City of Prince George

Civic Operations
Parks and Solid Waste

INTEGRATED PEST MANAGEMENT PLAN
PMP # 567-0012-26-31

MOSQUITO POPULATION MANAGEMENT AND CONTROL PROGRAM
2026 - 2031

City of Prince George

1100 Patricia Boulevard

Prince George, BC V2L 3V9

21 October 2025

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Figure 1: City of Prince George Mosquito Control Program Area Overview Map ..... Appendix A

1.0 PEST MANAGEMENT PLAN SUMMARY

The City of Prince George and surrounding area has significant recreational and environmental value, providing residents and visitors with many outdoor summer activities and employment. Walking, running, mountain biking, camping, bird watching, golfing and gardening are just a few of these. Adult mosquito annoyance can often conflict with these activities and potentially impact public health. Besides the negative impacts on the lifestyle and well-being of residents, there can also be considerable economic impact from mosquito annoyance on local businesses. 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 City. An integrated pest management (IPM) approach to mosquito population management and control can reduce overall annoyance levels and co-exist with these valuable resources.

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 would reduce larval habitat and enhance or conserve natural mosquito predators. Where required, larval mosquito populations would be controlled using the biorational larvicide products VectoBac® 200G (*Bacillus thuringiensis var. israelensis*, serotype H-14, strain AM 65-52, PCP #18158) and VectoLex (*Lysinibacillus sphaericus*, 2362, serotype H5a5b, strain ABTS 1743, PCP # 28008 & # 28009). A similar *Bti* product, AquaBac® 200G (*Bacillus thuringiensis var. israelensis*, Serotype H-14, Strain BMP-144, PCP #26863) may be used. All treatments would be completed in accordance with the methodologies and procedures prescribed in the BC Ministry of Environment-accepted Pest Management Plan (PMP) for Mosquito Control (this document), prepared for the City of Prince George by *Duka Environmental Services Ltd*.

Mosquito control services are 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 municipal boundaries of Prince George .

The PMP is 'owned' by the City of Prince George . It would remain in place for the purposes of larval mosquito population management and control for the five year period, 01 May 2026 to 30 April 2031. The mosquito control program and methodologies developed within this PMP are a hybrid of approaches adapted from 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. This PMP meets all the requirements of the Integrated Pest Management Act and will replace the previously approved, and soon to expire (April 2026), PMP # 567-0011-21-26. The mosquito control program proposed for the years 2026-2031 is largely unchanged from that of past seasons and focuses on larval control and reduction of populations.

This PMP reviews mosquito biology, the types of larval mosquito habitats affecting the program area and the local mosquito species complex. An IPM approach to mosquito population management and control can reduce overall adult mosquito annoyance levels through education, prevention and biological controls. This PMP outlines the procedures and methodologies of an IPM approach which

will reduce local mosquito populations for the purpose of preventing mosquito annoyance for area residents, workers and visitors.

The City of Prince George Mosquito Population Management and Control Program Pest Management Plan, PMP # 567-0012-26-31 (this document) is presented in a format which adheres to the requirements of British Columbia's Integrated Pest Management Act and Regulation, including amendments, the Mosquito Management Sector Review Paper and BC Ministry of Environment, Indigenous Engagement: A Guide for Integrated Pest Management Act Proponents (2023). Copies of these documents may be accessed through the BC Ministry of Environment home page at https://www2.gov.bc.ca/gov/content/environment/pesticides-pest-management. Common themes of larval development prevention, and control necessary to achieve program goals, while ensuring environmental conservation, are repeated throughout this document.

A professional, experienced, environmental services firm (the consultant) is retained by the City of Prince George to deliver these specialized services and to ensure adherence to the Pest Management Plan. The consultants for the City of Prince George annual nuisance mosquito 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, is available to the general public in a variety of forms including informational brochures, websites, newspaper articles, open-houses, council meetings and farmer's markets etc. Resident requests for service are followed up with telephone contact and site inspection. Physical reduction, elimination or alteration of larval mosquito development habitats is an important aspect of the control program. Wherever possible, and practical, property owners are advised of measures they can complete to reduce mosquito development and adult mosquito annoyance.

1.1 Geographic Boundaries of this Pest Management Plan

The City of Prince George is the largest city in northern British Columbia, with a population of approximately 76,708 (2021). Located at the intersection of Highways 16 and 97, it is some 782km north of Vancouver, BC. Prince George proper contains several areas; South Fort George, the Hart, the residential and light industrial neighbourhoods north of the Nechako River; College Heights, Cranbrook Hill the southern portion of the city which contains a mix of residential and commercial areas, and the Bowl, the valley which includes most the City and downtown.

The total area of the City of Prince George is ~318.26 km2 or 31,826 hectares. The area is surrounded by forested mountains and is located at the confluence of the Fraser and Nechako

Rivers. Summer recreation includes golf courses, an extensive trail system, passive parks and sports fields. Residential, commercial, light industrial properties, several pulp and paper and sawmills, and two universities are located within its boundaries.

This PMP includes all areas within the municipal boundaries and some additional areas located outside, but immediately adjacent to City boundaries, including sites within the Regional District of Fraser-Fort George. These areas may include:

- West of the City boundary along the Nechako River along Takla Forest Road.
- East of the City boundary to the Denicola Subdivision.
- Southeast of the City boundary adjacent to Blackburn.
- Northeast of the City boundary adjacent on Goose Country Road.
- South of the City boundary along Haldi Lake Road including Haldi Lake.
- South of the City boundary, ditches on East Beaverley Road.
- The Lheidli T'enneh office and vicinity ranging south to the floodwater channel off Beaver Forest Road.

Within this area, all municipal, private, crown, and Regional District land is included with permission of the applicable owner, agency or authority. A map of the geographic boundaries to which this PMP applies can be found in the Appendix. Detailed maps displaying larval development site locations are available by contacting Ms. Mandy Jones, Manager, Development Services and Approving Officer, City of Prince George, at 250-614-7861.

1.1.1 Regions Within the City

For the purposes of mosquito control operations, the city is divided into six community areas: Blackburn, City Centre, College Heights, Cranbrook Hill, Fraser Vista, and the Hart:

- ***Blackburn***

The Blackburn area is located in the eastern area of City limits and encompasses the area surrounding the Prince George Airport. Ditches, sewage lagoons, irrigation ponds, and snowmelt and precipitation-influenced depressions in fields and wooded areas are the predominant larval development sites in this area.

- ***City Centre***

The City Centre is the area commonly referred to as the "the Bowl" in Prince George. The sites in this area are primarily located in public spaces and are generally snowmelt and precipitation-influenced temporary ponds, pools and ditches. Cottonwood Park, a natural area, located at the confluence of the Nechako and Fraser Rivers and affected by rising river levels and seepage.

- ***College Heights***

College Heights is located in the southwestern region of the City and contains the areas also known as Vanway and Beaverly. This area is primarily comprised of permanent woodland ponds, swamps, grassland pools and temporary snowmelt and rain pools.

- ***Cranbrook Hill***

Cranbrook Hill is small agricultural community located along the mid-western border of city limits. The mosquito development sites in this area are mostly temporary, snowmelt and precipitation-influenced, surface water accumulations in field depressions, ditches, woodland ponds and swamps. There are untreatable areas in this region including certified organic farms. As the location of active fields can change from season to season, the organic farmer should be contacted prior to program start-up each year to update a map of these areas to ensure their avoidance.

