, long-term contribution to overall mosquito control program success through reduction of mosquito populations and conservation of natural controls including insect, fish and birds. Elimination of stagnant water and increased flows in natural or created ecosystems will be of benefit to overall control program efficacy through decreasing habitat for mosquitos and increasing natural mosquito predators. The use of a biological control products such as *Bacillus thuringiensis* var. *israelensis* (VectoBac 200G) and *Bacillus sphaericus* (VectoLex CG) maximizes the effectiveness and environmental compatibility of the program.

Property owners should reduce thick vegetation and landscaped areas which provide adult mosquito harbourage adjacent to residences and buildings. Use mosquito netting for babies and toddlers in cribs and strollers. Installation and maintenance of window screens, mosquito magnets™ (adult mosquito traps) and the use of mosquito repellents provides additional protection from adult mosquito annoyance and potential disease transmission. Residents, workers and visitors should minimize outdoor activity at dusk and dawn, wear light coloured, loose fitting clothing and minimize the use of fragrant shampoos, perfumes and colognes to further reduce potential adult mosquito nuisance.

Mosquito control programs of the type described herein are routinely conducted throughout British Columbia. Such IPM-focused mosquito control programs do not have deleterious effects on humans, domestic pets and livestock, wildlife, fish and their food and are routinely conducted throughout British Columbia. There are three larval mosquito control options available to the program. These are physical, biological and bio-rational product oriented.

3.5.1 Physical Source Reduction and Site Modification

A continued focus for the control program field personnel and public education initiatives would be the identification, and reduction or elimination, of larval mosquito development habitats wherever possible. Residents and business operators are encouraged to remove, or alter, standing waters which provide suitable habitat for larval mosquito development. For most property owners this involves eliminating water-holding containers, such as buckets and boats or

canoes and the draining or regular changes of water in bird baths, livestock watering troughs, unused wading pools and display ponds. When done by the homeowners, this permits residents an opportunity to actively participate in their control program. This can be especially important for residents, as two of the most common West Nile virus vector mosquitos, *Culex tarsalis* and *Culex pipiens,* make ready use of manmade habitats, including containers.

Ditching of roadside depressions may be a suitable solution to larval development by permitting the drainage of temporarily flooded areas. Grading or filling of depressions and tire ruts may reduce an area's potential to retain water. Clearing ditches of obstructions or vegetation, replacing failed culverts or grading them to increase flow, drainage or access by fish or aquatic insect predators can further limit mosquito development. When completed as part of routine maintenance activities by public works crews they can be effective means of reducing local mosquito populations. Any such activities along public roadways, in parks or other publicly-owned properties would be coordinated through the appropriate public works and engineering departments. The BC Ministry of Environment, the Department of Fisheries and Oceans and other government regulatory agencies, as appropriate, may need to be consulted prior to any such planned works.

Removal or alteration of mosquito producing habitat does not necessarily mean drainage resulting in habitat destruction for other organisms and natural predators such as birds and fish. As part of a comprehensive approach to mosquito control, property owners are encouraged to manage stagnant and non-flowing waters to minimize their use as sources for mosquito development. For example, the removal of emergent shoreline vegetation, combined with either water level management at greater than one metre in depth, or a shoreline groomed to a gradient of 3:1 or steeper, effectively eliminates mosquito production in irrigation and settling ponds or other water impoundments. The installation of fountains in man-made golf course and display or irrigation ponds can reduce their suitability and use as larval mosquito development habitat.

Mosquitos require water to develop, and any efforts to reduce or eliminate standing or stagnant waters, particularly in depressions, tire ruts and containers will prevent larval development and subsequent adult mosquito nuisance. Source reduction around homes and businesses can be easily achieved by residents and owners, allowing them to actively participate in their mosquito control program.

3.5.2 Biological Control

Biological control involves the use of predators, pathogens, and parasites to reduce mosquito populations. Insects predators, both aquatic (ie. dragon flies, beetles, backswimmers, amphibians, fish) and terrestrial (ie. dragon flies, spiders, wasps, birds, bats), contribute to the natural mortalities of both larval and adult mosquitos. Conserving, or enhancing natural habitats wherever possible, allows these predators to contribute to control program effectiveness.

Control options involving the relocation of mosquito predators such as insects or fish is not a practical or feasible solution for most natural development habitats. Of all the various predator control methods tested, only larvivorous fish are used operationally in programs located, largely, throughout the southern United States. Regan *et al.* (1980) evaluated the effects of three-spined stickleback fish (*Gasterosteus aculeatus*) on mosquito larvae located in the Fraser Valley. They were found to be effective in reducing larval populations. Their natural fecundity combined with their ubiquitous nature makes these fish an ideal natural (biological) control agent. They are a common occurrence in many of ditch systems.

