THE CITY OF DELTA

MOSQUITO POPULATION MANAGEMENT AND CONTROL

INTEGRATED PEST MANAGEMENT PLAN
2021 - 2026

PMP # 700-0005-2021/2026

Adult mosquito, *Aedes sp.*

Plan Prepared by
Duka Environmental Services Ltd.
Langley, BC

for
The City of Delta
Climate Action and Environment
Delta, British Columbia

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1.0 PEST MANAGEMENT PLAN SUMMARY

The City of Delta and surrounding area has significant recreational and environmental value, providing residents and visitors with many outdoor summer activities and employment. Walking, running, cycling, bird watching, outdoor sports, 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. An integrated pest management (IPM) approach to mosquito population management and control can reduce overall annoyance levels and co-exist with these valuable resources.

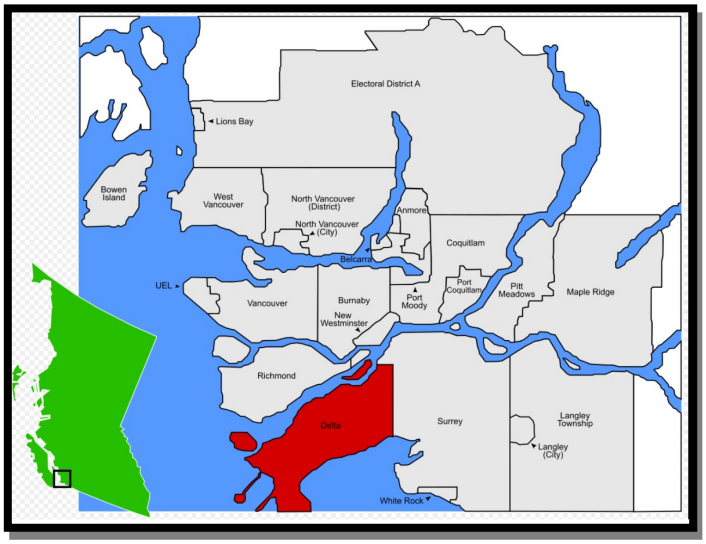
The annual mosquito population management and control program provided by the City of Delta (Delta) would employ a comprehensive, Integrated Pest Management (IPM) approach to control. This approach focuses on the timely detection and treatment of larval mosquito populations using biological products and methodologies. Where possible, and appropriate, physical or cultural controls are recommended, and implemented, that reduce larval habitat and enhance, or conserve natural mosquito predators. Where required, larval mosquito populations would be controlled using the bio-rational larvicide product VectoBac® 200G (*Bacillus thuringiensis* var. *israelensis,* PCP #18158) and VectoLex (*Bacillus sphaericus,* PCP # 28008, 28009). All treatments would be completed in accordance with the methodologies and procedures prescribed in the BC Ministry of Environment-accepted Pest Management Plan for Mosquito Control, prepared by *Duka Environmental Services Ltd.* on behalf of the City of Delta for the years 2021-2026.

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 Delta. 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 Delta.

The mosquito control program proposed for the years 2021-2026 is largely unchanged from that of past seasons and focuses on larval control and reduction of populations. This PMP meets all the requirements of the *Integrated Pest Management Act* and will replace the previously approved, and soon to expire (2020), PMP # 700-0004-16/21.

Pest Management Plan (PMP)# 700-0005-21/26 reviews mosquito biology, the types of larval mosquito habitats affecting the program area and the local mosquito species complex. An integrated PMP approach to mosquito population management and control can reduce overall adult mosquito annoyance. This PMP outlines the procedures and methodologies which will reduce local mosquito populations and their habitat, where appropriate, for the purpose of preventing mosquito annoyance for area residents and visitors.

1.1 Geographic Boundaries of this Pest Management Plan



Delta is located within the Fraser Valley Lower Mainland, south of the Fraser River and the Municipality of Richmond, and west of the City of Surrey. It encompasses a total area of some 364 km^2 or 36,400 hectares and is home to over 100,000 people.

The southern and western boundaries of Delta are defined by Point Roberts (USA) and the Pacific Ocean: Boundary Bay and Mud Bay to the south and Roberts Bank to the west. With a rich farming and agricultural history, Delta contains three distinct community centres where residential, commercial and light industrial businesses are concentrated. These are Ladner, Tsawwassen and the North Delta /Tilbury areas.

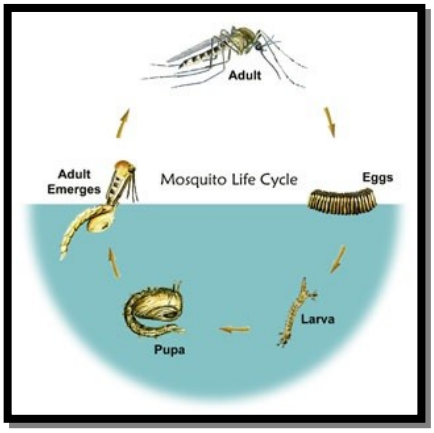
These four distinct areas provide a varied mixture of farmlands, sport fields and parklands, golf courses, natural forested areas, creeks, swamps, ponds, coastal beaches, mudflats and salt marshes. The largest raised peat bog (Burns Bog) in North America is located roughly in the centre of Delta, between the Fraser River to the north and Mud Bay to the south, and between the communities of Ladner and North Delta. Recreational summer activities include organized sports (baseball, football) camping, hiking, fishing, boating, bird watching, swimming, sight-seeing, photography, cycling and golfing. Widespread annoyance from adult mosquitos detracts from outdoor enjoyment and worker safety.

In addition, the Tsawwassen First Nation (TFN) is located adjacent to Delta, south of Roberts Bank and near the BC Ferries terminal. TFN is a distinct community outside of the municipal boundaries of Delta and is approximately 660 hectares in size and home to about 700 residents. Residential and commercial development on TFN lands has added upwards of 1000 additional residents and a large shopping mall development. TFN intend to prepare their own Pest Management Plan and delivery of nuisance mosquito control services to their community independent of Delta.

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.

Adult mosquitos feed on plant juices and it is only the female which requires a necessary blood meal to complete the development of her eggs. Any container, pond, or depression, either natural or manmade, which is capable of holding water for several days, to a few weeks, can provide development habitat for larval mosquitos.

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

Mosquitos are best known as vectors of 'tropical' diseases such as malaria and yellow fever. Although these exotic afflictions are extremely rare in British Columbia, mosquitos can still pose a serious health concern. Extreme allergic reactions or secondary infections from mosquito bites can occasionally require hospitalization. Diseases such as canine heartworm, Western Equine Encephalitis (WEE) and West Nile virus (WNv) are transmitted from some mosquito species to family pets, humans, and livestock.

The BC Centre for Disease Control (Vancouver) and local health authorities are responsible to coordinate the surveillance, identification and reporting of these diseases and their mosquito vectors. As part of this planning the BCCDC has developed the *Arbovirus Surveillance and Response Guidelines for British Columbia,* and the BCCDC has a provincial database containing all mosquito, bird and human health surveillance data relating to WNv and 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. Specific details on the response guidelines, surveillance, permitting, and other related information is available online through www.BCCDC.org

1.3 Need for Mosquito Control

The purpose of an annual mosquito control program is provide residents, workers and visitors to the City of Delta with relief from extreme and/or persistent adult mosquito annoyance. The control program is not intended to, nor is it possible to eradicate local mosquito populations.

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.

The goal of the annual mosquito control program is to provide residents and visitors to the City of Delta area with relief of adult mosquito annoyance through proactive larval mosquito control using an Integrated Pest Management (IPM) approach to surveillance and control. However, since mosquitos capable of vectoring diseases to man are often the source of localized annoyance (human biting), the control of mosquito populations known to cause nuisance also provides the benefit of controlling mosquito species having the potential to vector disease, including WNv. 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.

The City of Delta Mosquito Population Management and Control Program Pest Management Plan, PMP # 700-0005-21/26, described in detail below, is presented in a format which adheres to the

requirements of *Integrated Pest Management Act and Regulation,* including amendments, the *Mosquito Management Sector Review Paper* and BC Ministry of Environment, Integrated Pest Management Program (2007) *Guidelines for IPM Proponents Conducting Consultations with First Nations*. Copies of these documents may be accessed through the BC Ministry of Environment home page at www.env.gov.bc.ca/epd/epdpa/ipmp/pestact/index.html. Common themes of larval development identification, prevention and control necessary to achieve the program's goals, while ensuring environmental protection, are repeated throughout this document.

The Pest Management Plan is 'owned' by the City of Delta. It would remain in place for the purposes of larval mosquito population management and control for the five year period, 15 April 2021 to 14 April 2026. 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.

A professional, experienced, environmental services firm (the consultant) is retained by the City of Delta to deliver these very specialized services and to ensure adherence to the Pest Management Plan. The consultants for the City of Delta annual 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 notice boards, informational brochures, websites, newspaper articles, websites 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 were advised of measures they could undertake to reduce mosquito development and annoyance from adult mosquitos.

1.4 Term of the Pest Management Plan (PMP)

A five year period, extending from 15 April 2021 to 14 April 2026.

The designated contact for this Plan is Mr. Mike Brotherston, Manager, Climate Action and Environment, City of Delta, 4500 Clarence Taylor Way, Delta V4K 3E2. Telephone # 604-946-3253.

2.0 MOSQUITO CONTROL PROGRAM BACKGROUND

The geographical area covered under the PMP is defined as the boundaries of the Corporation of Delta which has a total area of approximately 364 km^2 (36,400 ha). Larval mosquito habitats within this area include river flood and seepage areas, freshwater marshes, ponds and ditches located in low-lying forested areas, farm fields, undeveloped areas, along roadsides and salt marsh habitats located along the Boundary and Mud Bay areas. Additional larval development habitats include roadside catch basins and temporary sites such as water-filled tire ruts, depressions, un-used or abandoned pools or boats, canoes and containers.

Mosquito control in Delta was first undertaken in 1980-1981 when in-house Environmental Department personnel completed initial surveys and treatments using Abate 2G (temephos, an organophosphate) in Tsawwassen and Mud Bay salt marshes in response to resident reports of nuisance by area residents. Beginning in 1982 the Corporation began to contract the work to outside environmental consultants with specific pest management experience.

Control program operations have always sought to reduce adult mosquito annoyance for residents in North Delta, Ladner and Tsawwassen to acceptable, tolerable, levels. Over these forty seasons the annual program has continued to evolve to increase its environmental compatibility, it effectiveness, and its affordability for Delta residents. The City of Delta annual mosquito control program has always been one of innovation and adaption.

Delta has been involved in several larvicide research trials including Federal regulatory agencies such as the Environmental Protection Service (EPS), Agriculture Canada, the Pest Management Regulatory Agency (PMRA) and the provincial BC Ministry of Environment, Integrated Pest Management Branch, with regards to the Canadian Pest Control Products Act (PCP) registration of the bio-rational larvicides VectoBac (*Bacillus thuringiensis* var. *israelensis*) and VectoLex (*Bacillus sphaericus*). These products are now the most widely used bio-rational larvicides in North America and developed countries throughout of the world. The establishment of predictive indices for larval mosquito development, particularly for *Aedes* mosquitos, using river freshet and tidal height fluctuations were first developed at Delta, and modified over the past forty seasons to effectively forecast the onset of larval eclosion (hatching) and distributions, both temporal and by location.

The first 21 years of mosquito control at Delta were focused exclusively on nuisance mosquito control efforts. Beginning in 2003, mosquito control was expanded with increased surveillance, development site identification, mapping and the inclusion of new habitats, such as catch basins, which had previously never been considered for routine larval mosquito control. These expansions of surveillance and control activities occurred province-wide and with provincial funding support for the purposes of preventing disease occurrence, specifically, West Nile virus.

Surveillance and pre-emptive control of WNV vector mosquitos by participating communities was suspended province-wide in 2010 with the elimination of provincial funding and support. The BC Centres for Disease Control (BCCDC) is responsible for coordinating the province's response should WNv occur in BC.