- ***Fraser Vista***

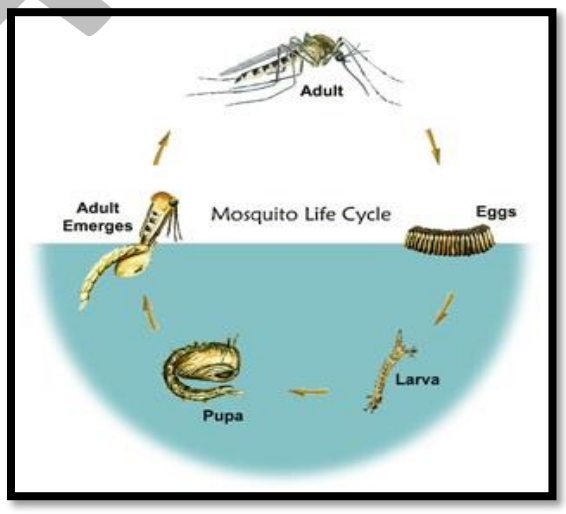
Fraser Vista is located in the northeast corner of the City and includes a small area near the Prince George Sawmill and Canfor properties and includes the Shelley Reserve. The region includes several large sites that are categorized as Fraser River level-influenced old river oxbows, back channels, flood and seepage water influenced farm fields, woodlands and cotton wood swamp.

- ***The Hart***

The Hart region is located north of the Nechako River and extends north to the City Boundary. This is the largest region with respect to area and number of larval mosquito development sites. These range from ornamental ponds on residential properties to large woodland ponds and swamps located on both private, and public properties.

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 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 inundated.



Mosquito larvae undergo four larval instars (or moults), each time emerging larger, but virtually unchanged from the previous instar. This is the 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 it often requires 10-14 days, depending on temperatures. Adult mosquitos feed on plant nectar and other fluids, and it is only the female which requires a necessary 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 freshwater, ponds, marshes, ditches and catch basins. Birdbaths, plugged rain gutters, livestock watering troughs and any man-made container capable of holding water for a period of 7 to 21 days can provide suitable larval mosquito habitat.

1.3 Need for Mosquito Control

The purpose of the annual mosquito control program is to provide residents, workers and visitors of the City of Prince George, and immediate area, with relief from extreme and/or persistent adult mosquito annoyance using an Integrated Pest Management (IPM) approach to surveillance and population management. The control program is not intended to, nor is it possible to eradicate local mosquito populations. An effective, pro-active mosquito control program which focuses on the identification, prevention, or timely control of larval mosquito populations, also contributes to the protection of public health.

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. 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.

Although not a common occurrence in most areas of British Columbia, mosquitos are capable of transmitting (vectoring) diseases. A well organized and effective larval mosquito control program is important to limit the potential for both, widespread adult mosquito annoyance, and potential for disease transmission. Despite the best of efforts though, some adult mosquito annoyance may still occur during the months of June through August, and residents are encouraged to avoid areas of mosquito harbourage (typically treed, forested or landscaped areas) during certain times of day, and to use repellents and approved adult mosquito control devices and products as per label directions.

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. A few years ago (2019), the mosquito-associated flavivirus disease caused by Zika virus (ZIKV) became a prominent health concern in several areas of the world, including the southern USA. Locally in British Columbia, the recent discovery (July 2025) of a “cluster” of Jamestown Canyon virus and Snowshoe Hare virus infections in several residents of

Squamish, BC (BCCDC, July 2025) has increased concerns for invasive species and disease range expansions.

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 flavivirus 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 ongoing surveillance, identification and reporting of WNv, ZIKV, and new or emerging diseases, and their mosquito vectors. As part of this planning the BCCDC has developed the Arbovirus Surveillance and Response Guidelines for British Columbia, and the BCCDC has a provincial database containing all mosquito, bird and human health surveillance data relating to WNv with ongoing updates for other, new vector mosquito species.

Due to the low and stable incidence of 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. Human clinical testing will continue. Human clinical testing continues as part of routine blood donor collection programs. Dead birds such as crows and ravens are tested when WNv is suspected and horses are also tested, on a case-by-case basis, by provincial veterinarians.

1.4 Term of the Pest Management Plan (PMP)

A five-year period, extending from 14 April 2026 to 15 April 2031.

The designated contact for this Plan is Mr. Neil Matheson, Supervisor, Parks and Solid Waste, 1100 Patricia Boulevard, Prince George, BC V2L 3V9 Telephone # 250-614-7816.

2.0 MOSQUITO CONTROL PROGRAM BACKGROUND

The geographical area covered under the PMP is defined as the boundaries of the City of Prince George and immediate areas (see figure in Appendix A). This includes forested and agricultural areas, local golf courses, parks, residential, commercial and light industrial developments.

The primary source of nuisance mosquito development for residents and businesses of Prince George can be divided into two basic types; river flood and seepage influenced stagnant sloughs, back channels/old oxbows, ponds and depressions scattered throughout the forested and farmed areas adjacent the Fraser River, northeast of downtown Prince George; and, temporary and permanent ponds, swamps, ditches, snowmelt and precipitation-filled depressions and excavations

in recreational, commercial and residential areas of the Hart, City Centre, Cranbrook Hill and College Heights areas. Over 350 accessible development sites and 325 hectares of potential larval mosquito development habitat have been recently confirmed within control program boundaries. Many of these sites can be become active with larval development on more than one occasion during the moths of April through August, depending on weather conditions and river levels. The Figure at the end of this PMP document presents an overview map of development site locations.

The mosquito control program and methodologies (the PMP) developed for the City of Prince George 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. A variety of monitoring and control methods, including physical site reduction or modification and the use of biological control products support the principles of an Integrated Pest Management (IPM) approach to mosquito control. They are the most effective means of reducing adult mosquito populations and the potential for annoyance or disease transmission. This IPM protocol consists of five components:

1) Public Education. Explains mosquito biology, the program, and how the public can contribute to successful operations;
2) Surveillance, identification, and distribution of mosquito species;
3) Timely implementation of mosquito controls and preventative measures;
4) Adaptive management of operations during a season in response to observations; and
5) Program evaluation and assessment to ensure sustainable, effective controls have been achieved and the need for modification in future seasons.

Control program operations have always sought to reduce adult mosquito annoyance for residents, businesses and visitors to the City of Prince George to acceptable, tolerable, levels. Operating annually since 1986, this successful program has continued to evolve and increase its environmental compatibility, effectiveness, and affordability for residents.

The annual mosquito population management and control program focuses mosquito surveillance and control efforts in areas where larval populations are 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.

2.1 Primary Land Use

The primary land uses of the areas within the control program are residential, industrial, recreational (golf courses, passive parks, trails, playing fields, etc.) and forested, undeveloped lands. In addition to organized sports activities, outdoor summer recreational activities include walking, hiking, photography, bird watching and sight-seeing, horseback, motorbike and mountain bike riding.

2.2 Mosquito Species Identified within the City of Prince George

Mosquito development occurs in a wide range of open water larval habitats, ranging from snowmelt and precipitation-influenced flood and seepage water pools and channels along rivers, streams and lake shorelines, to permanent ponds, marshes, ditches and similar water-holding depressions. Bird baths, plugged rain gutters, livestock watering troughs, irrigation and surface water run-off collection ponds and any other man-made container or excavation capable of holding water for a period of at least 7 to 10 days can provide suitable larval mosquito habitat. Left undetected, larval mosquitos will complete their development to adult within this time span. Larval populations are sampled using a standard 350 ml dipper and area recorded as number of larvae/350 ml dip sample, and by their age class; 1st, 2nd, 3rd or 4th instar or pupae.