Introduction of fish (Koi, gold fish) to manmade, self-contained outdoor display or irrigation ponds may also reduce, or eliminate larval mosquito development in such habitats. In areas with very cold winters, this type of control requires considerable work and cost which many include the over-wintering of fish indoors or annual replacement. The relocation, or introduction of fish to any natural water course requires approval and permitting through various governmental agencies including Department of Fisheries and Oceans and the BC Ministry of Environment.

Although flying insects can form a large component of the diet for insectivores (*eg.* bats, swallows), there is no evidence which suggests they provide a detectable level of mosquito control. Both birds and bats are also opportunistic feeders and adult mosquitos have been identified as a small component (<2%) of their diet, (Fang 2010 and 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.

A one-hectare site, the size of 2 football fields, having a larval population density of just 1 larvae/dip sample, can produce 4,285,714 mosquitos. Reported to eat up to 300 mosquitos a day, a total of some +13,300 birds and/or bats would be required to consume the mosquitos emerging from just one hectare of

habitat. Larval populations in much of the program area average between 10-30 larvae/dip sample and in floodwater sites can often exceed 100 larvae/dip sample. With between 600 – 1,000 hectares of treated habitat, and much of it located within 100-200m of residents and businesses, the sheer potential for adult mosquito populations, likely in the billions, would make a reliance on solely natural controls unlikely to have a noticeable impact on annoyance levels for area residents.

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Interested residents would still be encouraged to install bird nesting boxes or bat houses though since it allows individuals to contribute to a comprehensive, integrated mosquito control program, and in some cases may provide residents with a sense of reduced adult mosquito annoyance. Additional predators for adult mosquitos include insects such as wasps, deer flies, dragonflies, damsel flies, etc. and spiders.

Pathological agents such as viruses and certain parasites have received much research attention, but none of these are commercially available or approved for use in Canada. The naturally occurring soil bacteria, *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *Bacillus sphaericus* (*Bsph*) have highly specific insecticidal properties. They are commercially available, have been successfully, and safely employed worldwide since the early 1980s. They are discussed below.

3.5.3 Bio-rational Control

The mosquito surveillance and control program would use VectoBac 200G and VectoLex CG larvicide products for larval mosquito control. VectoBac and VectoLex are the closest form of a natural or biological control agent currently available for routine use in operational mosquito control programs.

VectoBac 200G (PCP # 18158) contains spores and crystals produced by the bacterium (*Bacillus thuringiensis* var. *israelensis*, *Bti, Serotype H-14, Strain AM65-52*) and, as such it is classed as a bio-rational, rather than conventional, pesticide. A naturally-occurring soil bacteria, it has no residual activity, is species-specific, does not bio-accumulate and has no impact on other organisms found in aquatic habitats. It is recommended for use in standing water habitats such as temporary and permanent pools in pastures and forested areas, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons.

VectoBac's mode of action is on the larval mosquito stomach, and it must be eaten to be effective. It is very specific, producing rapid lethal effects (within hours) in larval mosquitos. Negative or toxic effects on mammals, birds or other wildlife have not been observed. Formulated as a corn cob granule it requires no mixing and is ready to apply by hand, backpack blower or by helicopter.

The granule allows the larvicide to penetrate vegetative covers and reach the water surface where the *Bti* is "released" for consumption by mosquito larvae.

Similar to VectoBac 200G, VectoLex CG (PCP # 28008) also contains a naturally occurring, spore-forming soil bacterium. VectoLex contains spores and crystals produced by *Bacillus sphaericus.* It also is classed as a bio-rational, rather than conventional, pesticide. Like VectoBac, VectoLex larvicides 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 *Aedes vexans* and most *Culex* mosquito species. 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. Vectobac often requires re-application to control additional larval development occurring several days after treatment. VectoLex achieves this extended control because the *B. sphaericus* toxin 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 the dead mosquito larvae. This is known as recycling and is the mechanism which allows VectoLex to provide long-term, extended control (upwards of 28 days) 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.

Both *Bti* and *Bsph* products are species (target) selective and non-toxic to other aquatic organisms which co-exist in these habitats, including insects, fish and amphibians. Their use maximizes the environmental compatibility of the annual mosquito control program. When used in circumstances where other control options such as physical or natural (biological) control are not practical, they support the principles of an IPM approach to control. Extensive product information can be found at the manufacturer's website www.valentbiosciences.com or through the Health Canada, Pest Management Regulatory Agency (PRMA) website www.pmra-arlc.gc/ca. and the Pesticide Label Search www.hc-sc.gc.ca.