The annual mosquito control program provided by the City of Delta focuses mosquito population 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.

The largest sources of mosquito development within Delta, totalling some +20 hectares, are two salt marsh habitats located along Boundary Bay and Mud Bay. Another large saltmarsh habitat exists at the TFN adjacent, and to the north of the BC Ferries Highway 17 causeway. Additional habitats include Fraser River flood and seepage areas, natural sloughs, marshes, ponds and manmade irrigation and display ponds, ditches, roadside catch basins and temporary habitats along public roadsides, in parks, on private properties and in farm fields and undeveloped lands. Figures 1–4 present the primary sources of larval mosquito development (salt marshes) and other, smaller larval habitats known in the Delta.

Approximately 80 hectares of potential nuisance mosquito development habitat have been identified within control program boundaries. There are over 100 larval development site locations and some +120 sites, excluding the multiple pools, ponds and channels of salt marsh habitats.

The mosquito control program and methodologies (the PMP) developed for Delta 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 which explains mosquitos, the program, and how the public can contribute to successful operations;
2) Surveillance and identification of mosquito species and their distribution;
3) Timely implementation of mosquito controls and preventative measures;
4) Review of results achieved and adaptive management during a season; and,
5) Program evaluation and assessment to ensure sustainable, effective controls have been achieved.

The annual mosquito control program focuses mosquito population 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 contained within the control program are agricultural, residential, light industrial and commercial properties (lumber yards, landscaping, shopping malls), recreational (golf courses, passive parks, sport and playing fields, etc.), forested and undeveloped lands. In addition to organized sports activities, outdoor summer recreational activities include walking, hiking, photography, golfing, camping, fishing, boating, sight seeing and bike riding.

2.2 Mosquito Species Identified within Delta

Mosquito development occurs in a wide range of open water larval habitats, ranging from tidally-influenced flood and seepage water pools and channels to permanent freshwater, ponds, marshes, ditches and similar water-holding depressions. Bird baths, plugged rain gutters, livestock watering troughs, irrigation and surface water run-off collection ponds, ditches and any other man-made container or excavation capable of holding water for a period of at least seven to ten days days can provide suitable larval mosquito habitat. Left undetected, larval mosquitos will complete their development to adult within this time span.

Mosquito species collected locally from Delta include:

Aedes cinereus	*Culex pipiens*	*Culiseta impatiens*	*Anopheles punctipennis*
Aedes dorsalis	*Culex tarsalis*	*Culiseta incidens*	
Aedes implicatus	*Culex territans*	*Culieta inornate*	*Coquillettidae perturbans*
Aedes increpitus			
Aedes intrudens			
Aedes sticticus			
Aedes vexans			

Aedes mosquitos comprise, depending on conditions, 20-40% of annual sample collections. *Aedes* mosquitos are aggressive biting pests which prefer permanent, or recurring habitats such as salt marshes (*Ae. dorsalis*), and temporary habitats (*Ae. vexans*, *Ae. sticticus, Ae. increpitus)* including surface water run-off, and freshwater seepage, floodwater and precipitation accumulations in low-lying fields, backwater sloughs, marshes and deciduous forest areas. Developing in response to fluctuating water levels occurring with river freshet and regular tidal fluctuations, *Aedes* mosquitos are the most numerous during the first half of the season, from

late April through July. Receding river levels, decreasing tides and increasing ambient temperatures, evaporation and decreased precipitation typical to late July and August causes many of these habitats dry, drain and disappear.

Culex and *Culiseta* mosquitos typically develop later in the season, from June through August, and require a different set of cues to initiate the onset of larval development including day length and temperatures. They prefer permanent and slow-draining, or frequently-refilled sites including natural and man-made irrigation and display 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. Species such as *Culex tarsalis* are able to withstand brackish waters and a high degree of pollution. They can inhabit areas with high organic content, including septic field seepage, sewage lagoons and livestock hoof prints around barns, feed lots and along creeks. *Culex pipiens*, the "house mosquito", can use a large variety of freshwater habitats including manmade containers and they are the predominant (+99%) mosquito developing in catch basins.

Culex, Culiseta and *Anopheles* are the most numerous during late summer when drier conditions and warmer conditions typically exist. Although their populations and individual development sites are not usually as large as the synchronous hatching *Aedes* mosquitos, *Culex* and *Culiseta* mosquitos are capable of producing several generations in a typical season. They can be a source of reportable annoyance since their preferred habitats are common to residential, commercial, recreational and agricultural properties.

All of the species collected above are able to develop as multiple hatches during the season. With the exception of *Cu. territans*, all are capable of causing reportable and often extreme annoyance, particularly *Aedes,* and locally collected *Ae. dorsalis*, *Ae. vexans* and *Ae. sticticus* are all potential West Nile virus (WNv) vectors. *Culex* and *Culiseta* mosquitos are not only a source of annoyance but they too are also recognized as vectors of several diseases, including WNv. *Culex tarsalis, Culex pipiens* and *Culiseta incidens* are identified by the BC 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.

2.3 Mosquito Control Program Operations

In response to resident, workers and visitor reports of recurring adult mosquito annoyance, the City of Delta has worked to provide an effective nuisance mosquito control program for residents, workers and visitors, annually for nearly forty years. During this time the program has evolved to become an example of environmentally-sound, and sustainable mosquito control using an 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 are 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 one hundred natural and man-made larval mosquito development habitat areas, several with many individual sites, have been identified within the Corporation of Delta, Figures 1 - 4. Ranging in size from less than $10m^2$ to over 25 hectares in total treatment area, these sites vary in description from a single, roadside ditch, irrigation or golf course display pond to salt marsh habitats which may contain a hundred or more individual, temporarily-filled ponds, ditches and depressions. Flooding and seepage water accumulations from spring and summer tides provide extensive habitat for repeated *Aedes dorsalis* larval development in area salt marshes. Stagnant and non-flowing ponds and ditches, most of them manmade or influenced, provide ideal freshwater larval mosquito development habitat and often have the greatest diversity of species. Catch basins are located throughout the community along roadsides, in parking areas and in non-playing and passive grass areas at sports fields and ball diamonds.

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 habitat.

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 larval mosquito development site database.

2.4 Control Products (Larvicides) Proposed for Use

The City of Delta annual mosquito control program has been developed with a focus on larval reduction and control initiatives which use biological control products. The bacterial mosquito larvicides VectoBac 200G (PCP # 18158), VectoLex CG (PCP # 28008) and VectoLex WSP (PCP # 28009) are the control products of choice under this PMP. Both VectoBac 200G and VectoLex

contain spores and crystals produced by *Bacillus,* a naturally-occurring soil bacteria and as such they are classed as a bio-rational control. See the Appendix for copies of the manufacturer's product labels, or contact www.valentbiosciences.com for more information.

Larval mosquito populations would be controlled from the ground and by hand or motorized back pack spreader-broadcast using VectoBac 200G and VectoLex CG or WSP. Section 3.4.3 Bio-rational Control, and the Appendix discuss the products VectoBac and VectoLex further. Other, equivalent products may be used. These would be identified to the BCMOE with the annual Notification of Intention to Treat.

3.0 CONTROL PROGRAM METHODOLOGIES

The objective of the annual mosquito control program is to reduce the potential for widespread adult mosquito annoyance for residents, workers and visitors to Delta and its community centres of Ladner, Tsawwassen and North Delta. A program of this scope is not intended, nor could it, eliminate the local mosquito population. The total eradication of a widespread, fecund insect pest such as mosquitos is not feasible.

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.

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 bio-rational control (larvicide) products, VectoBac and VectoLex. Drainage, filling of depressions, restoration of flow in ditches or other physical alterations to appropriate larval mosquito development sites is the preferred and permanent control method. Physical control 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. Specifically, the bio-rational larvicides, VectoBac 200G and VectoLex both made with the *Bacillus* sp. bacterium are the larval control products of choice. Section 3.4.3 discusses these products in detail and sample labels are provided in Appendix 1 or available on-line through www.valentbiosciences.com.

Routine adult mosquito control applications (adulticiding) for the purposes of nuisance mosquito control **are not** a component of the City of Delta Mosquito Population Management and Control Program and this Pest Management Plan.

The operational components of the PMP and the successful, annual, City of Delta 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 his or her designate, on PMP contents and the proposed mosquito population management and control program. In addition, those individuals or groups which had requested information or who have supplied input when the local mosquito control program was last advertised and approved are contacted directly each time the PMP is renewed.

The annual nuisance mosquito control program is well known and supported by area residents and businesses. Its highly visible nature using field biologists working along roadsides, in parks, golf courses, along dykes and salt marshes 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, television and radio interviews, 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.

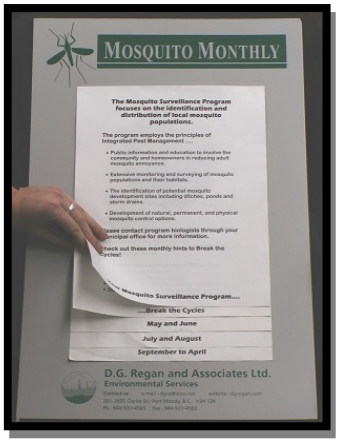
Considerable value can be obtained through exposure of the control program and interactions with the public. For example, public contact can result in the locating of new mosquito development sites thus augmenting efficacy. Residents are encouraged to contact control program consultants through Delta municipal offices (604-946-3253 or www.delta.ca) to report

potential sources of larval mosquitos (a waterbody) or adult mosquito annoyance. Suggestions for physical removal or source reduction on private property allow the owner to participate on a smaller scale. Once accomplished, physical source reduction, especially the removal of artificial containers, grading of depressions or filling of tire ruts eliminates the need for further attention.

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 given the nature of local geography. Public education further encourages residents and businesses to undertake actions for excluding adult mosquitos and modification of personal behaviours which will reduce the potential for annoyance. Through eliminating development sites on their property and learning to reduce adult mosquito annoyance through preventative actions residents can actively participate in their program. In addition to providing residents with information on how they can reduce larval development and annoyance around their properties, education initiatives help residents understand that the control program can only suppress mosquito populations, not eradicate them, and that some adult mosquito annoyance may be anticipated at certain locations, times of day and during some years.

Examples of some various public education and information initiatives which have been successfully employed in our other programs and which are available and have been deployed within the Corporation of Delta throughout the years include:

- *Informational Brochures* – these review mosquito biology and control, mosquito "myths", program operations and contact information for program biologists.
- Cardboard *Door Knob Hangers* - these "*Sorry we missed you*" door knob messages are left when residents aren't home during property inspections. They summarize field biologist site observations and have return contact information for resident use.
- Web-based (*www.delta.ca*) program information and service contact details



- Facebook account – another method of public access/information
- *Laminated posters* – durable. Can provide basic information on protection from annoyance. Installation along walking trails, picnic and camping areas is possible.
- *Mosquito Monthly* poster board - a 'flip chart' type of display board for placement in public access and reception areas of City Hall, at libraries, Recreation Centres, including pools and ice rinks etc.

- Newspaper Display Advertisements – placement in local newspapers from April – September. Provides pubic information relevant to each month and program contact/access information.
- *Newsmedia interviews* – provides opportunities to update the public on program operations and status, mosquito biology and additional public outreach
- *Presentations at Council meetings - (Power Point™).*
- *Open houses, farmers markets*
- *Radio, television and newspaper interviews and /or articles*

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

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 Mosquito Control Program Data Collection and Reporting

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

The City of Delta, Office of Climate Action and Environment would be regularly informed of control program activities of this contractor/consultant through personal contact, telephone, facsimile or e-mail with consulting 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 program consultants and submitted to the City on a regular basis during the operational phases of the control program.

At the conclusion of each annual nuisance mosquito control program season, a summary report detailing all activities and pesticide treatments completed under the PMP and it's BCMOE issued Confirmations is produced. 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, Integrated Pest Management would be completed by the consultant (as agents for the City), as requested and necessary.