Larval Mosquitos in 350ml Dipper (200 larvae / dip, 2nd & 3rd instars)

Over twenty five species of mosquitos have been collected as either larvae or adults at Prince George . All of the following species present in the city 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 from the City of Prince George include:

Aedes aloponotum	*Aedes impiger*	*Culiseta alaskaensis*
Aedes campestris	*Aedes implicatus*	*Culiseta impatiens*
Aedes cataphylla	*Aedes intrudens*	*Culiseta incidens*
Aedes communis	*Aedes mercurator*	*Culiseta inornata*
Aedes diantaeus	*Aedes provocans*	*Culiseta morsitans*
Aedes dorsalis	*Aedes punctor*	*Culex pipiens*
Aedes euedes	*Aedes riparius*	*Culex tarsalis*
Aedes excrucians	*Aedes sticticus*	*Culex territans*
Aedes fitchii	*Aedes vexans*	
Aedes hexodontus	*Anopheles punctipennis*	

The large majority of mosquito species collected from the area, over 70%, are a complex of Aedes mosquitos often containing large populations of Aedes sticticus and Aedes vexans. All Aedes mosquitos are aggressive biting pests which prefer flooded, temporary or recurring habitats such as

over-irrigated fields, ditches, marshes, snowmelt, river flood and seepage-filled pools in woodlands, sloughs and depressions in cleared or logged areas, golf courses and walking, cycling trails. Aedes mosquitos lay their eggs in moist soil along the edges of recently flooded areas where the eggs can lay dormant for many years. Following a period of wetting, and drying, eggs become "primed" to hatch. Aedes larvae, once inundated, can hatch out in large numbers with populations typically ranging from 50-100 larvae/dip sample, although + 200 larvae/dip sample isn't uncommon. This is comparable to upwards of 2000-3000 mosquitos per square meter of surface water. Aedes mosquitos are typically the most numerous during the first half of the season, from late April through early July. Receding river levels, increasing ambient temperatures, evaporation and decreased precipitation causes many of these habitats to dry, drain and numbers upwards of 200 larvae/350ml dip disappear over the course of a typical summer.

Culex, *Culiseta* and *Anopheles* mosquitos comprise the balance (20-30%) of mosquito pest species for the area. 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. They 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. *Anopheles* mosquitos prefer permanent sites or slow draining and flowing ditches or stream margins. Larval populations typically range from 1-20 larvae/dip sample and multiple, or recurring hatches are possible with additional egg laying by female adults. Although their populations and individual development sites are not usually as large as the synchronous hatching *Aedes* mosquitos, *Culex* and *Culiseta* can be a source of reportable annoyance since their preferred habitats are common to residential, commercial, recreational and agricultural properties. Species such as *Culex tarsalis* are able to withstand a high degree of pollution and can inhabit areas with high organic content, including septic field seepage, sewage lagoons and livestock hoof prints around barns, feed lots and along creeks. *Culex pipiens*, the "house mosquito", can use a large variety of freshwater habitats including manmade containers and they are the predominant mosquito developing in catch basins.

All of the species listed above are able to develop as multiple hatches (generations) during the season and most of them are capable of causing reportable and often extreme annoyance, particularly *Aedes*. Locally collected Ae. *sticticus* and Ae. *vexans* are also 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*, *Culiseta incidens,* and *Culiseta inornata* are identified by the BC Centres for Disease Control (BCCDC) and the Centers 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, businesses and visitors, but also contributes to the protection of public health. Mosquito surveillance, collection and identification are components of an ongoing operational control program. The mosquito species listing and development site database would be updated as required.

2.3 Mosquito Control Program Implementation

In response to resident, workers and visitor reports of recurring adult mosquito annoyance, the City of Prince George has worked to provide an effective nuisance mosquito control program for residents, workers and visitors since 1989. During this time the program has evolved to become an example of environmentally sound and sustainable mosquito control using an Integrated Pest Management (IPM) approach. This methodology incorporates public education, development site identification and categorization, surveillance, prescriptions for alteration or modification, and where required, larval mosquito control completed using the safest, most effective biological control agents available.

Ongoing mosquito development site surveys, monitoring and identification of larval and adult mosquito specimens updates the local mosquito species complex and development site database. Identified mosquito habitats are monitored throughout the season, typically from late April through August, to assess the abundance and species of mosquitos developing in them. New Jersey or CDC (Atlanta) light traps and standardized mosquito biting and landing counts can be used to sample and monitor adult mosquito populations. During the course of program operations many development habitats have been eliminated and many others created.

Over 325 hectares of natural and man-made mosquito development site areas, and many individual sites, have been identified as potential habitat within, and adjacent to, the City of Prince George, Appendix. Most of the larval development habitats affecting the area are temporary, precipitation, snowmelt and river level flood and seepage water-created sites located in ravines, logged or industry-cleared areas, wooded sites, farm fields and undeveloped lands. Other sites are permanent waterbodies and include sloughs, marshy areas and roadside or site drainage ditches and ponds.

Other habitats such as bird baths, buckets, stored boats, livestock watering troughs, 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. 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 habitats for removal or routine management.

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

The City of Prince George's annual Mosquito Population Management and Control Program employs a pro-active, Integrated Pest Management (IPM) approach to reducing mosquito populations. A comprehensive, IPM approach to mosquito control includes property owners, businesses and the general public. The methodologies and operational procedures described within this Pest Management Plan are endorsed by the City of Prince George.

2.4 Control Products (Larvicides) Proposed for Use

The City of Prince George mosquito population management and control program reduces adult mosquito populations 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 controls, and when these are ineffective, or inefficient, the use of only biological and biorational control products.

The bacterial mosquito larvicides VectoBac 200G (PCP #18158) and a similar product AquaBac 200G (PCP #26368), have been routinely used in the annual program for its 25+ years of operation. Other similar products, VectoLex CG (PCP #28008) and VectoLex WSP (PCP #28009), are also available for use in Canada and may be used by the program contractor. VectoBac 200G and AquaBac 200G contain spores and crystals produced by *Bacillus thuringiensis var. israelensis* (*Bti*) Serotype H-14 and VectoLex CG & WSP contains spores and crystals produced by *Lysinibacillus sphaericus* (*Lsph*), both naturally occurring soil bacterium, and are classified as biorational control products.

Each of these products are very specific to mosquito larvae and have no impact on non-pest insects, fish, amphibians, birds, reptiles and mammals. Extensive product information can be found for VectoBac and VectoLex at the manufacturer's website www.valentbiosciences.com. Product information for these and AquaBac 200G can also be found through the Health Canada, Pest Management Regulatory Agency (PRMA) website https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and the Pesticide Label Search https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php. Section 3.4.3 Biorational Control, discusses the products further. Other new or equivalent *Bti* or *Lsph* products may be used. These would be identified to the BCMOE with the annual Notification of Intention (NIT) to treat.

3.0 CONTROL PROGRAM METHODOLOGIES

The objective of the annual mosquito control program is to reduce the potential of widespread adult mosquito annoyance for residents and visitors to the City of Prince George. A program of this scope is not intended to eliminate the local mosquito population. The total eradication of a widespread, fecund insect pest is not feasible nor desirable. The potential impacts of control products and activities, combined with a need to coexist with a delicate 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 methods.

Control of or prevention of larval mosquito development is preferred over control of the often widely dispersed and mobile adult mosquito. Mosquito larvae are concentrated in one place, must remain there for 7-21 days, and are very susceptible to the biorational control products VectoBac and VectoLex. Drainage, filling of depressions, restoration of flow in ditches or other physical alterations to appropriate larval mosquito development sites is preferred as it provides permanent control.

Physical site reduction or modifications can be integrated into local public works and construction activities such as roadside grading, ditch maintenance and cleaning. For home and business owners it can include the removal of water-holding containers such as buckets and unused pools, or the regular draining and refilling of livestock watering troughs and bird baths. Only the most environmentally compatible, least toxic and persistent control products would be deployed for use within this annual program.

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.

Routine adult mosquito control applications (adulticiding) for the purposes of nuisance mosquito control **are not** a component of the Prince George Mosquito Population Management and Control Program and this Pest Management Plan. The operational components of the PMP and the successful, annual, Mosquito Population Management and Control Program may include the following activities, as detailed in Sections 3.1 through to Section 4.5.

3.1 Public Information and Education

The general public must be advised of control program efforts in their area and provided with the opportunity to have input to their mosquito control program. Public input is invaluable to any community function, and it is a key component of all successful, pro-active mosquito control programs. This is essential since, in the final analysis, it is the general public which must be satisfied with control efforts.