3.5.4 Chemical Control

Chemical control products and equipment are predominantly used for the purposes of reducing adult mosquito populations. As with most adult insect control programs, adult mosquitos are typically controlled using a broad-spectrum (adulticide) insecticide. Although there are 'natural' adult mosquito control products make from chrysanthemum flower extracts (pyrethrins) and their synthetic equivalents, all adulticides only provide temporary control and are typically broad spectrum, having a deleterious effect on any insect which may come in contact with them.

Typically applied from the ground using cold aerosol sprayers or misters, and much less commonly, from the air using helicopters of fixed-wing aircraft, their mode of action is on the nervous system following contact with the organism and absorption across through the exoskeleton. Because they are applied to the air, and the fact they are non-specific, such applications will not only control adult mosquitos which come in contact with the spray mist, but other non-target organisms such as moths, flies, flying beetles and other insects. Restrictions on applications include habitat type, timing of applications, mosquito population thresholds, weather conditions and areas of identified avoidance.

Because of the variable dispersion patterns of mosquitos, geography, types of vegetation encountered and ambient weather conditions at the time of treatment, it is difficult to provide anymore than temporary control of localized adult mosquito annoyance. Unless regular and routine treatment of 'problem areas' is completed, uncontrolled adult mosquitos developing in other areas will often move into these treated areas to again cause annoyance.

Routine adulticide applications **ARE NOT** a component of the proposed mosquito control program for the RDNO. The annual mosquito control program described within this PMP does not utilize any chemical control methods for the abatement (control) of larval or adult mosquitos.

- **Devices, pesticides and repellants**

Adult mosquito collection devices such as Mosquito Magnets™, which uses propane to emit CO_2 an attractant, and sometimes pheromones, 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 localized annoyance on a community level is unlikely.

Citronella candles, mosquito coils, Konk™ Automatic Aerosal 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. Property owners may also use items such as these, as required, and as instructed on the product labels.

3.6 Mosquito Control Program Operations

The well-organized, pro-active, integrated pest management approach to mosquito surveillance and control reduces the potential for adult mosquito annoyance. The annual program focuses

efforts on the identification and timely control of larval populations occurring in, and adjacent to, residential, recreational, agricultural and commercial areas of the program.

3.6.1 Larval Mosquito Control, Treatment Thresholds and Application Rates

VectoBac and VectoLex are only applied when larval mosquitos are present. Larval mosquito populations would be controlled by air and ground using VectoBac 200G and where appropriate, with VectoLex CG. VectoLex CG could also be used to control developing larval mosquito populations occurring in roadside catch basins. Section 3.5.3 discusses VectoBac 200G and VectoLex CG further. To review or print product labels and Material Safety Data Sheets please see www.valentbiosciences.com

Larval mosquito surveillance and control protocols would focus efforts on the timely identification and treatment of larval mosquito populations with surveillance and control efforts targeting 1st through 3rd instar larvae. In addition to treating the most actively growing and feeding instars, this approach also allows for retreatment (touch-up) of sites, or portions of sites, that may have not have been treated as completely, as desired, because of conditions on the day, changing water levels or because of subsequent hatching. Also, application rates can be lower, and therefore material costs, and overall mosquito larvicide use rates in the environment are reduced. Even though the products, Vectobac 200G (*Bti*) and VectoLex (*Bsph*), proposed for use in the program have the safest environmental profiles of any bio-rational larvicides in common use, decreasing any volume of control product is beneficial and maximizes environmental compatibility.

Treatments targeting all mosquito populations with later 3rd or 4th instars under the guise of allowing natural predators to impact some level of control is not encouraged. While there may be predation of some mosquito species occurring in permanent ponds, such as *Culex* or *Culiseta*, the two most common genera in these types of sites, this strategy is wholly impractical for *Aedes* mosquitos. *Aedes* hatch in large numbers, typically +100/dip, and inhabit temporary pools created by snowmelt, precipitation or river flood and seepage waters which may only last several days or weeks. These types of temporary habitats seldom have established natural predators and where they may occur they are typically inadequate to deal with larval populations of such extreme magnitude.

Delaying treatments to target populations with later 3rd or 4th instars is also not ideal as the potential for reduced feeding rates of later instar larvae may provide incomplete control, and may result in a number of undesirable outcomes;

1) that larvae develop into the untreatable pupal stage, and then onto nuisance causing adults;

2) that field staff may not be able to return at an appropriate time to treat them before pupation occurs. Changing weather conditions and temperatures over a few days can dramatically accelerate larval development rates; and lastly

3) product manufacturers recommend that later instar larvae are treated with higher application rates, upwards of 10kg/ha (1 gm/M), thereby requiring more larvicide, increased helicopter or personnel field treatment time, reduced environmental compatibility, and increased cost ($) per hectare treated.