At a minimum, the consultant would maintain the following information for their use in managing the program and to complete the reporting and information requirements of the City, the PMP, the Pesticide Use Confirmation, the *Integrated Pesticide Management Act and Regulations*, and the BC Ministry of Environment:

- a mosquito development site database with information including property ownership, address, contact telephone number, maps, photographs, GPS identification, public access information (paths, trails, roadways), 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 contractor, or the City, their wish to be excluded from the mosquito control program. The City will forward any such requests for program exclusion (avoidance) to the contractor who will confirm the request.

- a list and/or maps identifying, where necessary, 'AVOID' areas such as fish-bearing waters or other 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 (eg. bird nesting sites) is unknown, a local representative of the Department of Fisheries and Oceans (DFO) Canada or the BC Ministry of Environment (BCMOE), or other agencies where appropriate, would 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.

3.3 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 Delta 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.

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, river levels, tidal heights, 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 river levels, tidal fluctuations and summer weather conditions, 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.

- ***Larval mosquito monitoring***

~200 larvae/350ml dip sample

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 completed on a 6-10 day basis, depending on conditions and observations, throughout the operational season, typically mid-April to mid-September.

Larval mosquito populations as small as one larvae per 350ml dip sample in an area as small as a backyard swimming pool (5m x 10m) can produce thousands of adult mosquitos over the course of a season. Located adjacent to established outdoor recreational facilities including golf courses, sports parks, water

slides, picnic areas, campgrounds and nearby residential and commercial areas, salt marsh and permanent sites (ponds, ditches, catch basins) are a major source of potential mosquito annoyance and a primary focus of the annual mosquito control program.

Pre-treatment surveys determine the extent of larval development which ensures that control measures are directed only to those areas containing larvae. In addition to providing pre-application information essential to timely control applications, surveying and monitoring following treatment, 'post-treatment monitoring' allows for an evaluation of the degree of control achieved from a particular 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 (VectoBac 200G and Vectolex CG and WSP) application.

- ***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 infra-red 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 $C0_2$, 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 in our laboratory according to the taxonomic keys of Darsie and Ward (1981) and Wood, Dang and Ellis (1979), and others as appropriate.

3.3.1 Mosquito Development in Delta

The largest mosquito development sites in Delta are tidally-influenced ponds, channels, ditches and temporarily flooded depressions in salt marsh habitats located in two primary locations: outside the Boundary Bay dyke between 72nd-96th Streets, and outside the dyke at Mud Bay. The extent and frequency of *Aedes dorsalis* larval development in these habitats occurs in response to a number of influences including precipitation, temperature, tidal fluctuations and resultant seepage. Developing in a synchronous response to fluctuating water levels *Ae. dorsalis* mosquitos hatch throughout the salt marsh and are most numerous during the first half of a season when flooding is also greatest, typically April through July.

In addition to the Delta salt marsh sites is the Tsawwassen First Nation (TFN) salt marsh which is the most prolific salt marsh mosquito development site in the area. Although largely contained within a dyking system, direct connection to Georgia Strait is permitted through five large culverts, ditches and a large, natural channel. Several days of sustained tides exceeding 4.0 metres (measured at Point Atkinson), fills the expansive 'culvert and ditch'

system. Resultant lateral and vertical seepage produces water accumulations in ponds and isolated channels scattered throughout the marsh. With extreme tidal heights (greater than 4.5m), or frequent rainfall, much of the expansive, low-lying grassy areas in the marsh become flooded. Egg eclosion (hatching) occurs within hours of inundation and over the next several days larval development occurs throughout the Tsawwassen salt marsh, and is at its greatest during peak tides in excess of 4.5 m. The Tsawwassen salt marsh will be covered under a separate PMP with larval surveillance and control to be provided by TFN personnel and a selected contractor. Delta and TFN share information on treatment and monitoring efforts that have implication across their jurisdictional boundaries.

The other salt marsh habitats important to the nuisance mosquito control program and area residents are those at Mud Bay and the end of 72nd Street. Both salt marshes are located outside the Boundary Bay dyking system adjacent to large, un-vegetated mud flats. They contain numerous depressions, winding channels and a perimeter of grasses along the dyke edge. Because they are located outside the dyke, there are no barriers to rising tidal waters. Tidal heights as low as 3.0m (as measured at Pt. Atkinson) produce flooding sufficient for larval development. Higher tides (4.0m and greater) produce water accumulations in the driftwood and grassy areas adjacent the dyke. Larval development in these sites is often delayed, typically occurring 1-2 days after 'mud flat' and margin areas and can be protracted since the deeper waters do not often recede or evaporate rapidly.

Regular monitoring of salt marsh habitats and correlations with tidal heights during the season ensures that larval mosquito development does not proceed unchecked. With larval populations averaging between 50-100 larvae/350ml dip sample, multiple hatches in a season, and an area amounting to upwards of 50% of the total mosquito development habitat in Delta, the control of larval development in salt marshes is essential to prevent widespread adult mosquito annoyance.

Irrigation, display and water run-off/collection ponds located on farmlands, residential properties, public parks and area golf courses also provide ideal habitat for larval development. Largely permanent, these sites fluctuate in size and depth throughout the season in response to seepage and surface water runoff accumulations from precipitation and human activities including field irrigation, equipment and vehicle washing, dust control and site clean-up. These permanent and temporary development sites can support larval mosquito populations for as long as they contain water. The remaining larval mosquito development habitats of this type are roadside ditches and depressions. As a result of ongoing and long-term ditch maintenance programs (grading, vegetation removing, culvert cleaning) larval development in these types of sites is highly variable from season to season and site to site.

The locations and distribution of freshwater mosquito development sites such as ditches, ponds and tire ruts or seepage near outdoor work sites, recreational areas, businesses and residential properties makes them important sources of localized adult mosquito annoyance if not effectively monitored and controlled. Species collected from manmade and natural, freshwater development sites locally during the past few years include: *Aedes increpitus*, *Aedes vexans, Culex pipiens*, *Culex tarsalis, Culiseta incidens* and *Culiseta inornata.*

Although their populations and individual development site sizes are not usually as large as the synchronous hatching *Aedes* sp. mosquitos in salt marsh flood and seepage water habitats, *Culex* and *Culiseta* mosquitos make use of a large variety of habitats, including catch basins and containers such as stored tires and equipment, livestock watering troughs, buckets and bird baths. When discovered by field personnel during site inspections these man-made sites would be brought to the attention of property owners for removal, drainage or regular water changes which would eliminate their potential as sources of mosquito development and annoyance.

In response to resident and user reports (2013-2014) of adult mosquito annoyance at a number of Delta sports fields and parks, catch basins (CBs), located within the fields and parking lots at several sports fields and parks in Tsawwassen, Ladner and North Delta were first sampled in August 2014 and larval development was confirmed. Routine sampling of some 250+ CBs, located in 18 municipal parks had been completed annually during June, July, and August each year since. Field irrigation, precipitation, and water run-off cause many of these to hold water during a typical season.

Larval sampling confirms the predominant species occuring in catch basins is *Culex pipiens*.

3.4 Mosquito Control Options

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 development site water levels, fluctuations, water and ambient temperatures, humidity, and precipitation.

Each mosquito development site will have its own unique requirements and treatment options. The PMP for this mosquito control program uses a combination of techniques, and an IPM approach, to achieve the management and 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 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 increasing habitat for natural mosquito predators. The use of a bio-rational control products such as *Bacillus thuringiensis* var. *israelensis* (VectoBac 200G) and *Bacillus sphaericus* (VectoLex CG and WSP) 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 bio-rational product oriented.

3.4.1 Physical Control

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. Clearing ditches 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 of roadside depressions may be a suitable solution to localized larval development by permitting the drainage of temporarily flooded areas. Grading or filling of depressions and tire ruts may reduce an area's potential to retain water. When completed as part of routine maintenance activities by public works crews they can be effective means of reducing local mosquito populations. Any such activities along public roadways, in parks or other publicly-owned

properties would be coordinated through the appropriate public works and engineering departments. The BCMOE, DFO and other government regulatory agencies, as appropriate, may also need to be consulted prior to any such planned work.

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.

Where possible, and appropriate, public works crews, residents and business operators are encouraged to remove, or alter standing waters which provide suitable habitat for larval mosquito deveopment. 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, 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.

Installation and maintenance of window screens, mosquito magnets™ (adult mosquito traps) and the use of mosquito repellents by individuals provides additional protection from potential adult mosquito annoyance and potential disease transmission.

3.4.2 Biological Control

Biological control involves the use of predators, pathogens, and parasites to reduce mosquito populations. Insects predators, both aquatic (ie. dragon flies, beetles) and terrestrial (ie. 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, gold fish) 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 (*eg.* 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. Interested residents would however still encouraged to install bird nesting boxes or bat houses 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 naturally occurring soil bacteria, *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *Bacillus sphaericus* (*Bsph*) have highly specific insecticidal properties and are discussed below.

3.4.3 Bio-rational Control

The mosquito control program at Delta would use VectoBac and VectoLex larvicides products for larval mosquito control. VectoBac and VectoLex are the closest form of a natural or biological control agent currently available for routine use in operational mosquito control programs. 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 thurinigiensis* var*. israelensis, Serotype H-14 Strain AM65-52; Bti)* and, as such, is classed as a bio-rational, rather than conventional, pesticide.

VectoBac acts on the larval mosquito stomach and must be eaten to effective. VectoBac 200G 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 is recommended by the manufacturer 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.

Similar to VectoBac 200G, VectoLex CG also contains a naturally occurring, spore-forming soil bacterium. VectoLex CG contains spores and crystals produced by *Bacillus sphaericus.* It also is classed as a bio-rational, rather than conventional, pesticide. Like VectoBac, VectoLex acts on the larval mosquito stomach and must be eaten to be effective. VectoLex is very specific and produces lethal effects in a narrow range of mosquito species, including *Aedes vexans* and most *Culex* and *Culiseta* mosquito species. It has also been found to be an effective control for *Coquillettidae perturbans,* an aggressive adult pest of humans. Known as the "cattail mosquito" because of the unique adaption of the larval siphon and pupal "trumpets", which are serrated, for attachment to young cattails, they can access the air in these hollow plants as a source of oxygen. Because there are not "free swimming" like most other larvae they are not generally collected in larval sampling. Several areas in Delta (Tilbury, Ladner and North Delta) have a

significant amount of cattail (*Typha* sp.) swamps. The use of VectoLex CG and VectoLex WSP in several of these sites has greatly reduced anecdotal reports of adult mosquito annoyance. Like VectoBac, VectoLex larvicides do not have any effects on man or animals, fish and other insects which may use these aquatic habitats.

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

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.

Catch basins in 18 municipal parks, typically located in the grass areas and spectator seating areas between sport fields and baseball diamonds, and others around picnic and parking areas could also be treated with VectoLex WSP. Applied as one 10gm satchel per catch basin, typically two applications per summer season have been required.

The use of *Bti* and *Bsph* 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.

See the Appendix for copies of the manufacturer's product labels for VectoBac 200G and VectoLex CG and WSP, or contact www.valentbiosciences.com for more information.

3.4.4 Chemical Control

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

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

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

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

The City of Delta 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.

3.5 Mosquito Control Program Operations

Approximately 100 potential larval development sites and over 80 hectares of mosquito habitat have s been identified within the City of Delta. The actual total area that will become infested and require larvicide treatment each season is dependent on hydrological and meteorological events. Fluctuating water levels in floodwater and seepage-influenced development sites, both freshwater (Fraser River) and salt marsh (tidal) cause recurrent larval development with many sites requiring 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 of Delta reduces the potential for adult mosquito annoyance by focusing on the identification and timely control of larval populations occurring within the City.

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.

3.5.1 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 conditions of the approved PMP, with regulations contained in the *Pest Control Products Act*, the *Pesticide Control Act*, 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 City of Delta mosquito 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.