The *Integrated Pest Management Act and Regulation* requires public notification of Pest Management Plan preparation through newspaper notices which must be published twice in a two week period starting at least 45 days before submission of a notice 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 to provide comments on the PMP and to consult with the PMP holder or their designated consultant, 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 population management and control program is well known and supported by area residents and businesses. Its highly visible nature using field biologists working along roadsides, fields, in parks, golf courses, along dykes and lake shorelines has ensured that property owners, facility managers and residents remain familiar with their annual program. In annual operation for over thirty years, it has been providing mosquito surveillance, monitoring and larval control services for the benefits of residents, businesses and visitors to the area. Throughout this time, newspaper articles and advertisements, brochures, posters and interactions with field

personnel have provided the general public with regular and frequent information on mosquitos and program service access.

Considerable value can be obtained through exposure to the control program and interactions with the public. Residents are encouraged to contact City of Prince George offices 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.

Examples of some various public education and information initiatives which could be employed in the City of Prince George in the following years 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 – another method of public access and information sharing.
- 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 – September. Provides public information relevant to each month and program contact/access information.
- Cardboard Doorknob Hangers – These "Sorry we missed you" doorknob messages are left when residents aren't home during property inspections. They summarize field technician observations and have return contact information for resident use.
- Newsmedia interviews/articles – TV, Radio provides public with updates on program operations and status, mosquito biology and additional public outreach
- Presentations at Council meetings.
- Information at Open houses, farmers markets

Movement of adult mosquitos, either by active flight or passively by wind, from outside of treated areas into built up and developed areas is always a possibility. 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 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.

As part of annual control program start-up in early April and May, program personnel would contact property owners, residents and facility operators listed in the database to determine site status and confirm program participation and property access. As part of these initial contacts, field personnel answer inquiries, supply relevant literature and complete on-site property inspections. Ongoing interactions and conversations with property owners, residents and the general public provides opportunities to discuss program operations, goals and allow for the distribution of public outreach materials. Office and field personnel response to service requests, by telephone, email, and in person 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 program personnel do not conflict with those of residents. By staying informed of community events such as baseball games, golf tournaments, community or corporate picnics 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 and 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 area. Prevention of adult mosquito annoyance through pro-active, larval mosquito control provides significant benefit to outdoor worker and recreational uses.

3.2 Protection of Archaeological Sites

Archaeological sites on both public and 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 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 City of Prince George and the 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 population management and control program for the City of Prince George is responsible to follow the data collection and reporting requirements of the PMP and the *Integrated Pest Management Act and Regulations*.

The City of Prince George would be regularly informed of control program activities of this contractor/consultant through personal contact, telephone, facsimile or e-mail with program managers and field personnel. In addition, written progress reports summarizing weather conditions, surveying and monitoring results, treatment areas and interactions with the public are typically prepared by the program consultants and submitted to the City on regular basis during operational phases of the control program.

At the conclusion of each annual mosquito control program season a summary report detailing all activities and pesticide treatments completed under the PMP is provided by the consultant to the City. All 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 District), as requested and necessary.

At a minimum, the contractor would maintain the following information for their use in managing the program and to complete the reporting and information requirements of the City, the PMP and the Pesticide Management Program, 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, public access information (paths, trails, roadways), development site maps, photographs, GPS identification, records of 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 city or its consultants, their wish to be excluded from the mosquito control program.

- A list and/or maps identifying 'AVOID' areas of environmental sensitivity, including provincial or regional parks, habitat conservation areas and other identified or designated speciality management areas.
- When the status of a waterbody or other area of potential environmental concern (e.g. bird nesting sites) is unknown, a local representative of Fisheries and Oceans Canada (DFO) or the BC Ministry of Environment (BCMOE), or other agencies where appropriate, may be consulted.

The development site database and avoid area lists are 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, areas of concern and control program operations are reviewed at this time. Regular contact is maintained with these individuals throughout the season to provide updates on control program operations and opportunities for input and comment on the control program. Ongoing activities related to surveying, monitoring and mosquito control operations are recorded in the historical data section of the database as they occur. Database information would be used to respond to any requests for program information from the public, City representatives or government regulatory agencies.

The consultant is responsible to ensure that all private and personally identifiable information within the database is managed in a secure, ethical, and legally compliant manner. This includes, but is not limited to, names and contact information linked to individuals or private properties, and any other data that could reasonably be used to identify a person. All handling of such information must adhere to the requirements set out in both the Personal Information Protection and Electronic Documents Act (PIPEDA) and the Personal Information Protection Act (PIPA). These Acts govern how private-sector organizations collect, use, disclose, and protect personal information in the course of commercial activities.

3.4 Surveying and Monitoring of Mosquito Populations

As part of the annual program start-up, and throughout the season, program field biologists conduct regular, comprehensive surveys of the program area by ground and air, as appropriate. The goal of these surveys is to confirm the extent and locations of existing, known mosquito development sites and to identify any new, or previously undetected, larval habitats. Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos, the need for control and allows for regular update of the database. Where observed, larvae are collected and enumerated using a standard 350 ml white larval mosquito dipper. Preserved larval specimens are identified to the species when 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. Provincial and

regional snowpack accumulations and rate of melt, river level fluctuations, precipitation and temperatures are reviewed as necessary to ensure timely surveying to detect mosquito development.

Monitoring and correlation of fluctuating temperatures and precipitation levels over several seasons allows for the determination of 'thresholds' which aid in the prediction of larval development and distributions. Review of winter snowpack accumulations, summer weather conditions, and river 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 Monitoring

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.

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 application. Environmental compatibility and cost effectiveness of a control program is dependent on proper pesticide use through the application of control measures directed only to those areas requiring them. Post-treatment monitoring to confirm to larval mortalities is typically completed within 2-96 hours of larvicide.

Surveying and monitoring of larval development sites (always waterbodies) determines the presence of larval mosquitos and the need for control. Larval habitats would be monitored throughout the season using a standard 350ml white larval mosquito dipper to assess the relative abundance and species of larval mosquitos found in these habitats. Routine sampling of development habitats is ideally 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 larva 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, sports parks, picnic areas, campgrounds and nearby residential and commercial areas, seepage and snowmelt influenced sites, including river level-influenced sites, are a major potential source of mosquito annoyance, and a primary focus of the annual mosquito control program

3.4.2 Adult Mosquito Monitoring

To objectively measure the success and effectiveness of larviciding efforts in reducing adult mosquito populations, two internationally accepted sampling methods are employed. 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.

CDC Light Trap

The second method used for adult mosquito population assessments uses either Standard New Jersey or Center of Disease Control (CDC, Atlanta) Adult Mosquito Light Traps. Both types of traps use a normal incandescent light source as an infrared attractant and are programmed to start collections at sunset and terminate at sunrise. Samples are typically retrieved the following morning and forwarded to the laboratory for enumeration and identification. These traps can be augmented (baited) with CO_2, in canisters, or as dry ice, to increase capture rates as it is another key attractant for female mosquitos. 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. 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 collect and identify 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 Prince George

The largest and most prolific sources of mosquito development in the Prince George area are naturally occurring sloughs and snowmelt, precipitation and river flood or seepage water-filled habitats located in forested, cleared and farmed areas adjacent the Fraser River. Indirect flooding through river seepage and surface water runoff can lead to water accumulations in areas that have no direct connection to local creeks and ponds. The widespread, permanent and temporary ponds, marshes and swamps in the Hart, College Heights and Cranbrook Hill areas also provide a localized, potentially season-long source of mosquitos. These natural and diverse habitats with fluctuating water levels and persistence often have the greatest diversity of species.

Slough south of Shelley at Beaver Forest Service Road

Winter snowpack accumulations and local weather conditions, including total precipitation and frequency, humidity and winds also impact on mosquito development and survival rates. 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 *Aedes* mosquitos from April through late June, they are a recognizable source of adult mosquito nuisance for area residents. Subsequent larval development, which includes *Culiseta* and *Culex* mosquitos, also causes localized annoyance which may extend through to July and August.