Typically 5 - 10 dip samples per development site, depending on site size, would be the completed. Larger sites will have a greater number of dip samples. Larval mosquito dip samples averaging from 1-3 larvae/350ml sample in sites containing predominantly 2nd and 3rd instar larvae would be the minimum treatment threshold for mosquito larvae found in permanent sites which typically contain a high proportion of *Culex* and *Culiseta* mosquito larvae. A treatment threshold of five, 1st instar larvae/350ml dip sample is utilized when monitoring synchronous, extensive *Aedes sp*. larval development common to early-season snowmelt, seepage water and similar temporary habitats. The threshold for 2nd and 3rd instar *Aedes* larvae would be 1 or more larvae/dip sample. These thresholds are representative of programs and members of the Northwest Mosquito and Vector Control Association (NWMVCA) and American Mosquito Control Association (AMCA).

Larval dip sampling, light trap collections and landing/biting counts completed by field personnel, where appropriate, would be employed to evaluate post-application larval control results. Larval mortalities of at least 95% would be considered successful. If required, and where indicated by post application sampling, additional, or expanded treatments of nearby areas would be completed to achieve desired efficacy.

- ***Larvicide Applications***

VectoBac 200G and VectoLex CG are the larvicides of choice for aerial and ground-based larvicide applications. These products maximize the environmental compatibility of the Town's mosquito control program since they are currently the most effective, selective, and least persistent larval control agents available. VectoBac 200G and VectoLex CG are only applied when larval mosquitos are present.

All Vectobac 200G and Vectolex CG application rates would be within those recommended by the manufacturer. These rates range from 2.5 to 10.0 kilograms per hectare with applications completed under this PMP to be conducted at rates ranging from 4.0 to 8.5 kilograms per hectare. Typically, VectoBac and VectoLex application rates average 7.0-8.0 kg/ha for ground applications and 4.25-5.0 kg/ha for aerial (helicopter) applications. These application rates have been demonstrated as effective under the conditions encountered in the Okanagan. Factors influencing application rates include application method (aerial or ground) the density and type of vegetation cover at treatment areas (grasses, deciduous forest), organic matter, water depths etc. All applications are followed with post-application monitoring to confirm the effectiveness of treatments.

Rapid, synchronous larval development over an expansive area, largely inaccessible from the ground, makes aerial larvicide applications essential to control program success.

Aerial larvicide applications are most commonly completed by rotary winged aircraft (helicopters) fitted with under-slung granular application equipment. There are two primary makers of this equipment, Simplex ™ and Chadwick™. Both manufacturers make use of a fiberglass 'hopper' to hold the granules and an externally mounted Honda™ or Briggs and Stratton™ 5 HP motor which operates the 'disc gate' or 'piston/ram' and the rotary, granule dispersal impeller. Both buckets are suspended below the aircraft, and from its secure cargo hook. The certified pilot or applicator, through a direct wire connection, controls the on and off operation of the bucket and the opening and closing of the application gate or ram. All aerial larvicide application equipment is supplied and maintained by the aerial contractor and is calibrated as directed by the equipment and product manufacturers.

The application rate is calculated by using the equipment's measured swathe width (impeller dispersal), the speed of the aircraft during application and the volume of granular material/per minute dispensed through the adjustable ram or gate opening. The distance of the ram or the disc opening can be adjusted to achieve the desired flow rate. The swath width is constant and is a function of the granule size. This equipment is specifically designed for the application of 'dry' products including grass seed, fertilizers and granular pesticides used for agriculture, forestry and public health.

Prior to aerial larvicide applications, pilots are accompanied on reconnaissance flights by control program personnel to review treatment and any avoidance areas. Treatment site locations are confirmed by GPS (Geographical Positioning System) coordinates provided by on-board navigation equipment. These maps are unique, and constructed with multiple layers, including individual development site polygons, site identification, areas of avoidance and other features of note. Maps are uploaded into a computer tablet which is mounted in the helicopter prior to each treatment campaign. Using a moving map display technology these maps, and the active tracking of flight paths which results, guides the application pilots to individual sites, displays their boundaries, and allows the pilot to visually monitor and record their treatments (swaths), as they complete them, and in real-time. This "live report" and the resultant digital record generated allows the pilot to visually confirm effective coverage of specified, targeted treatment areas. In addition to the tracking (plotting) of the entire flight path, additional data recorded includes elevation, distance, speed, time etc. Continuous radio contact is maintained between pilots and management personnel during all aerial larvicide applications.