• confirm the boundaries and/or locations of 'AVOID' areas, including surface (drinking) water intakes or wells, and identify these with flagging tape, ribbons or suitable equivalent, if required.

• identify AVOID areas, fish-bearing waters or other areas of environmental sensitivity (ie. bird nesting sites) and the need for, and size of, any Pesticide Free Zones (PFZs) and Pesticide Buffer Zones (PBZs).

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

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

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

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

• 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 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 general public of impending applications through public notices, news media articles, advertisements and ongoing personal contact.

3.5.2 Larval Mosquito Control, Treatment Thresholds and Application Rates

VectoBac and VectoLex 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 in recurring salt marsh habitats, 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 have not have been treated as completely, as desired, because of conditions on the day, changing water levels or because of subsequent hatching. Also, application rates can be lower, and therefore material costs, and overall mosquito larvicide use rates in the environment are reduced. Even though the products products, Vectobac 200G (*Bti*) and VectoLex (*Bsph*), proposed for use in the program have the safest environmental profiles of any bio-rational larvicides in common use, decreasing any volume of control product is beneficial and maximizes environmental compatibility.

Treatments targeting all mosquito populations with later 3rd or 4th instars under the guise of allowing natural predators to impact some level of control is not encouraged. It is not recommended on *Bti* or *Bsph* product labels, or by the *Municipal Mosquito Control Guidelines (Ellis, 2005)*. Controlling mosquito larvae at their source, and as 2nd through 3rd instar larvae still contributes to the "food web". Predators will feed on 1st through 3rd instar larvae, and 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 some mosquito species occurring in permanent ponds, such as *Culex* or *Culiseta*, the two most common genera in these types of sites, this strategy is wholly impractical for *Aedes* mosquitos. *Aedes* hatch in large numbers, typically +100/dip, and inhabit temporary pools created by snowmelt, precipitation, river flood and seepage waters or salt marsh which may only last several days or weeks. These types of temporary habitats seldom have established natural predators and where they may occur they are typically inadequate to deal with larval populations of such extreme magnitude.

Delaying treatments to target populations with later 3rd or 4th instars is also not ideal. The potential for reduced feeding rates of later 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/M), thereby requiring more larvicide, increased field personnel surveillance and treatment time and reduced environmental compatibility.

VectoBac 200G larvicide is only applied when larval mosquitos are present. Typically upwards of 10 dip samples per development site, depending on site size, would be the minimum completed. 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 snowmelt, seepage water and similar temporary habitats. The threshold for 2nd and 3rd instar *Aedes* larvae would be 1 or more larvae/dip sample.

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 *Coquillettidae 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.

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.

All Vectobac 200G and Vectolex CG application rates would be within those recommended by the manufacturer. These rates range from 2.5 to 10.0 kilograms per hectare with applications completed under this PMP to be conducted at rates ranging from 4.0 to 8.5 kilograms per hectare. VectoBac and VectoLex application rates typically average 7.5 kg/ha which has been demonstrated over some 30 years on annual operation as effective under the conditions encountered at Delta. All applications are followed with post-application monitoring to confirm the effectiveness of treatments.

For catch basins, VectoLex WSP 10gm satchels, are applied as one per CB. 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 10m2 surface water. 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.

Applications of VectoBac 200G and VectoLex CG to within 10 metres of fish-bearing waters, or waters contiguous to fish–bearing waters, and potable waters or wells is anticipated. Waters contiguous with fish bearing water may be treated, as permitted on the Health Canada, Pesticide Regulatory Management Agency (PRMA) approved product labels.

3.5.3 Post Application Monitoring

Within 02-96 hours after (post) treatment with VectoBac 200G, larval mortalities would be confirmed through monitoring using a standard 350 ml mosquito dipper. The goal is for larval population reductions of 95%, or to levels averaging less than 1 larvae/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.

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 would be monitored at select locations to compare adult mosquito populations between various location and community centres. 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 Delta 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, residents and businesses 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.

4.0 QUALIFICATIONS OF PROGRAM PERSONNEL

The contractor supplying mosquito control services to the City of Delta will have all necessary Pesticide Vendor and/or Pest Control Service Licences. As required, all personnel working in the annual mosquito control program will be certified as pesticide vendors in the category of

"*Commercial Pesticides*" and/or as pesticide applicators in the category of '*Mosquito and Biting Fly Abatement*' or equivalent, as accepted by the BC Ministry of Environment.

Consultant mosquito control program management personnel would be Registered Professional Biologists. Field personnel would 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, 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 above, and in other sections of this PMP would be reviewed before handling, transporting, storing or applying pesticides.

Mosquito control program personnel will take all practical precautions to protect application personnel, the environment and the general public during all pesticide applications. Prior to any pesticide application field personnel are responsible to:

- review, and as required update, the development site database information for the mosquito control program. The database contains information on property ownership, address, contact telephone number, development site maps, photographs and records of past monitoring and treatment results. The database is continually being updated and contains information on all known mosquito development habitats, including those located on public and private lands.

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

- confirm the status and boundaries of properties where the owner or resident have indicated they wish to be excluded from the mosquito control program (AVOID).

- identify AVOID areas, fish-bearing waters or other areas of environmental sensitivity (ie. bird nesting sites), Pesticide Free Zones (PFZs) and Pesticide Buffer Zones (PBZs).

- confirm the locations of wells or other potable (drinking) water sources. No larvicides will be applied to potable waters for the purposes of mosquito control.

- inform the general public of impending applications through public notices, news media articles, advertisements and/or personal contact with property owners prior proposed treatments.

- review pesticide product labels, and comply with recommended application rates and directions regarding pesticide handling and application including safety gear, weather restrictions (wind, temperatures, etc) and other listed precautions.

5.1 Larvicide Transportation

During transportation, all pesticides would be secured to prevent an accidental spillage or theft. Granular VectoBac 200G and VectoLex CG larvicide products would be secured and handled to prevent tearing of bags, spillage and exposure to adverse weather conditions such as precipitation.

Mosquito Control program personnel will carry within their vehicles a suitable spill clean-up kit, basic first aid and appropriate personal safety gear and supplies.

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

5.2 Larvicide Storage

The City of Delta would provide secure, dry, well ventilated pesticide storage space for mosquito control larvicide (VectoBac 200G, VectoLex CG) within their secure public works facility. No large volumes of larvicide are stored on-site over the winter. In an average year, less than 200 kg of VectoBac and VectoLex larvicide is stored on-site to be available for program start-up in late April.

Emergency telephone numbers for police, fire, ambulance, Canutec, Dangerous Goods Emergency Spills, Poison Control, 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 larvicide use as described above and in relevant references. All avoidance areas, pesticide free zones and pesticide buffer zones would be established and appropriately identified prior to larvicide application.

No mixing is required. VectoBac and VectoLex granular larvicides are 'ready to apply'. They are supplied in thick, plastic plastic bags. All used and empty bags would be disposed of in municipal or regional landfills as directed by the manufacturer on the Pesticide Management Regulatory Agency-approved pesticide label and MSDS sheets. All handling of larvicides for application would be conducted in well ventilated, outside areas. 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, MSDS sheets and the manufacturer.

All larvicide applications would be completed from the ground by hand broadcast or backpack applicator.

Weather forecasts would be consulted, and current weather conditions (wind speed, temperature, precipitation) would be noted, and recorded, during all larvicide applications. Treatments would be suspended 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. Similarly, should precipitation be sufficient to cause larvicide (corn cob) granules to clump and clog backpack blowers, or similarly affect hand broadcast applications, treatments would be suspended until suitable conditions return.

In the event of accidental spillage, personnel would follow accepted spill containment and clean-up 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.

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) applicator.

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.

6.0 CONTROL PROGRAM SYNOPSIS

The mosquito population management and control program developed for the City of Delta utilizes a pro-active, integrated approach which focuses on larval mosquito control. The City of Delta 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 will involve regular news media exposure, public information meetings, pamphlets, doorknob hangers and notice boards, 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 bio-rational larvicides VectoBac 200G, VectoLex CG and VectoLex WSP.

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 Delta.

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

7.0 REFERENCES AND BIBLIOGRAPHY

American Mosquito Control Association 1973. Elements of Comprehensive Mosquito Control. Mosquito News. Vol. 3, No. 18, 86pp.

BC Centre for Disease Control, March 2004. *Arbovirus Surveillance and Response Guidelines for British Columbia. www.BCCDC.org*

BC Centre for Disease Control, 03 July 2008 ,. *BC WNv Mosquito Control Working Group. excerpt*: BC provincial *Mosquito Pest Management Plan.*

BC Centre for Disease Control website: http://www.bccdc.org

BC Centre for Disease Control, 29 May 2015. Email from Marsha Taylor, Epidemiologist, BCCDC.

B.C. Ministry of Agriculture and Food. *Mosquito Control Guide.* Queens Printer, Victoria, 1984.

Belton, Peter. *The Mosquitos of British Columbia.* Victoria: Handbook (British Columbia Provincial Museum) No 41, 1983, 189 pages.

Darsie, R. and Ward, R. , 1981. Identification and Geographical Distribution of the Mosquitoes of North America, North Mexico, American Mosquito Control Association, 313pp.

Ellis, R.A., 1985. Survey of Approaches Taken to Mosquito Control by other North American Jurisdictions, City of Winnipeg Parks and Recreational Branch, 19pp.

Ellis, Roy., 21 May 2001. *Municipal Mosquito Control Guidelines,* Health Canada Bureau of Infectious Diseases, 54 pages.

Fyfe, M., 2004. *Arbovirus Surveillance and Response Guidelines for British Columbia,* Draft 4.1., BC Centre for Disease Control, Vancouver, BC, 46p., www.bccdc.org

Lacey, L.A., M.S. Mulla., 1988. Safety of *Bacillus thuringiensis* ssp. *israelensis* and *Bacillus sphaericus* to Nontarget Organisms in the Aquatic Environment, 19pp.

Regan, D.G., et al., 1980. Investigations into the Use of Three Spined Stickleback Fish as a Mosquito Control Agent. Appendix to Lower Mainland Regional Districts' Mosquito Control Board Report, 18pp.

Regan, D.G., Harvey, D. et al., 1982. Use of *Bacillus* var. *israelensis* as a mosquito control agent. Can. Journ. Env. Hlth. Review, 14pp.

D.G. Regan and Associates Ltd., *Corporation of Delta, 2003-2010 Nuisance Mosquito Control Program Summary Reports.* Supplied annually.

D.G. Regan and Associates Ltd., *Corporation of Delta, 2005-2010 West Nile virus Control Program Summary Reports.* Supplied annually.

D.G. Regan and Associates Ltd., *Corporation of Delta, 2010-2015 Nuisance Mosquito Control Program Summary Reports.* Supplied annually.

Duka Environmental Services Ltd., *City of Delta, Pest Management Plan for 2016-2020 Nuisance and Vector Mosquito Control Programs.* March 2016.

Duka Environmental Services Ltd., *City of Delta, 2016-2020 Nuisance and Vector Mosquito Control Program Summary Reports.* Supplied annually.

Muhammad Morshed, BCCDC. *Sampling/identification of all specimens recommended.* Email 13 February 2015

Mahmut Dogramaci, et al. A method for Subsampling Terrestrial Invertebrates Samples in the Laboratory: Estimating Abundance and Taxa Richness, March 2010

Rebekah Sudia, Public Health Ecologist, Multnomah County Vector Control District, Portland Oregon. *Random sampling and procedures for adult mosquito sample identifications.* Email 17 February 2015

Service, R., 1976. Mosquito Ecology: Field Sampling Methods. Halsted Press, Toronto, 583pp.