Smaller depressions and non-flowing drainage ditches, tire ruts and artificial containers such as livestock watering-troughs, old tires, landscape, 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, business' 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 during the past few years include: *Aedes vexans*, *Aedes sticticus*, *Culex pipiens*, *Culex tarsalis*, *Culiseta incidens* and *Culiseta inornata*. The great majority (+90%) of mosquitos developing at Prince George are *Aedes*.

3.5 Mosquito Control Options

Simple, but established key elements of a sound IPM approach 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 applications of the best site-specific controls, and;
3) As a feedback mechanism, assess the results achieved and adapt 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 Integrated Pest Management approach, to achieve the management and control 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 controls. These control 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 habitats, 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 habitats has the best opportunity for a meaningful long-term contribution to overall mosquito control program success through reduction of mosquito populations and enhancement of natural controls including insect, fish and birds. Elimination of stagnant water and enhancements in natural or created ecosystems will be of benefit to overall control program efficacy through decreasing larval habitats and increasing natural mosquito predators. The use of a biorational control products such as *Bacillus thuringiensis* var. *israelensis* (VectoBac / AquaBac 200G) and *Lysinibacillus sphaericus* (VectoLex CG / WSP) when natural control are insufficient, or absent, maximizes the effectiveness and environmental compatibility of the program.

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 biorational product oriented.

3.5.1 Physical Source Reduction and Site Modification

A continued focus for the control program technicians 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. Installation and maintenance of window screens, Mosquito Magnets (adult mosquito traps) and the use of mosquito repellents by individuals 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.

Maintaining permanent ditches so they are clear of obstructions or vegetation, replacing failed culverts or grading to effect flow may increase flow, drainage or access by fish or aquatic insect predators. Ditching, grading or filling of roadside depressions may be a suitable solution to decreasing, or preventing, larval development by reducing an area's potential to retain water. When completed as part of routine maintenance activities by public works crews they can be effective means of suppressing 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 BCMOE, DFO and other government regulatory agencies, as appropriate, may also need to be consulted prior to any such planned work in area ditches.

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 park 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.

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

3.5.2 Biological Control

Biological control involves the use of predators, pathogens, and parasites to reduce mosquito populations. Insects predators, both aquatic (i.e. dragon flies, beetles) and terrestrial (i.e. spiders, wasps), 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.

Of all the various predator control methods tested, only larvivorous fish are used operationally in widespread programs. Regan *et al.* (1982) 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, goldfish) to manmade, self-contained outdoor display or irrigation ponds may also reduce, or eliminate larval mosquito development in such habitats. Most practical in the warm, lower mainland Fraser Valley and Vancouver Island, 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 flying insectivores (*e.g.* bats, swallows, Purple Martins), 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 can often exceed 100 larvae/dip sample. With 300+ hectares of treated habitat, and much of it located within 200-300m 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.

Interested residents would still be encouraged, however, to install bat houses or bird nesting boxes if they wish, 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.

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 closest form of a naturally occurring control agent which can be readily, easily and safely applied to reduce mosquito populations are products made with the soil bacteria, *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *Lysinibacillus sphaericus* (*Lsph*), which have highly specific insecticidal properties. Theses larvicides are discussed below.

3.5.3 Biorational Control

The control program at Prince George would use VectoBac 200G, and VectoLex CG and WSP larvicide products for larval mosquito control. A secondary product, AquaBac 200G, may be used as a substitute when necessary. VectoBac/AquaBac and VectoLex are the closest form of a natural or biological control agent currently available for routine use in operational mosquito control programs. The use of these products 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.

Property owners would be consulted with prior to any larvicide applications and for any recommended physical of 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. The product VectoBac 200G contains spores and crystals produced by the bacterium (*Bacillus thuringiensis var. israelensis*, Serotype H-14 Strain AM65-52) and, a similar product, AquaBac 200G is made with *Bti* Serotype H-14, Strain BMP144) as such, they are classed as biorational, rather than conventional, pesticides.

VectoBac 200G Granules

VectoBac and AquaBac act on the larval mosquito stomach and must be eaten to be effective. It is very specific, producing rapid lethal effects (within hours) in larval mosquitos. It has no residual activity, does not bio-accumulate and has no impact on beneficial organisms found in mosquito development habitats. 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.

VectoBac 200G and AquaBac 200G is recommended by their manufacturers for use in standing water habitats including 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.

VectoLex CG and WSP also contain naturally occurring, spore-forming soil bacterium. VectoLex contains spores and crystals produced by *Lysinibacillus sphaericus*. It also is classed as a biorational, rather than conventional, pesticide. VectoLex also 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 or AquaBac are speed of action and persistence in the larval habitat. Larval mortality can take several days for VectoLex versus several hours with VectoBac 200G. This occurs because *L. sphaericus* is more stable, has a slower settling rate in the water column and the unique ability for its spores to germinate, grow and reproduce in dead mosquito larvae. This is known as recycling and is the mechanism which allows VectoLex to provide long-term, extended control of recurring larval mosquito development. VectoLex CG and WSP are recommended by the manufacturer for use in standing water habitats including temporary and permanent pools in pastures and woodlots, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing waters, catch basins and sewage lagoons.

The use of *Bti* and *Lsph* maximizes the environmental compatibility of the annual mosquito control program since both products are species (target) selective and non-toxic to other aquatic organisms which co-exist in these habitats including insects, fish and amphibians. When used in circumstances where other control options such as physical or cultural control are not practical, they support the principles of an IPM approach to mosquito control.

Extensive product information for VectoBac and VectoLex products can be found at the manufacturer's website www.valentbiosciences.com. The product manufacturer/distributor for AquaBac 200G is AFA Environment Inc. Additional information on all the larvicide products proposed for this program can be found through the Health Canada, Pest Management Regulatory Agency (PRMA) website https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and the Pesticide Label Search https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php.

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 made 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. 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.

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 any more 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 expand into these treated areas to again cause annoyance.

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

- ***Pesticides and repellents***

Citronella candles, mosquito coils, Konk Automatic Aerosol Sprayers and other such products are marketed as mosquito repellants, or for adult mosquito or biting insect control. These are readily available to residents, campers, and property owners. Property owners may also use items such as these, as required, and as instructed on the product labels.

The mosquito control program would continue to use only the least toxic, most environmentally sound control products available. As new products become available and registered in Canada, their suitability for use in annual control program will be reviewed.

3.6 Mosquito Control Program Operations

A total of some 300+ larval mosquito development site locations habitats have been identified within the defined boundaries of the City of Prince George mosquito control program. The actual total area that will become infested and require larvicide treatment is dependent on hydrological and meteorological events. Fluctuating water levels in floodwater and seepage-influenced development sites, causes recurrent larval development and for many sites multiple treatments to effect control. Precipitation, seepage and surface water run-off into permanent or temporary sites can also result in multiple generations of mosquito during a typical season.

The well organized, pro-active, integrated pest management approach to mosquito control which has been developed for the city reduces the potential for adult mosquito annoyance by focusing on the identification and timely control of larval populations occurring within the City of Prince George and surrounding areas. In situations where physical alteration of development habitats are impractical or undesirable, or where natural controls are insufficient to reduce nuisance mosquito populations, VectoBac and VectoLex applications would be completed to control larval populations. Control of larvae at their source reduces annoyance levels for area residents and visitors. New or previously undetected, larval mosquito development sites, once identified, are monitored, treated as required with permission, and added to the site database for future surveillance and control as necessary.

As required by the *BC Integrated Pest Management Act and Regulations*, all larvicide applications would be completed, and/or supervised by, personnel certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement*, or equivalent. All larvicide treatments would be completed using application rates, equipment and methods recommended by the pesticide manufacturer.