All ground-based larvicide applications to small and accessible sites are completed, where required, by hand broadcast or motorized back-pack type (leaf blower) applicator. Fluctuating water levels in many of these sites cause recurrent larval development requiring repeated treatment. Certified applicators achieve the label recommended application rates (kg/ha) by applying the larvicide granules and at the appropriate concentrations of granules/ft^2. For

VectoBac 200G and VectoLex CG with application rates of 4.25 kg/ha, it is ~3 granules/ft^2, and for 7.5 kg/ha, it is ~5 granules /ft^2.

Before treating an area, applicators review available site maps, estimate the site size (m^2) and then perform a calculation to determine the volume of VectoBac 200G to be applied. With an application rate of 7.5 kg/ha, and a site size of 1000m^2, the applicator would measure out 750gms of VectoBac. Applicators then do their best to distribute the granules equally across the water surface while they move around the perimeter of larger and deeper sites, or as they walk through shallower (<30cm deep) sites and as they broadcast the granules by hand or with a back-pack applicator. The desired application rate is achieved by modifying the walking or throttle speed, when using a back pack applicator, or by adjusting the frequency and number of "hand broadcasts" for granules being thrown across the surface by applicators.

A well organized, pro-active, integrated pest management approach which concentrates on larval mosquito control ensures a safe, effective, sustainable and environmentally compatible program.

3.6.2 Post Application Monitoring

Mosquito larvicides (VectoBac and VectoLex) are only applied when larval mosquitos are present. Different species of mosquito larvae have different, preferred habitat types. *Aedes* mosquito prefer temporary, snowmelt, seepage water and river level influenced habitats. *Culex* and *Culiseta* mosquitos will use more diverse habitats including temporary sites and permanent habitats such as natural and man-made ponds, marshes, swamps and water-filled ditches etc. Some species of *Culex* and *Culiseta* will also use containers and catch basins. Typically upwards of 5 - 10 dip samples per development site, depending on site size, are completed. Larger sites will have a greater number of dip samples.

Within 2-96 hours after (post) treatment with VectoBac 200G, larval mortalities would be confirmed through monitoring using a standard 350 ml mosquito dipper. The goal is for larval population reductions of 95%, or to levels averaging less than 1 larvae/500ml dip sample. Post-application monitoring confirms treatment success and allows for the 'touch-up' treatment of any areas which may have, for reasons of geography, vegetative cover, or access, received inadequate application. Because larval mortality from VectoLex can take several days to occur, and can continue to occur for several weeks, treated larval habitats would be monitored on a regular basis with re-treatment completed as required.

Adult mosquito populations would be monitored in harbourage (forested, landscaped) areas adjacent to treated larval development habitats to confirm the effectiveness of larval controls in reducing adult mosquito annoyance. In addition, adult mosquito populations would be monitored at select locations within control program boundaries to collect adult mosquito specimens for identification and to determine localized populations. Given the difference in individual tolerances to mosquito annoyance, the success of larval control in limiting adult mosquito populations would

be determined through resident reports, interviews and requests for service. The program's goal is minimize the scope and duration of any adult mosquito annoyance for residents and visitors.

The general public is aware that short-lived adult mosquito annoyance may occur at some locations during a typical season. The goal of the control program, through pro-active larviciding with VectoBac 200G and VectoLex CG, is to suppress local populations and prevent adult mosquito annoyance through timely larval control. Adult mosquito control applications **are not** intended as part of the annual mosquito control program.

4.0 QUALIFICATIONS OF PROGRAM PERSONNEL

The consultant supplying mosquito control services to the Regional District of North Okanagan will have all necessary Pesticide Vendor and Pest Control Service Licences. All personnel working in the annual mosquito control program will be certified pesticide applicators in the category of '*Mosquito and Biting Fly Abatement*' or equivalent, as accepted by the BC Ministry of Environment.

Control program management personnel will be Registered Professional Biologists. Field personnel should include University and College graduates or Co-Operative Education students studying within the disciplines of biology and environmental science or equivalent practical experience with mosquito population management practices and training.

5.0 LARVICIDE HANDLING AND APPLICATION

As required by the BC Integrated Pest Management Act, all personnel handling and applying pesticides for the annual mosquito control program would be certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement,* or equivalent. Pesticide applicators will comply with regulations contained within the Pest Control Products Act, the *Integrated Pest Management Act*, the Transportation of Dangerous Goods Act and other relevant government regulations.