Schleier, J.J., 2008. *Are Mosquito fish safe? – An ecological Risk Assessment for use in the Northwest.*, Montana State University, Bozeman, Montana. Presentation 48th Annual Northwest Mosquito and Vector Control Association meeting, Couer d'Alene,

Wood, D.M., Dang, P.T., Ellis, R.A., 1979. The Insects and Arachnids of Canada; Part 6, Diptera; Culicidae. Canadian Government Publishing Centre, Ottawa, 390pp

FIGURES

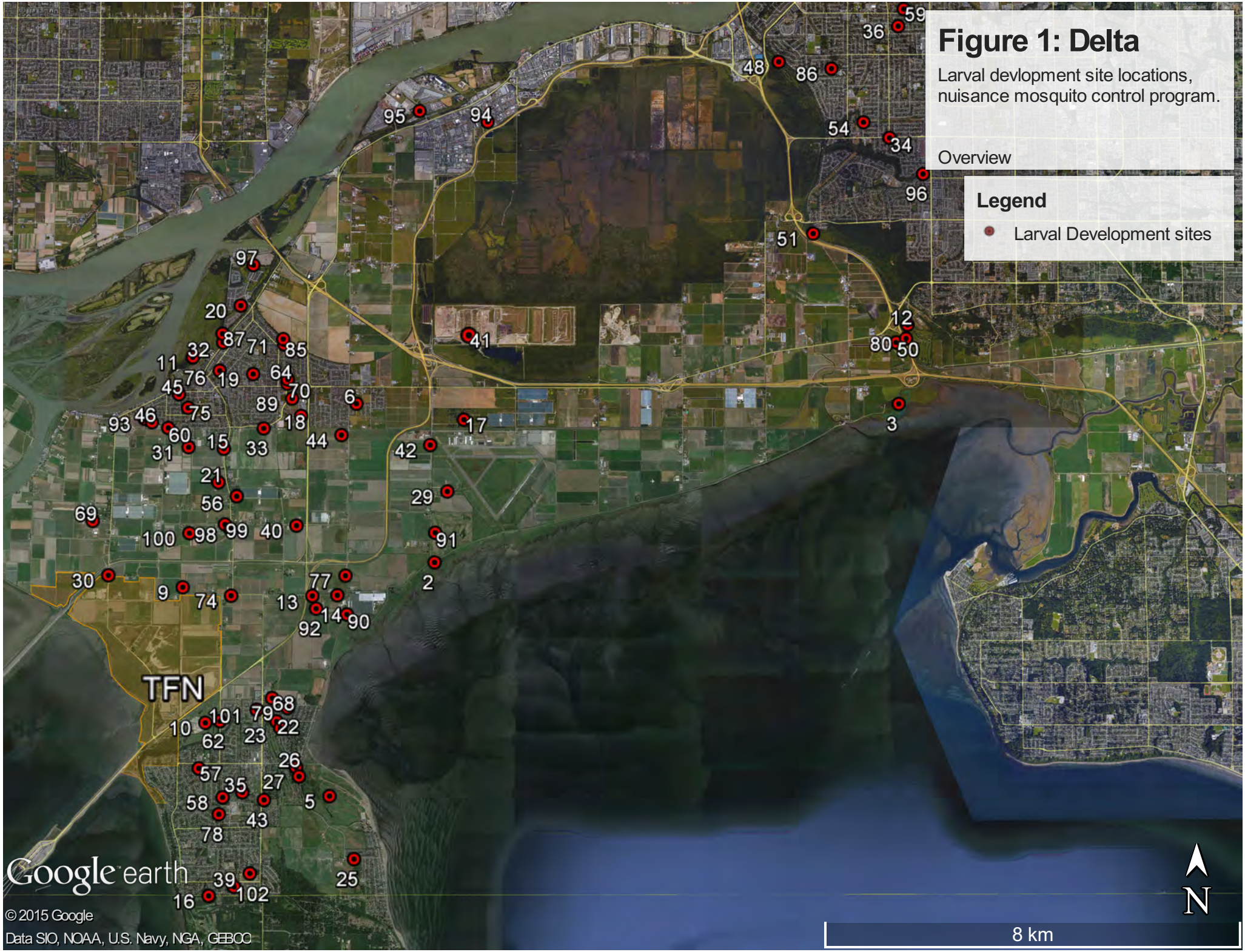


Figure 1: Delta
Larval devlopment site locations, nuisance mosquito control program.
Overview
Legend
Larval Development sites
TFN
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97
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12
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32
87
71
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Google earth
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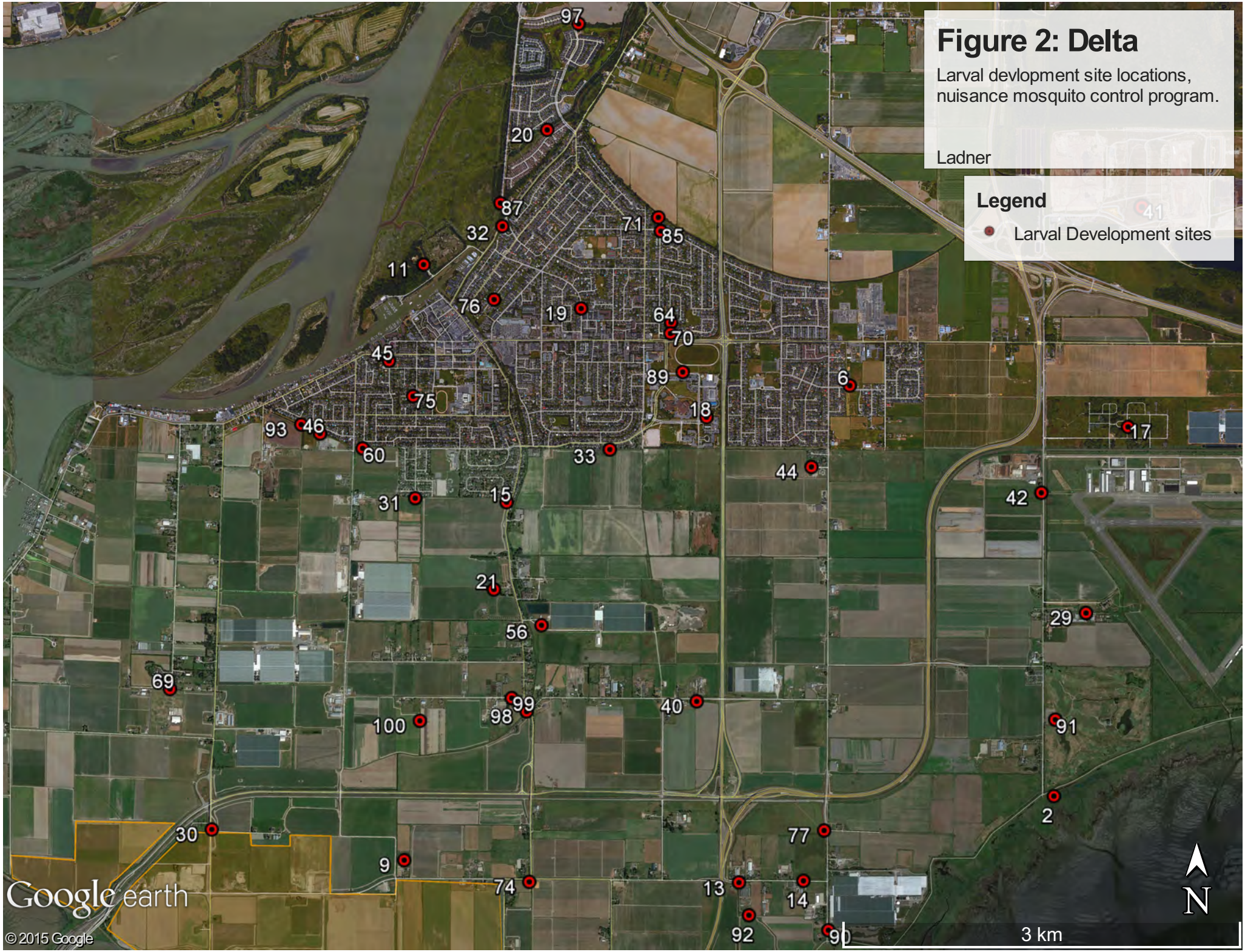
Figure 2: Delta
Larval devlopment site locations, nuisance mosquito control program.
Ladner
Legend
Larval Development sites
97
20
87
32
71
85
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76
19
64
70
45
89
6
75
18
93
46
17
60
33
44
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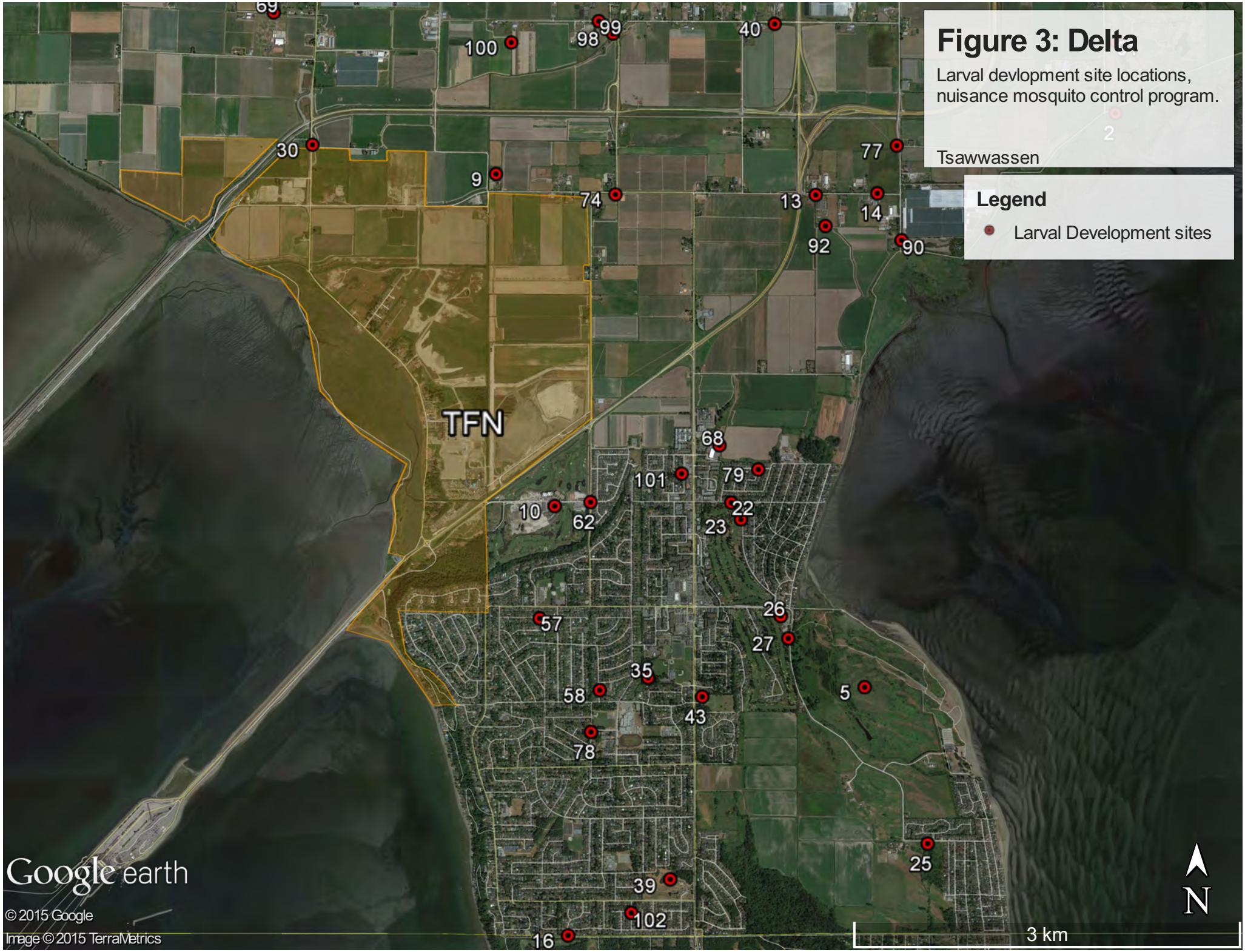
Figure 3: Delta
Larval devlopment site locations, nuisance mosquito control program.
Tsawwassen
Legend
Larval Development sites
TFN
69
100
99
98
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30
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74
77
13
14
92
90
68
101
79
10
62
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23
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27
35
58
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78
25
39
102
16
Google earth
© 2015 Google
Image © 2015 TerraMetrics
N
3 km