3.6.1 Public, Worker and Environmental Safety During Mosquito Control

To ensure public and worker safety, all conditions and restrictions governing biorational larvicide (VectoBac and VectoLex) applications would be followed. Pesticide applicators will follow the guidance of the approved PMP, with regulations contained in the *Pest Control Products Act*, the *Pesticide Control Act*, the *Integrated Pest Management Act and Regulation*, the *Transportation of Dangerous Goods Ac*t 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*' and associated reference materials supplied through the BC Ministry of Environment.

The “Workplace Hazardous Materials Information System” (WHMIS) is a national system designed to protect Canadian workers from the adverse effects of hazardous materials by providing relevant information. All pest control products intended for use in a workplace require this information on the label or need to have a Safety Data Sheet (SDS) prepared to be eligible for registration.

Pesticide handling, storage and application procedures would conform with those detailed on product labels, Material Safety Data Sheets and endorsed in the 'Pesticide Applicators and

Dispensers Handbook' and associated reference materials supplied through the BC Ministry of Environment.

The City of Prince George mosquito population management and control program is intended to provide residents, workers and visitors relief from extreme or persistent adult mosquito annoyance. The control program is not intended to eliminate the mosquito population and as such landowners and residents who want to be excluded from the control are recorded and their wishes respected.

Landowner permission to survey, monitor and treat infested larval mosquito habitats located on private property is confirmed each season. Treatment of developing larval mosquito populations in waterbodies on public lands are permitted under this approved PMP. Program personnel will take all practical precautions to protect application personnel, the environment and the general public during all larvicide applications. Prior to any larvicide application field personnel:

- Verify property ownership, treatment site boundaries, public points of access (paths, trails, roadways), pest presence and population size, both pre- and post-treatment.
- Identify AVOID areas, fish-bearing and flowing waters or areas of environmental sensitivity (i.e. bird nesting sites) and the need for, and size of, any Pesticide Free Zones (PFZs) and Pesticide application Buffer Zones (PBZs), if required.
- Community watersheds can be determined by accessing the BC Ministry of Environment Community Watershed listings and informational website:
    - https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/community-watersheds
- A listing of registered groundwater Wells and Aquifers and an interactive map of active wells is available at:
    - www.gov.bc.ca/gov/content/environment/air-land-water/water/groundwater-wells-aquifers
- Larvicides will not be applied to finished drinking water and no Pesticide Free Zones (PFZs) are required for bacterial pesticides as indicated in Section 71(12) of The Integrated Pest Management Act and Regulations. Potable (drinking) water well locations and open water intakes will be identified with the property resident/owner prior to any larvicide treatments.
- Review larvicide product label and comply with recommended precautions for handling and application, safety gear, weather restrictions (wind, temperatures, etc.) and other listed precautions.
- Inform the public of larvicide applications through ongoing public notices, news media articles, advertisements, and personal contact.

3.6.2 Larval Mosquito Control, Treatment Thresholds and Application Rates

VectoBac (*Bti, Strain AM 65-52*), AquaBac (*Bti, Strain BMP-144*) and VectoLex (*Lsph*) are only applied when larval mosquitos are present. 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. Given that the most extensive larval development locally involves synchronous hatching *Aedes* mosquitos this strategy ensures maximum control. In addition to treating the most actively growing and feeding instars, it also, allows for retreatment (touch-up) of sites, or portions of sites, that may 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 biorational larvicides containing *Bti* and *Lsph* proposed for use in the program have the safest environmental profiles of any larvicides in common use, decreasing any volume of control product is beneficial and maximizes environmental compatibility.

Treatments targeting mosquito populations with later 3rd or 4th instars under the guise of allowing natural predators to impact some level of control is not encouraged. It is not recommended on *Bti* or *Lsph* product labels, or by the *Municipal Mosquito Control Guidelines (Ellis, 2005)*. Using biorational larvicides to control mosquito larvae at their source, and as 2nd through 3rd instar larvae still contributes to the "food web". Dead larvae become food for many other organisms, including insect detritivores, fungi and bacteria which in turn become food for other aquatic insect and vertebrate predators and grazers. While there may be predation of mosquito species, such as *Culex spp*. or *Culiseta spp.*, which occur in permanent ponds, and are the two most common larvae in these sites, there are typically zero to very few natural predators in *Aedes* mosquito habitats which are typically dry fields and depressions until inundated with water through snowmelt, precipitation, or river seepage.

Delaying treatments to target mosquito populations with later 3rd or 4th instars is not ideal. The potential for reduced feeding rates of later (4th) instar larvae may provide incomplete control, reduced efficacy and may result in a number of other undesirable outcomes:

1) That larvae develop into the untreatable pupal stage, and then onto nuisance causing adults;
2) That field staff may not return at an appropriate time to treat them before this 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/metre), thereby requiring more larvicide, increased field personnel time and reduced environmental compatibility.

Changing weather conditions and temperatures over a few days can dramatically accelerate larval development rates; and lastly product manufacturers recommend that later instar larvae are treated with higher application rates, upwards of 10kg/ha (1 gm/M) for VectoBac 200G and 20 kg/ha for AquaBac 200G (2gm/M), thereby requiring more larvicide, increased helicopter or personnel field treatment time, reduced environmental compatibility, and increased cost ($) per unit treated.

Aedes hatch in large numbers, typically +300/dip sample, and inhabit temporary pools created by snowmelt, precipitation, 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. A pond the size of a back yard swimming pool ($50m^2$), with a larval population of just 1 larvae/350ml dip sample, can produce over 24,000 larvae. A one hectare site, about the size of 2 football fields, with a larval population density of 1 larvae/dip sample can produce 4,285,714 mosquitos.

Typically, upwards of 10 dip samples per development site, depending on site size, are completed. Larger sites will have a greater number of dip samples. Larval mosquito dip samples averaging from 1-3 larvae/350ml dip 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, temporary, snowmelt, seepage water and river level influenced habitats. The threshold for 2nd and 3rd instar *Aedes* larvae would be a minimum of 1 -3 larvae/dip sample. Depending on site location, and its size, and permanence a site may be left untreated if the potential for subsequent adult mosquito nuisance is low, regardless of the larval population size.

VectoLex larvicides, which are largely ineffective against *Aedes* mosquitos would only be utilized to control developing larvae in those permanent and temporary sites having *Culex, Culiseta* and *Coquillettidia perturbans* larvae. Larval populations averaging 1-3 larvae/350ml dip sample will be the threshold for treatment using VectoLex larvicides.

These thresholds are based on the "industry standard" used by operational mosquito control programs in the Northwest Mosquito and Vector Control Association (NWMVCA) and American Mosquito Control Association (AMCA). Larval dip sampling, light trap collections and where appropriate, adult mosquito emergence traps 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.

VectoBac 200G, AquaBac 200G, and VectoLex CG are the larvicides of choice for aerial and ground-based larvicide applications. The use of *Bti* and *Lsph* maximizes the environmental compatibility of the annual mosquito control program since both products are species (target) selective and non-toxic to other aquatic organisms which co-exist in these habitats including insects, fish and amphibians. When used in circumstances where other control options such as physical or cultural control are not practical, they support the principles of an IPM approach to mosquito control, and they are the most effective, selective, and least persistent larval control agents available.

All Mosquito *Bti* larvicide 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 7.5 kg/ha for ground applications and

4.25 kg/ha for aerial (helicopter) applications. These application rates have been demonstrated as effective under the conditions encountered at Prince George. Routine application rates for AquaBac 200G are reported to range from 4.0-13.0 kg/ha. Factors influencing application rates include application method (aerial or ground), larval age classes (instars) and populations, the density and type of vegetation cover at treatment areas (grasses, deciduous forest), organic matter, water depths etc. All application rates would be within the ranges, and recommendations of the PMRA-approved manufacturers labels. All applications are followed with post-application monitoring to confirm the effectiveness of treatments.