Larvicide handling, storage and application procedures would conform with those detailed on product labels and endorsed in the '*Pesticide Applicators and Dispensers Handbook*', '*Canadian Pesticide Education Program Applicator Core Manual*' and associated reference materials supplied through the BC Ministry of Environment. This PMP does not attempt to duplicate all the information contained within this handbook and other references. The 'Acts', handbook, product labels and any other resource materials detailed above, and in other sections of this PMP would be reviewed before handling, transporting, storing or applying larvicides.

The following sections provide details on procedures and protocols which will protect the public and the environment during larvicide transportation, storage, handling and applications. Only bacterial larvicide products are proposed for use in this mosquito surveillance and control program. No Pesticide Free Zones (PFZs) are required for bacterial pesticides as indicated in Section 71(12) of *The Integrated Pest Management Act and Regulations.*

5.1 Larvicide Transportation

During transportation, all larvicides would be secured to prevent an accidental spillage. VectoBac and VectoLex granular larvicide products would be secured and handled to prevent tearing of bags, spillage and exposure to adverse weather conditions such as precipitation.

Applicators would only transport the minimum amounts of pesticide required to complete the proposed treatments. It is common for field personnel to require less than forty kilograms of Vectobac 200G or VectoLex CG for a typical workday.

Larvicides would not be transported in the passenger compartment of a vehicle and would remain separate from food, clothing or similar items during transport. Any pesticide applicator who has had product stolen or removed from his/her vehicle would follow the notification procedures for the appropriate authorities immediately, including police.

Mosquito Control program personnel will carry within their vehicles a suitable pesticide spill kit, eyewash water, first aid and appropriate safety gear and supplies. Emergency telephone numbers for police, fire, ambulance, Canutec, Dangerous Goods Emergency Spills, Poison Control, local hospitals, and the Ministry of Environment would be available within the work vehicle.

5.2 Larvicide Storage

The Regional District of North Okanagan, and its participating communities, will provide secure, dry, well ventilated pesticide storage space for mosquito control larvicides (VectoBac 200G, *Bti* and VectoLex, *Bsph*) within their locked, alarmed public works yards and or facilities. The majority, over 95% of larvicide required for each season is delivered in late April and consumed between May and July. No large volumes of larvicide are stored on-site over the winter. In an average year, less than 100 kg of Vectobac and VectoLex larvicide is stored on-site to be available for program start-up in late April.

Emergency telephone numbers for police, fire, ambulance, Canutec, Dangerous Goods Emergency Spills, Poison Control, the BC Ministry of Environment and appropriate/requisite pesticide storage room warning signage would be posted on-site.

5.3 Larvicide Mixing and Loading

Applicators will follow the directions and precautions warranted by pesticide use as described above and in relevant references. All avoidance areas, pesticide free zones and pesticide buffer zones would be established and appropriately identified prior to larvicide pesticide application.

VectoBac and VectoLex granular larvicides are 'ready to apply'. No pesticide mixing is required. All used and empty bags would be disposed of in municipal or regional landfills as directed by the manufacturer on the Pesticide Management Regulatory Agency-approved pesticide label and MSDS sheets.

All handling of pesticides would be conducted in level, well ventilated, outside areas under conditions or minimal winds and no precipitation. VectoBac and VectoLex bags are emptied directly into the 'hopper' when it is on the ground and between aerial applications. In the event of accidental spillage personnel would follow accepted spill containment, clean-up and reporting procedures. With granules this typically involves recovery with brooms and dustpans or shovels. This 'recovered' larvicide would be used for the treatment of intended habitats.

All aerial larvicide applications would be completed by a minimum, two person team. Larvicide applications to smaller sites would be completed by hand broadcast or backpack applicator. Field personnel would wear suitable safety gear, including the appropriate respirator, ear protection, rubber gloves, boots, non-absorbent coveralls and other protective equipment as indicated by pesticide labels, MSDS sheets and the manufacturer.

All work staging (bucket loading) areas are located as close to proposed treatment sites as possible. These areas may include secure, fenced and gated private and business properties, local, public and private airfields and publicly-inaccessible areas, with permission.

Applicators will follow the directions and precautions warranted by pesticide use as described above and in other relevant references. All avoidance areas, pesticide free zones and pesticide buffer zones would be established and appropriately identified prior to pesticide application.

5.4 Larvicide Applications

The Regional District of North Okanagan mosquito surveillance and control program provides residents, workers and visitors with relief from extreme mosquito annoyance. The control program is not intended to eliminate the mosquito population, nor could it, and as such landowners and residents who want to be excluded from the control are recorded and their wishes respected. Since the majority of larval mosquito habitats are located on private property, landowner permission to survey, monitor and treat is confirmed each season.