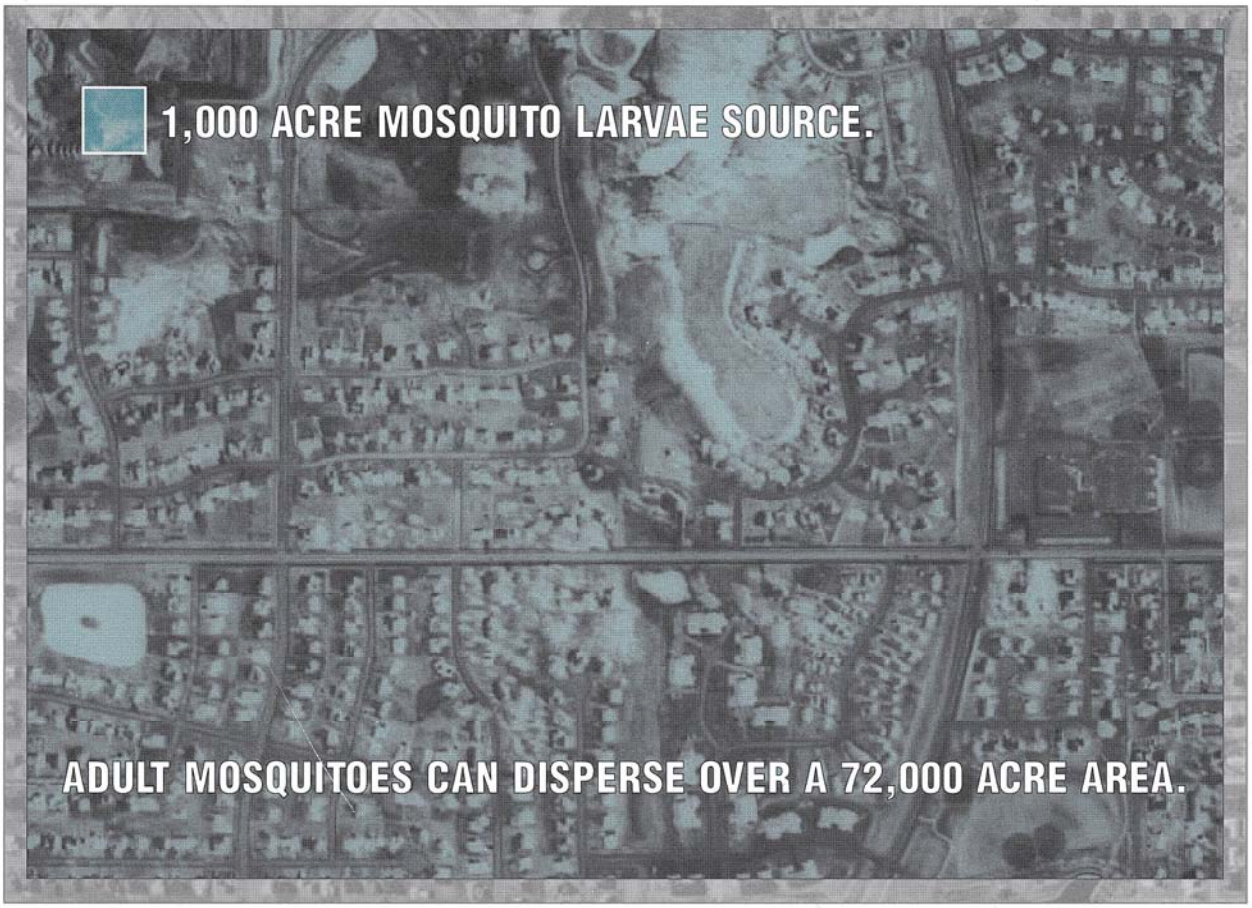

Figure 4: Delta
Larval devlopment site locations, nuisance mosquito control program.
North Delta and Mud Bay
Legend
Larval Development sites
49
59
36
48
86
54
34
96
51
12
80
50
3
N
3 km
Google earth
© 2015 Google

APPENDIX

VectoBac and VectoLex Product Information Package

LARVICIDING LOGIC

An example of the advantages of larviciding compared to adulticiding.



(image not to scale)

Why fog the air over **72,000 acres** of schools, residences, parks and wildlife areas when you can get superior mosquito control by larviciding only **1,000 acres** with VectoBac and VectoLex?

Pre-hatch: A sampling of a 1,000 acre source yields 10 larvae per dip. Conservative estimates project the mosquito population at this source to be approximately **5,000,000,000 mosquitoes.**

Post-hatch: With a 15 mile flight range and a 90° downwind spread, the 5 billion adult mosquitoes will disperse over a 72,000 acre area.

Larviciding at the 1,000 acre source with VectoBac or VectoLex will control the immense mosquito population with minimal cost per mosquito killed and minimal effect to aquatic life. This gives you the ability to STOP the pest BEFORE they ever get a chance to fly or take their first bite.

Adulticiding 1,000 acres once the mosquitoes have dispersed will control ONLY 69,000 of the 5 billion adult mosquitoes. To achieve the same control as VectoBac and VectoLex larvicides, you will need to spend more time and money to fog the entire 72,000 acres to suppress the mosquito nuisance which means spraying chemicals into your residential and wildlife areas.

NOTE: The model above does not fit all situations.

VectoLex® **For each extreme and everything in between** **VectoBac®**

VALENT BIOSCIENCES CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 • 800-323-9597

VectoBac and VectoLex

Making Cost-Effective Choices for Control.

VectoBac is most cost effective in habitats that tend to produce single, univoltine broods of larvae upon flooding, but do not hold water long enough for development of secondary larval broods. Examples include river flood plains, woodland pools, mangrove swamps, some salt marshes, prairie potholes and certain types of flood irrigated pastures. The key is that the habitat only remains productive for mosquito larvae long enough to produce one generation. Residual control is not as important in many of these situations.

VectoLex offers superior cost-effective control under the following scenarios:

Permanent water habitats where species, such as *culex* mosquitoes are the primary targets. These are the habitats that VectoLex has been commonly used in and include waste lagoons, septic ditches, catch basins, irrigation runoff areas, marshes and continuously irrigated crops such as rice.

Intermittently flooded sites that stay wet long enough for production of additional broods which may be made up of multiple mosquito species after the first flood.These sites include duck clubs, flooded citrus furrows, inland floodwater pools and pastures that remain wet for more than a week. Often, an *Aedes* or *Psorophora* hatch can be controlled with VectoLex and, due to its residual effects, it will control the *Culex* larvae that follow.

Certain intermittently flooded sites, such as the high salt marsh that produces *Culex salinarius*. VectoLex has been shown to deliver control of the species after drying and re-flooding of the breeding site.

Sites with the cattail mosquito *coquillettidia perturbans*. VectoLex has shown control of this mosquito species, and Valent BioSciences is doing more trials on this tough mosquito for another future label expansion.

VectoBac and VectoLex are superior mosquito control products. Valent BioSciences welcomes your questions and ideas about how our products fit into your program. Contact your Valent BioSciences representative or call Valent BioSciences at 1-800-323-9597.

VectoBac® and VectoLex®

Two Excellent Choices for Mosquito Control.

When to Use VectoBac

- **Univoltine broods or single generation species**
- **Sites that don't hold water long enough to develop a second brood**
- **Sites where residual control is not necessary due to single generation mosquito species**

Common Sites to Apply VectoBac

River Flood Plains
Woodland Pools
Mangrove Swamps
Some Prairie Potholes
Certain Flood Irrigated Pastures
Snow Melt Ponds
Rice Fields

Formulations

VectoBac G
VectoBac CG
VectoBac 12AS
VectoBac WDG

When to Use VectoLex

- **Multivoltine broods of susceptible mosquito species or multi generation species**
- **Known *Culex* sites**
- **Permanent water habitats *(Culex)***
- **Intermittently flooded sites that stay wet long enough to develop a second brood**
- **Sites where residual control is needed**

Common Sites to Apply VectoLex

Waste Lagoons
Ditches
Duck Clubs
Flooded Citrus Furrows
Inland Floodwater Pools
High Salt Marshes
Pastures that Remain Wet
Catch Basins
Irrigation Runoff Areas
Continuously Irrigated Crops (i.e. rice)
Marshes
Fresh Water Swamps

Formulations

VectoLex CG
VectoLex WDG
VectoLex WSP

VectoBac and VectoLex are both available in liquid and granular formulations.
For a list of mosquito and black fly species controlled by VectoBac and VectoLex, please refer to the product labels.

Call your Valent BioSciences Representative or Valent BioSciences at 800-323-9597, to help you determine the product and formulation that best suits your needs.

VALENT BIOSCIENCES™ CORPORATION

870 TECHNOLOGY WAY, SUITE 100
LIBERTYVILLE, IL 60048 - 800-323-9597

AG5245/R2 February 2003

www. valentbiosciences.com

Valent BioSciences Canada

VectoBac® 200G

Biological Larvicide

Granule

RESTRICTED

GUARANTEE:

Bacillus thuringiensis subsp. *israelensis*, Serotype H-14, strain HD-14, 200 International Toxic Units (ITU) per milligram (0.2 billion ITU/L)

REGISTRATION NO. 18158

PEST CONTROL PRODUCTS ACT List No. 60214-13

KEEP OUT OF REACH OF CHILDREN

READ THE LABEL BEFORE USING

POTENTIAL SENSITIZER

1.0 RESTRICTED USES

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offence under the Pest Control Products Act to use a control product under unsafe conditions.

NATURE OF RESTRICTION: This product is to be used only in the manner authorized; consult local pesticide regulatory authorities about use permits which may be required.

DIRECTIONS FOR USE

Mosquitoes **Habitat: Standing water**	**Suggested Range Rate***
Temporary and permanent pools in pastures and woodlots, irrigation or roadside ditches, natural marshes or estuarine areas, waters contiguous to fish-bearing water, catch basins and sewage lagoons.	3-10 kg/ha* (0.3-1.0 g/m^2)

*Use higher rates in deep and/or polluted water, and when late 3rd and 4th instar larvae predominate.

Apply recommended rate by conventional aerial or ground equipment. Uniform coverage is necessary for best results. For aerial application, apply in uniform nonoverlapping swaths when conditions do not favour drift or when wind speeds are less than 10 km/h.

A 3 to 14 day interval between applications should be employed. Monitoring will indicate the appropriate retreatment interval. VECTOBAC (or B.t. H-14) does not affect non-target, aquatic, invertebrate predators and parasites which are non-filter feeders. Therefore, longer periods of suppression may result since these beneficials would be conserved to aid in mosquito population management.

LIMITATIONS: VectoBac 200G may be applied to any water sites except treated, finished drinking water.

2.0 PRECAUTIONS

KEEP OUT OF REACH OF CHILDREN

May cause sensitization. Avoid contact with skin, eyes, and clothing. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash before reuse.

FIRST AID INSTRUCTIONS:

If in eyes: Flush with plenty of water.

If on skin: Wash skin with plenty of soap and water. Obtain medical attention or contact a poison control centre IMMEDIATELY if irritation occurs and persists.

Take container, label, or product name and Pest Control Product Registration Number with you when seeking medical attention.

3.0 STORAGE AND DISPOSAL

Storage: Store at temperatures between 0°C and 25°C. Store container upright and keep tightly closed when not in use. This product should be used within 24 months of the date of manufacture.

Disposal: Triple- or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank. Follow provincial instruction for any required additional cleaning of the container prior to its disposal. Make the empty container unsuitable for further use. Dispose of the container in accordance with provincial requirements. For information on disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, and for clean-up of spills.