Applications of VectoBac 200G, AquaBac 200G and VectoLex to within 10 metres of fish-bearing waters and to waters contiguous to fish–bearing waters is anticipated and as permitted on the Health Canada, Pesticide Regulatory Management Agency (PRMA) approved product labels. Permanent fish-bearing and flowing waters would not be treated. A minimum 10 metre Pesticide Free Zone (PFZ) will be maintained from all potable open water sources, with other buffer zones as required through authorization by the BCMOE. As required by the BC *Integrated Pest Management Act* all larvicide applications are completed by personnel certified by BC Ministry of Environment as pesticide applicators in the category of *Mosquito and Biting Fly Abatement*, or an equivalent, appropriate category.

- ***Ground-based Applications***

All ground-based larvicide applications to small and accessible sites are completed, where required, by hand broadcast or backpack spreader during the mosquito control season. Fluctuating water levels in many of these sites cause repeated 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.

Before treating an area, ground 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 backpack applicator, or by adjusting the frequency and number of “hand broadcasts” for granules being thrown across the surface by applicators. Inaccessible and larger sites may be treated by air using remotely piloted aircraft systems (RPAS) once full approval and certification processes are finalized with the BCMOE.

For catch basins (CBs), VectoLex WSP 10gm satchels, are applied as one per CB. Alternatively, VectoLex CG can be applied to catch basins. If used, VectoLex CG would be applied using a standard measuring spoon to deliver 10 gm of granules/catch basin. VectoLex WSP used for the treatment of cattail swamps and similar, difficult to access sites, would be applied at a rate of one 10gm satchel for every $5m^2$-10m2 surface water. In permanent ponds and stagnant ditches with difficult access because of thick, overgrown, or dense vegetation (i.e. blackberries and Typha sp. cattails), the long-acting VectoLex WSP may be used for treatments. These 10gm satchels (2cm X 2cm) can be readily thrown into these sites where the bio-degradable, glucose-based bag quickly dissolves, and the granules disperse across the water surface. Application to the water surface is at rates of 1 x 10gm satchel/5m2 to 10m2 area.

- ***Aerial Applications - Helicopters***

Rapid, synchronous larval development over an expansive area, largely inaccessible from the ground, makes aerial larvicide applications essential to control program success. Fluctuating water levels in snowmelt, surface water run-off and seepage-influenced development sites cause recurrent larval development with many sites requiring multiple treatments to effect control.

Large scale aerial larvicide applications are completed by rotary winged aircraft (helicopters) fitted with under-slung granular application equipment. There are two primary makers of this equipment, Simplex TM 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 off and on 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.

This equipment is calibrated 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) to achieve the desired application rate, for the appropriate larval age class, is typically between 4.0 - 6.5 kg/ha for VectoBac 200G and 6.0 – 13.0 kg/ha for AquaBac 200G. The distance of the ram or the openings of the disc can be varied 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 use and application of 'dry' products including grass seed, fertilizers and granular pesticides used for agriculture, forestry and public health.

Prior to all aerial larvicide applications, pilots are accompanied on reconnaissance flights by control program management personnel and provided maps detailing treatment sites and areas of

avoidance. Treatment site locations are confirmed by GPS (Geographical Positioning System) coordinates provided by on-board navigation equipment and reviewed with the aerial applicator prior to treatment. Continuous radio contact is maintained between pilots and management personnel during all aerial larvicide applications.

- ***Aerial Applications – Remotely Piloted Aircraft Systems (RPAS – "Drones")***

A relatively new, innovative method for applying mosquito larvicides by air is through the use of an emerging technology called Unmanned Aerial Vehicles (UAV) or Remotely Piloted Aircraft Systems (RPAS), more commonly known as "drones". These devices could be used when development sites are too large for effective treatment coverage or where ground access is too difficult or dangerous. All RPAS treatments would be conducted with adherence to Transport Canada Regulations, certifications and training requirements. Application rates using this technology would be similar to those employed for other aerial (helicopter) applications.

Prior to any RPAS aerial larvicide applications, pilots and control program personnel 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 can be uploaded into the RPAS flight controller/computer station. These maps, and the active tracking of flight paths which result, can guide the application pilots to individual sites, displays their boundaries, and allows the RPAS to be programmed to 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 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. During RPAS operations, aircraft are not to be flown directly over private properties without express permissions from residents, and will focus on designated public lands, open spaces, and wetlands where mosquito development habitat has been identified. This restriction is in place to ensure the protection of privacy and avoid potential disturbances to residents.

VectoBac 200G and VectoLex CG are approved by the Pesticide Management Regulatory Agency (PMRA) for application by RPAS and select, targeted, applications may be made using this application method. When RPAS are used for the application of these products for mosquito control, the pilot must be certified in the use of RPAS for mosquito control by the BC Ministry of Environment (BCMOE), which is a separate category from ground or aerial (helicopter, fixed wing) certification. BCMOE certification was not available at the time of writing this document (Fall 2025) but expected to become available in the coming years.

3.6.3 Post Application Monitoring

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 with sampling results mostly measured at zero larvae/350ml dip sample and averaging much less than 1 larvae/350ml 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.

VectoLex post-application monitoring is completed 5-10 days following application, and then weekly to determine if additional treatment is required. VectoLex mortality is not as immediate as VectoBac, and its effectiveness is determined by the absence of developing fourth instar larvae when monitored post application. Because of its recycling in dead mosquito larvae, the appearance of fourth instar larvae indicates that concentration of VectoLex is insufficient to effect control.

Adult mosquito populations would be monitored in harbourage areas adjacent to treated larval development habitats to confirm the effectiveness of larval controls in reducing adult mosquito annoyance. In addition, adult mosquito populations may be monitored at select locations to compare adult mosquito populations between various locations. 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 goal of the annual City of Prince George Mosquito Population and Control Program is to decrease larval mosquito populations sufficiently to reduce, and/or prevent, adult mosquito annoyance for residents, workers and visitors. Property owners and residents are also expected to implement personal protective measures to limit their exposure to adult mosquito annoyance. These include repellent use, clothing choices (long sleeves, light coloured), avoidance of perfumed personal hygiene products (shampoos), window screens and temporal (minimize activity at dusk and dawn) or location avoidance measures which can lessen adult mosquito annoyance.

The general public should be aware that short-lived adult mosquito annoyance may occur during a typical season. The goal of the control program, through pro-active larviciding with VectoBac 200G and VectoLex CG and WSP, is to prevent extreme or persistent, extended adult mosquito annoyance through timely larval surveillance and prevention or control initiatives.

4.0 QUALIFICATIONS OF PROGRAM PERSONNEL

This annual program would be managed by environmental consultants experienced in integrated pest management.

The contractor/consultant supplying mosquito control services to the City of Prince George 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 should be Registered Professional Biologists. Field personnel should include University and College graduates or senior 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 and Regulations*, all personnel handling and applying larvicides for the annual mosquito control program must 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 T*ransportation 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 '*Canadian Pesticide Education Program Applicator Core Manual*', the '*Pesticide Applicators and Dispensers Handbook*' 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', the Handbook, product labels, manufacturers' websites and any other resource materials detailed in this PMP would be reviewed, as appropriate, before handling, transporting, storing or applying pesticides.

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 pesticides would be secured to prevent an accidental spillage or theft. Granular VectoBac 200G, AquaBac 200G and VectoLex larvicide products would be secured and handled to prevent tearing of bags, spillage and exposure to adverse weather conditions such as precipitation. They will be transported in secure lockable compartment such as a vehicle trunk, a locked storage box, container or truck canopy.

Applicators would typically only transport the minimum amounts of pesticide required to complete the proposed treatments. With granular products, it is common for field personnel to require less than forty kilograms of VectoBac 200G or VectoLex CG for a typical workday. Applicators will carry within their vehicles a suitable spill clean-up kit, basic first aid and appropriate personal protective safety gear and supplies, as required. For granular products, this is typically a broom and dustpan. Any spilled larvicide would be recovered and applied to active larval treatment sites.

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 applicator who has product stolen or removed from his/her vehicle would follow the notification procedures for the appropriate authorities immediately, including police.