Property owners would be consulted prior to any larvicide applications and any physical or biological/natural methods for control on their properties would be reviewed. Product brochures,

labels, MSDS sheets and website addresses would be discussed, and available, to ensure residents, business, and facility operators are comfortable with, and support, proposed treatments. Treatment of developing larval mosquito populations in waterbodies on public lands are permitted under this approved PMP.

Weather forecasts would be consulted, and current weather conditions (wind speed, temperature, precipitation) would be noted, and recorded, during all larvicide (ground or aerial) applications. In the event that wind speeds during larvicide applications are sufficient to cause the displacement, or drift, of granular larvicides outside of the treatment area, applications would be suspended until suitable conditions return. Similarly, should precipitation be sufficient to cause larvicide (corn cob) granules to clump and clog equipment, aerial applications will be suspended until suitable applications conditions return. Ground-based applications are seldom impacted by weather conditions, except for circumstances of heavy or extreme precipitation, when applications could be suspended until suitable conditions reoccur. Extreme thunder and or lightning conditions would result in the suspension of aerial, and possibly ground-based applications until suitable conditions return.

Due to the low toxicity of bacterial larvicides, applications may be conducted within riparian areas and sensitive wildlife habitat. Applications of VectoBac and VectoLex to within 10 metres of fish-bearing waters and potable (drinking) water sources is anticipated and as permitted on the Health Canada, Pesticide Regulatory Management Agency (PRMA) approved product labels. Pesticide free zones are not required and applications of VectoBac 200G and VectoLex CG may be completed in ephemeral waterbodies that are intermittently contiguous with fish-bearing waters (*ie.* impounded, receding flood or seepage waters).

Program personnel will take all practical precautions to protect application personnel, the environment and the general public during all applications. Prior to any larvicide application field personnel:

- confirm property ownership, treatment site boundaries, public points of access (paths, trails, roadways), pest presence and population size, both pre and post-treatment.

- confirm AVOIDANCE areas, including private properties wishing exclusion from program operations, permanent, flowing fish-bearing waters or areas of identified, protected environmental sensitivity (ie. bird nesting sites, amphibian refuge areas) and the need for, and size of any Pesticide Free Zones (PFZs) and Pesticide Buffer Zones (PBZs), if required. Where appropriate, identify the locations or boundaries of these areas with accurate digital mapping, flagging tape, ribbons, or suitable equivalent.

- ensure that larvicides will not be applied to finished drinking water. Potable (drinking) water well locations and open water intakes will be identified with the property resident/owner prior to any larvicide treatments.

• community watersheds can be determined by accessing the BC Ministry of Environment Community Watershed listings and informational website:

www.gov.bc.ca/wsd/data_searches/comm_watersheds/index.html.

• A listing of registered groundwater Wells and Aquifers and an interactive map is available at:

www2.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers

• review product labels and comply with recommended precautions regarding handling and application, safety gear, weather restrictions (wind, temperatures, precipitation etc) and other listed precautions.

• inform the general public of routine program operations and applications through public notices, news media articles, advertisements and ongoing personal contact.

Program personnel maintain regular and frequent contact with all private property owners having larval and adult mosquito habitat on their property. Regional District of North Okanagan administrators would be kept appraised of program operations throughout the season. Ongoing news media coverage of routine program operations would provide the public with useful, current information on mosquito control activities. The general public can access the control program for more information or service through the RDNO administrative or public works offices, their website or social media accounts. All resident requests are followed-up with telephone contact and on-site inspection by program personnel where appropriate.

6.0 MOSQUITO CONTROL PROGRAM SYNOPSIS

Prior to the introduction of a pro-active, integrated approach to mosquito control in the prescribed areas of the RDNO, adult mosquito annoyance restricted many outdoor activities and had a negative impact on the economy and lifestyle of residents. The RDNO mosquito surveillance and control program is not intended, nor would it be possible, to eliminate the local mosquito population. An appropriate scope of operations, and the prevention, or timely treatment of larval mosquitos at their source, will reduce (suppress) local adult mosquito populations.

Public education during the term of this PMP will involve regular news media exposure, public information meetings, pamphlets, doorknob hangers, posters and field personnel interaction with residents, visitors and business operators. These initiatives increase the public's awareness of program operations and goals and encourages the general public to report adult mosquito annoyance, potential larval development sites and to have input into their control program.

Regular monitoring and treatment of larval mosquitos is a key element to mosquito control program success. These development habitats must be identified and regularly surveyed during a control season to ensure timely detection of larval mosquito development. Surveying, monitoring and control of larval mosquito infestations would begin in April and continue through August, and possibly September, depending on conditions. Program methodologies would continue to concentrate on larval control initiatives with a goal to reduce the extent of standing water development habitats. Developing larval mosquito populations would be controlled through the application of the bio-rational larvicides.