4.0 NOTICE TO BUYER

Seller's guarantee shall be limited to the terms set out on the label and, subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

VectoBac is a registered trademark of Valent BioSciences Corporation.

04-4428/R1

VectoBac® 200G

Larvicide Biologique

Granules

PRODUIT À USAGE RESTREINTS

GARANTIE:

Bacillus thuringiensis sous-espèce *israelensis*, sérotype H-14, souche HD-14, 200 unités toxiques internationales (UTI) par milligramme (0,2 milliard UTI/L).

NUMÉRO D'HOMOLOGATION 18158

LOI SUR LES PRODUITS ANTIPARASITAIRES List No. 60214-13

GARDER HORS DE LA PORTÉE DES ENFANTS

LIRE L'ETIQUETTE AVANT L'EMPLOI

SENSIBILISANT POTENTIEL

1.0 RESTRICTIONS D'EMPLOI

AVIS À L'UTILISATEUR: L'utilisateur est tenu de se conformer aux instructions imprimées sur l'étiquette. L'emploi de ce produit dans des conditions dangereuses constitue une infraction à la loi sur les produits antiparasitaires.

RESTRICTION: N'employer ce produit que de la façon autorisée se renseigner auprès des responsables locaux de la réglementation des pesticides sur la nécessité de se procurer un permis d'utilisation.

MODE D'EMPLOI

MOUSTIQUES **Habitat: Eaux stagnantes**	**Taux d'application recommandé**
Mares temporaires ou permanentes situées dans les prés et les boisés, fossés ou rigoles, marais naturels, estuaires, eaux contiguës à des eaux poissonneuses, bassins collecteurs et égouts.	3-10 kg/ha* (0,3-1,0 g/m^2)

*Augmenter ce taux dans les eaux profondes ou polluées et lorsque la majorité des larves sont à la fin du 3^e et au 4^e stades.

Appliquer le taux recommandé à l'aide du materiel habituel aérienne ou terrestre. Un épandage uniforme donne les résultats optimaux. Pour les traitements aériens, appliquer par bandes de pulvérisation uniformes et non chevauchantes, lorsque les conditions ne favorisent pas la dérive du brouillard d'insecticide et que la vitesse du vent est inférieure à 10 km/h.

Espacer les applications de 3 à 14 jours. On déterminera la fréquence des applications par une surveillance appropriée. VECTOBAC (ou B.t. H-14) n'a pas d'effet sur les prédateurs et les parasites invertébrés aquatiques qui ne se nourrissent pas par filtration. Par conséquent, la période de démoustication peut être prolongée grâce à ces ennemis naturels qui contribuent à maintenir la population de moustiques à un niveau acceptable.

RESTRICTION: Ne pas utiliser ce produit dans l'eau potable.

2.0 PRÉCAUTIONS

GARDER HORS DE LA PORTÉE DES ENFANTS

Peut causer une sensibilisation. Éviter le contact avec la peau, les yeux et les vêtements. L'utilisateur devrait se laver les mains après la manutention du produit, et se dévêtir immédiatement si le pesticide pénètre à l'intérieur. Se laver rigoureusement et se mettre du linge propre.

PREMIERS SOINS

Si dans les yeux: Laver à grand eau.

Si sur la peau: Laver à l'eau savonneuse.

Si l'irritation persiste, consulter un médecin ou un centre antipoison IMMÉDIATEMENT.

Emporter le contenant, l'étiquette ou prendre note du nom du produit et de son numéro d'homologation lorsqu' on cherche à obtenir une aide médicale.

3.0 ENTREPOSAGE ET ÉLIMINATION

Entreposage: Entreposer entre 0°C et 25°C. Garder le contenant dressé et fermé hermétiquement. Ce produit devrait être utilisé au cours de 24 mois de la date de manufacture.

Élimination: Rincer le contenant trois fois ou le rincer sous pression. Ajouter les rinçures au mélange à pulvériser dans le réservoir. Vérifier si un nettoyage supplémentaire du contenant avant son élimination est exigé en vertu de la réglementation provinciale. Rendre le contenant inutilisable. Éliminer le contenant conformément à la réglementation provinciale. Pour tout renseignement concernant l'élimination des produits non utilisés ou dont on veut se départir, s'adresser au fabricant ou à l'organisme de réglementation provincial. S'adresser également à eux en cas de déversement ainsi que pour le nettoyage des déversements.

4.0 AVIS À L'ACHETEUR

La garantie du vendeur est limitée et soumise aux conditions exprimées sur l'étiquette de sorte que l'acheteur assume les risques corporels ou matériels que l'utilisation ou la manipulation du produit peuvent entraîner et accepte celui-ci à cette condition.

VectoBac est une marque deposee de Valent BioSciences Corporation.

800-323-9597

04-4428/R1 VID 5.28.03

Tomorrow's Answer... Today

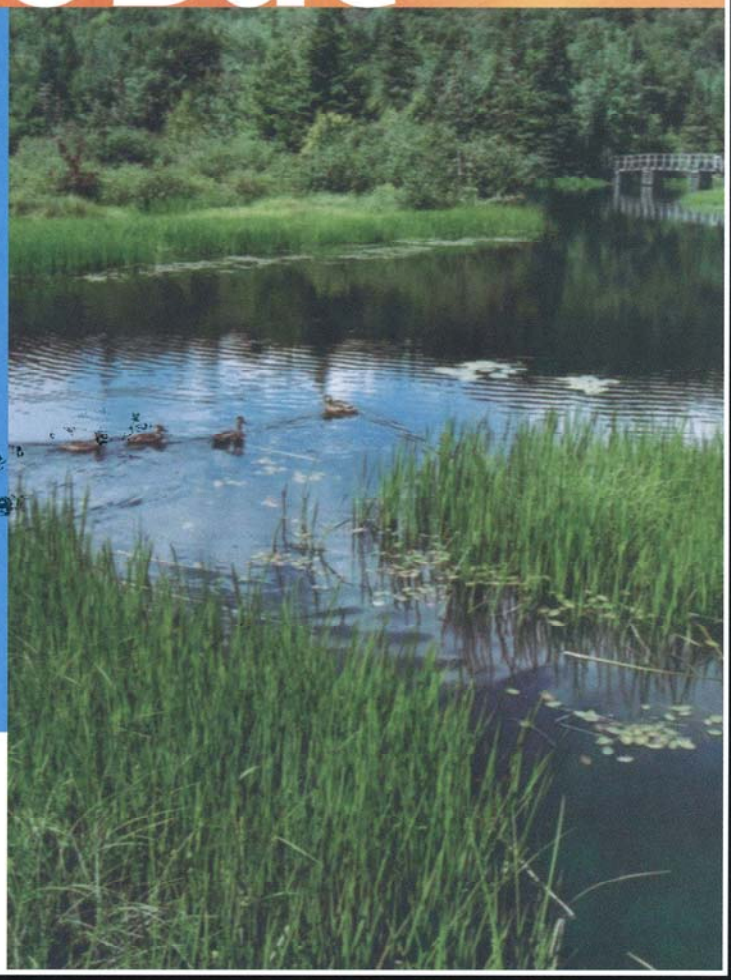
VectoBac®

The Effective,

Economical

Biological Larvicide

For Mosquito and Black Fly Control



VALENT BioSciences™
CANADA LTD


Introduction

Effective, economique, and environmentally compatible biting fly control is available today. In fact, many communities throughout North America have renewed their enthusiasm for outdoor activities now that mosquitoes and black flies are becoming less of a nuisance or health problem.

More than twenty years of extensive commercial experience has demonstrated that *Bacillus thuringiensis israelensis (Bti)* is the most environmentally friendly larvicide available for mosquito and black fly control.

The Biological Approach to Mosquito and Black Fly Control

VectoBac, a highly selective biological larvicide, is used to control mosquitoes and black fly larvae. The contribution of VectoBac to health care is quite significant, because black flies and mosquitoes are vectors of some of the world's most severe diseases and account for more human suffering than any other single pest known to man. For example, onchocerciasis (river blindness) is a debilitating disease caused by parasitic worms which are transmitted by black fly bites. VectoBac has been the cornerstone of the World Health Organization's river blindness program and this problem has been almost eliminated from West Africa. Other diseases transmitted by mosquitoes include West Nile virus, encephalitis, malaria, dengue, yellow fever, and dog heartworm. Mosquitoes and black flies are often chronic nuisance pests throughout the spring and summer, and their bites may cause allergic reactions in many people.

VectoBac is Valent BioSciences trademark for its *Bti* product. Manufacturing occurs via fermentation, a process in which Valent BioSciences expertise, experience and facilities rank among the best in the world.

Bti is a bacterium occurring naturally in soils and aquatic environments. Since its discovery, the organism has shown rapid larvicidal activity against both mosquitoes and black flies. The rapid action, typically resulting in mortality within 4 to 24 hours, is compatible with the inspection and evaluation methods used in most mosquito and black fly abatement programs, and offers a sensible and effective alternative to chemical control for mosquitoes and black flies.

VectoBac is ideally suited for and is used in integrated pest management programs and environmentally sensitive areas because of its excellent safety profile.

Many communities have observed the use of VectoBac to be compatible with natural predators such as mosquito fish, flatworms, and other predators.

VectoBac products are manufactured under the highest industrial standards of quality control (GMP and GLP) in modern and highly efficient fermenters. The potency of final product lots is established using an *Aedes aegypti* mosquito bioassay and black fly assay. Potency is expressed as International Toxicity Units per milligram (ITU/mg), the standard established and used by the World Health Organization. This is the internationally accepted standard. Each lot is tested several times to assure accurate potency and highest quality.

Mode of Action

The active ingredient in VectoBac is composed of viable *Bti* endospores and delta-endotoxin crystals. Larvicidal activity is dependent upon ingestion of these components by the larvae. Upon ingestion, pH conditions and enzymes in the gut of the larvae rapidly hydrolyze the material into active subunits which attack the midgut cells. Due to VectoBac's unique mode of action, it has negligible effects on the aquatic food chain.

General gut paralysis occurs within a few hours, and the cells of the larval midgut become extensively damaged causing the formation of holes or ulcers in the stomach wall. The subsequent flow of toxic substances into the larval body cavity causes death within 4 to 24 hours.

Although resistance to synthetic chemical pesticides has been observed, mosquitoes and black flies have not developed resistance to *Bti* in over twenty years of field use.

VectoBac and the Environment

As demonstrated by toxicological test results, VectoBac is one of the least toxic insecticides in use today. The active ingredient, *Bti,* is a naturally occurring bacterium which has a highly specific mode of action against a narrow host spectrum. This selective activity is limited to the Order Diptera, or flies, and more specifically, larvae of mosquitoes and black flies. *Bti* has shown activity on individuals of certain related species and populations of the families: *Dixidae*, *Chironomidae*, and *Ceratopogonidae*. These were the only groups affected in tests to determine the safety of *Bti* to non-target aquatic vertebrates and invertebrates.

Colbo and O'Brien (1984)[1] sampled non-target insects after normal and intentionally massive overdose rates of VectoBac during 1983 black fly control field trials in Labrador, Newfoundland, and found that major groups of caddisflies, mayflies, and non-biting midges actually increased after each treatment. No toxic effects have been demonstrated in mammals, fish, birds or other wildlife at tested field rates. In water, VectoBac has a half-life of less than 7 days, and is naturally degraded by aquatic micro-organisms and sunlight. For more than twenty years of commercial use as one of the most widely used larvicides, no toxic effects have been demonstrated against mammals, fish, birds, or other wildlife at tested field rates.

Additional evaluations conducted by Valent BioSciences have supported the safety of VectoBac for mammalian toxicity and pathogenicity in mice, rats, rabbits and other test animals. Also, extensive testing by independent scientists has shown no evidence of multiplication of the organisms in mammals.

No reports of adverse effects to the environment have been documented in over twenty years of commercial use. VectoBac is used throughout the world in all types of breeding sites which include freshwater and salt marshes, sewage lagoons, swamps and bog areas, creeks, streams, and rivers.