5.2 Larvicide Storage

The City of Prince George would make available a secure, dry, well-ventilated pesticide storage space for mosquito control larvicides (VectoBac 200G, AquaBac 200G and VectoLex) within their secure public works facility. The majority, over 95% of larvicide required for each season is typically delivered in late April and consumed between May and June. In an average year, less than 800 kg of VectoBac and VectoLex larvicide may be stored on-site and over the fall and winter to be available for program start-up in late April.

Emergency telephone numbers for police, fire, ambulance, CANUTEC, Dangerous Goods Emergency Spills, Poison Control, and the BC Ministry of Environment are posted on-site at the storage facility and available at Public Works offices

5.3 Larvicide Mixing, Loading and Application

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 pesticide application. No mixing is required as VectoBac and VectoLex granular larvicides are formulated as 'ready to apply' and are supplied in thick, plastic bags. All used and empty bags would be disposed of in municipal or regional landfills as directed by the manufacturer on the PMRA approved pesticide label and SDS sheets. Field personnel would wear suitable safety gear, including the appropriate respirator/dust masks, ear protection, rubber gloves, boots and other protective equipment as indicated by larvicide labels, SDS sheets, and manufacturer instructions.

All handling of pesticides would be conducted in level, well ventilated, outside areas under conditions or minimal winds and no precipitation. 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 bags are emptied directly into the seeder bucket when it is on the ground and between aerial applications. Staging (bucket loading) areas would be located as close to proposed treatment sites as safely possible. These areas may include fenced and/or gated private, business or City properties, farm fields, industrial sites, ball diamonds, local, public and private airfields/airports and publicly inaccessible or secure areas, with permission. Larvicide applications to smaller sites would be completed from the ground by RPAS, hand broadcast, or backpack applicator.

All RPAS staging (larvicide loading, landing, flying) areas would be located as close to proposed treatment sites as possible. These areas may include secure, fenced and gated private and business properties, public and private airfields, farm fields and publicly inaccessible, or limited access areas, with permission.

If implemented, aerial larvicide applications by RPAS/UAV ("drone") will be completed by a minimum two-person team. RPAS drone applications would be completed with adherence to Transport Canada guidelines. Larvicide applications to smaller sites would be completed by hand broadcast or backpack applicator. Field personnel would wear appropriate safety gear, including the appropriate respirator, ear protection, rubber gloves, boots, non-absorbent coveralls and other protective equipment as indicated by pesticide labels, MSDS, WorkSafeBC, the City of Prince George, and the manufacturer.

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 RPAS equipment, backpack blowers, or similarly affect hand broadcast applications, treatments would be suspended until suitable conditions return. Ground-based applications are seldom impacted, except in conditions of heavy or extreme precipitation and under those conditions applications could be suspended until suitable conditions reoccur. Extreme thunder and or lightning conditions would result in the suspension of aerial (RPAS) and possibly ground-based applications until suitable conditions return.

Property owners would be consulted with prior to any larvicide applications and for any recommended physical of 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.

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 (*i.e.* Impounded, receding flood, seepage or tidal waters).

5.4 Equipment Maintenance and Calibration

Ground-based applications of VectoBac 200G and VectoLex CG are completed by hand broadcast or motorized back-pack type (leaf blower) application. Applicators would adjust their walking speed, and throttle speed if using backpack blowers, to ensure they are achieving the correct application

rate/density of granules per square foot of water surface. For an application rate of 7.5 kg/ha this is 4-5 granules per square foot. All aerial larvicide application equipment (Helicopter / RPAS) is supplied and maintained by professional third parties and the aerial contractor. Application equipment calibration is confirmed prior to, during use, by the pilot and/or certified program personnel.

6.0 CONTROL PROGRAM SYNOPSIS

The mosquito population management and control program developed for the City of Prince George utilizes a pro-active, integrated approach which focuses on larval mosquito control. The City of Prince George mosquito 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 local adult mosquito populations.

Public education during the term of this PMP may involve regular news media exposure, public information meetings, pamphlets, doorknob hangers and notice boards within localised treatment areas, field personnel interaction with residents, visitors and business operators. These initiatives increase the general 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 biorational 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 Prince George.

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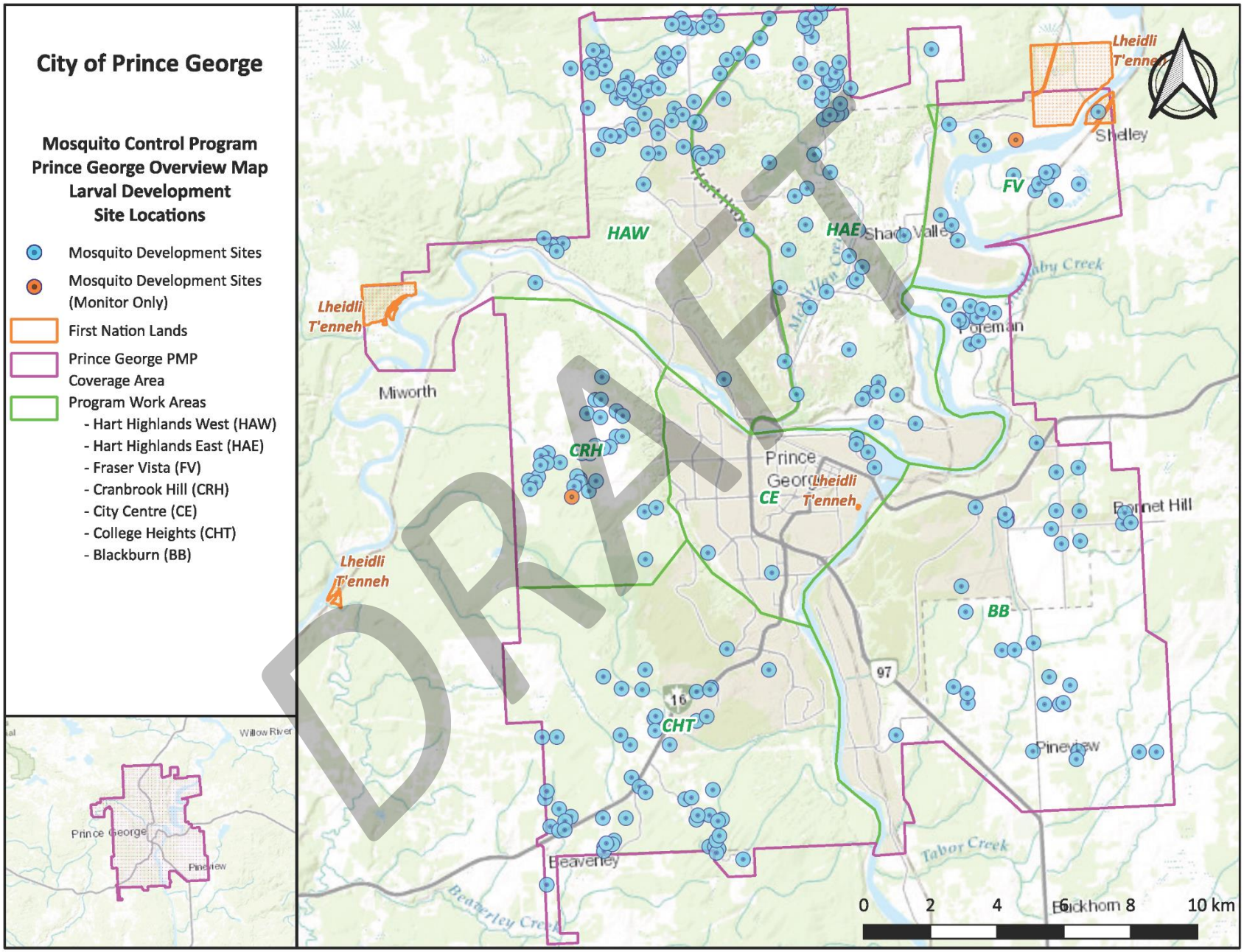

Figure 1: City of Prince George Mosquito Control Program Area Overview Map