Adult mosquito population monitoring would be conducted as part of routine control program operations. It allows for the evaluation of larvicide efficacy and provides control personnel with information useful in the location of any previously undetected larval development habitat.

Evaluation of the program in terms of effectiveness and ability to satisfy the needs of the general public is conducted as an on-going process. The cooperation and support of local businesses, ranchers, and property owners is indicative of true community spirit and support for a successful program which benefits workers, residents and visitors to the Regional District of North Okanagan.

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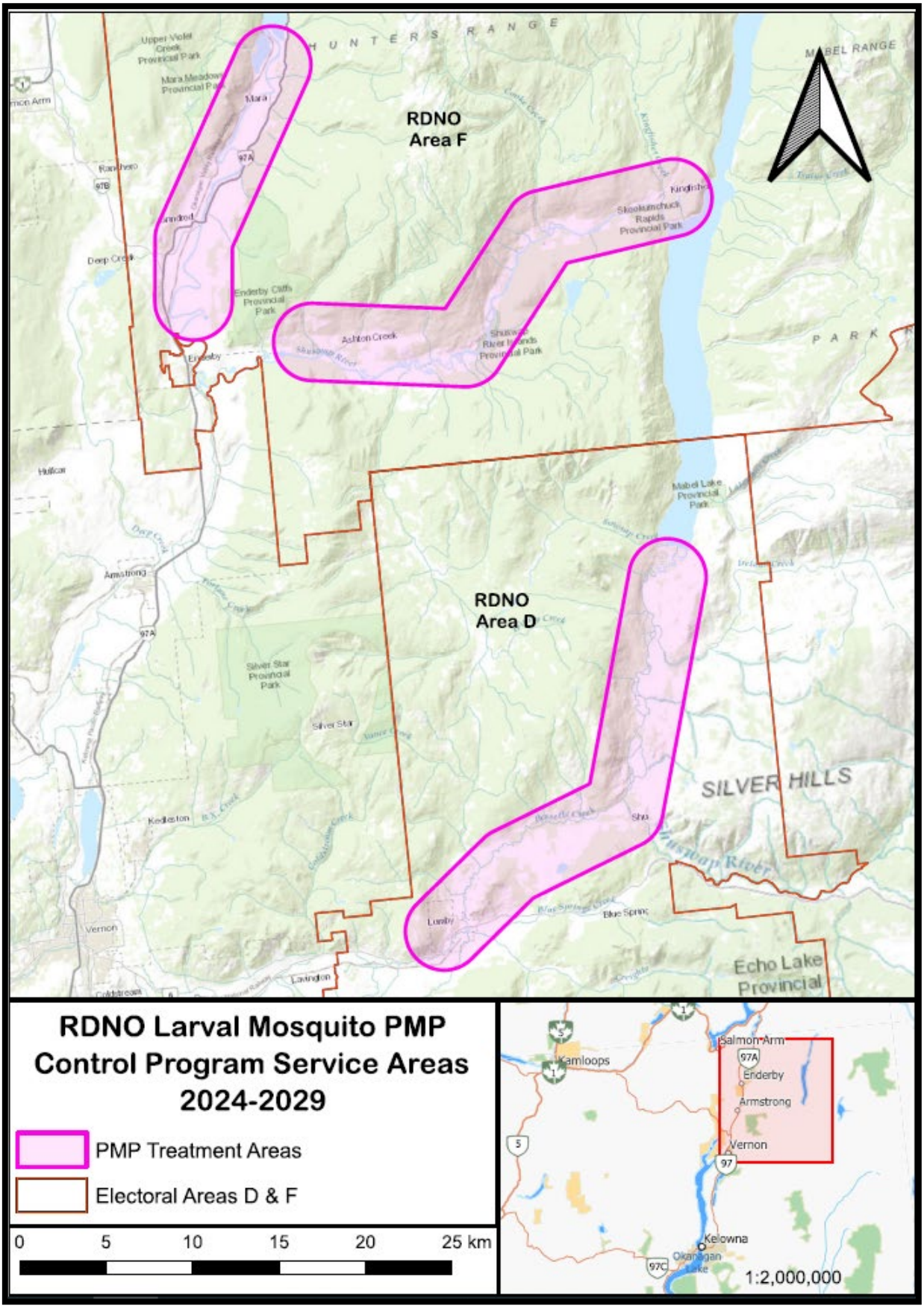
FIGURE

Larval Mosquito Control Program Service Delivery Areas,
Regional District of North Okanagan
Electoral Areas D + F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