(1) Colbo, M.H. and O'Brien, H. 1984. Can. Entomol. 116 : 1085-1096

Mammalian Safety

Acute and chronic toxicology studies have been conducted on a wide variety of species including various plants, birds, mammals, non-target insects, amphibians, and fish.

The toxicity of VectoBac formulations to mammals has been extensively evaluated. Studies reviewed by both the EPA and Health Canada (PMRA) have demonstrated that VectoBac formulations are non-toxic to mammals. For more information, refer to the VectoBac Toxicology Profile.

Oral Toxicity

No toxicity was observed in rats treated with the maximum dosage of 2 billion spores of *Bti* by oral gavage.

Dermal Toxicity

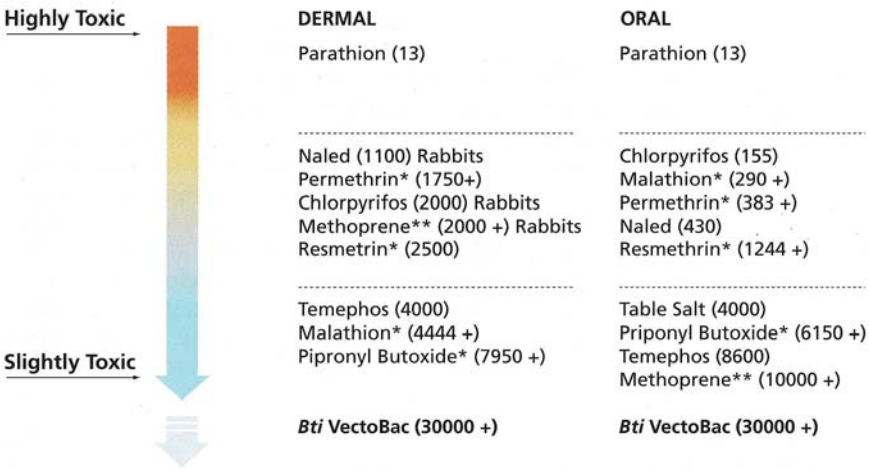
No erythema or edema formation was observed in rabbits after dermal exposure to 1.6 billion spores. All other parameters of the test animals were normal. There was no evidence that *Bti* multiplied on the abraided epidermis.

Inhalation Toxicity

No adverse effects were observed in rats given 80 million viable spores by instillation into the lungs. There was no histological evidence of multiplication of the organism in lung tissue.

Eye Irritation

Instillation of 100 million spores into the ocular cavity produced mild eye irritation in rabbits that was reversible in 48 hours. No multiplication occurred in the ocular cavity.



The graph illustrates the acute oral and dermal toxicities (LD_{50} mg/kg) of some insecticides used for mosquito control. Bti has shown no harm to humans, animals and useful insects, and accordingly has shown no harm for the environment. Figure based on tests with female rats except where otherwise noted.

Sources :
Farm Chemicals Handbook, 1985.

* *Répertoire des principaux pesticides utilisés au Québec, MEQ et INSPQ, 2002.*

** *Larvicides pour contrer la transmission du virus du Nil Occidental chez les humains, INSPQ, 2002.*

Recommendations for use - Mosquitoes

Application rates of VectoBac are related to surface area of water to be treated, not depth. The determination of a particular application rate will require consideration of one or more of the following factors :

Larval Stage and Population

Larvae in the early developmental stages are more susceptible to a given quantity of *Bti* than are those in the later stages. When VectoBac is ingested by first, second and third instar larvae, it is very efficacious, even under conditions of rapid larval development. If late third and fourth instar larvae predominate, higher rates should be used. Very high larval populations can remove significant amounts of the active ingredient from the water through their feeding activity. Therefore, to maintain an effective concentration of *Bti*, the upper rate range of VectoBac should be used in high population situations.

Often application timing can be delayed to when the majority of the eggs have hatched. This minimizes the necessity of re-application against this generation.

Water Quality

The higher recommended rates of VectoBac should be used in water having high concentrations of organic pollutants and/or abundant algae. This is due to ingestion of a smaller proportion of *Bti* delta-endotoxin and spores relative to the abundance of their food source. Also, *Bti* can be removed by feeding competition from other organisms and by absorbent binding to suspended particulate matter.

Other water quality parameters such as salinity and pH have little, if any, effect on the activity of VectoBac. Water temperature, because it influences larval metabolic activity, and thus larval feeding and development, can be a factor in determining the application rate. Higher water temperature generally produces a more rapid response to *Bti* and may require lower rates of application. Low water temperatures may reduce feeding activity and the effectiveness of lower rates.

Residual Activity

VectoBac is a bacteria preparation and all product components are biodegradable. The spores and crystals settle out of the upper water levels or the mosquito feeding zone over time. Residual activity typically begins to decline 24 hours after treatment. Extended residual effectiveness is not always necessary, as with temporary breeding sites or single-generation species. Depending on larval development rate, treatment intervals of 7-14 days are appropriate for control of species that undergo continuous development. Residual activity can be significantly affected by formulation and the ability of the formulation to retain bacterial particles in the larval mosquito feeding zone. VectoBac formulations are designed to offer maximum exposure of particules to larvae in the water column. When dealing with a species complex or multiple generation species, populations should be monitored and applications made as new larvae enter the fourth instar.

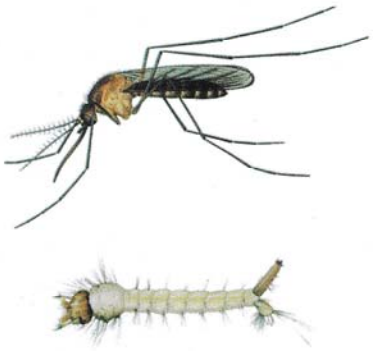


Photo : Jocelyn Moffet

Recommendations for use – Black Flies

Application rates of VectoBac aqueous suspensions as black fly larvicides, are related to the characteristics of the stream or river, as well as the method of application employed.

The principal factors used to determine use rate and duration are the width, the depth and the velocity of the stream or river channel (stream flow). These factors, along with physical characteristics of the bottom and sides of the streambed, determine the downstream distance for acceptable efficacy.

Experience is the best guide, but, in general, the lower rates and shorter application times should be used in waters of higher flow rates and those with conditions for good dispersal and downstream carry. The higher rates and application times are generally used in slow flowing waters and those with conditions expected to result in relatively poor dispersal and downstream carry. The higher rates are also used in streams containing high concentrations of silt, algae and macrophytes. (Refer to the VectoBac Technical bulletin for detailed information regarding calculation of rates).

Formulations

VectoBac is available as aqueous suspension and granular formulations.

VectoBac Aqueous Suspension (1200L)

VectoBac 1200L is an aqueous suspension formulation of *Bti*. This formulation is light brown in color and has a specific gravity slightly greater than 1.0. Viscosity is less than 500 CPS at 25°C. When added to water, a uniform suspension is obtained which can be maintained with minimal agitation. The dilution of VectoBac 1200L aqueous suspension with almost any volume of water will produce a final tank mix which exhibits the flow rates of water.

To maximize the availability of the active ingredient to the mosquito and black fly larvae, VectoBac 1200L has been formulated for rapid dispersal and a slow settling rate in the larval habitat which helps ensure maximum suspension and carry of particles.

VectoBac 1200L is used primarily for black fly control but some applicators prefer the liquid for application to mosquito larval habitats where penetration of the foliage canopy to the water's surface can be accomplished easily.

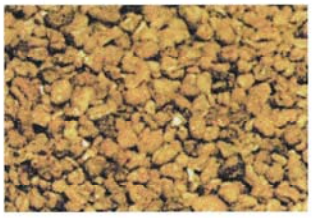
VectoBac Granular Formulations (200G)

VectoBac granular formulations use selected corn cob particles as a carrier for the active ingredient. The granules can be applied by ground or aerial equipment to penetrate vegetation and reach the aquatic larval habitat where mosquitoes breed.

The VectoBac granular formulations have been designed and produced to specifications which optimize safe handling, application, and efficacy. VectoBac granules are dust free and enable reproducible applications once a delivery system has been properly calibrated.

The size, shape, and density of the carrier impart other important properties to the formulations such as : reducing aerial drift, enabling good penetration of the vegetative overstory typical of flooded woodland, salt marsh, pond and ditch habitats with little concern about the granules sticking to wet foliage; and, ensuring the distribution of the active ingredient throughout the larval feeding zone by the presence of both floating and sinking granules.

Granular formulations are available in two sizes : VectoBac 200G (5/8) and VectoBac 200G (10/14) mesh. The smaller 10/14 granules are preferred by some applicators for use in specific aerial application equipment and in shallow water locations where very small, isolated pools predominate.



Environmental Safety

Toxicological Studies on Aquatic Invertebrates

Aquatic organisms are vital components of marine and freshwater ecosystems and often occupy the same habitats as mosquito and black fly larvae. Acute toxicological studies indicate that *Bti* products have no adverse effects on the following non-target organisms.

Non-target Aquatic Organisms Not Affected by *Bti**

AMPHIBIANS	*Hylo regilla*	tree frog tadpole		
	Bufo sp.	toad tadpole		
	Taricha torosa	California newt		
FISH	*Gambusia affinis*	mosquito fish		
	Lucania parva	rainwater killifish		
	Gasterosteus wheatlandi	twospine stickleback		
	Salmo gairdnerii	Trout		
	Lepomis macrochirus	bluegill		
CRUSTACEANS	**Amphipoda**	scuds	**Ostracoda**	
	Gammaridae sp.	sideswimmer	*Cypridae sp.*	seed shrimp
	Hyalella azetaca			
	Decapoda	purple shore crab	**Copepoda**	
	Hemigrapsus sp.		*Macrocyclops sp.*	copepods
	Anostraca	fairy shrimp	**Isopoda**	marine sow bug
	Artemia salina			
	Cladocera	water flea		
	Simocephalus vetulus			
INSECT	**Ephemeroptera**	mayfly nymphs	**Trichoptera**	
	Callibaetis sp.		*Mystacides alfunbriata*	caddisfly larvae
			Several species	caddisfly nymphs
	Odanata		**Diptera**	
	Ischnura sp.	damselfly nymphs	*Ephydra riparia complex*	brine fly larvae
	Anax sp	dragonfly nymphs	*Dicraneta sp.*	cranefly larvae
			Chelifera sp	dancefly larvae
	Hemiptera		**Plecoptera**	
	Trichocorixa reticulata	water boatmen (nymph)	Several species	stonefly nymphs
	Hesperocorixa laevigata	water boatmen		
	Trichocorixa sp.	water boatmen	**Hymenoptera**	
	Corixidea sp.	water boatmen	*Aps mellitfera*	honey bee
	Bueona scimitra	backswimmer		
	Notonecta kirbyi	backswimmer		
	Pleidae	oygmy backswimmer		
	Coleoptera			
	Tropisternus salsamentus	scavenger water beetle		
	Tropisternus sp	larvae		
	Dytiscidae	predaceous water beetle		
FLATWORMS	**Tubellaria**			
	Dugesia dorotocephala	flatworms		
EARTHWORMS	**Naididae**	earthworms		
	Lumbricidae	earthworms		
MOLLUSCS	**Gastropoda**			
	Physa sp.	fresh water snail		
	Pelecypoda sp.	mussels		

**In part from Garcia, R.B. DesRochers, and W. Tozer 1980. Studies on the toxicity of Bacillus thuringiensis ssp. Israelensis against organisms found in association with mosquito larvae. Proc. Ann. Conf. of the Calif. Mosquito and Vector Control Assoc, pp. 33-36.*

NOTE : Each river system is unique in its stream bed morphological/substrate profile, water chemistry and hydrological conditions. Stream and river dynamics are influenced by a gradient of physical factors formed by the drainage network. Black fly larval distribution is determined by hydrodynamics created by the uniqueness of the river/stream system. It is impossible to make specific recommendations on dose level and injection time that will provide effective control in all streams. Therefore, breeding sites should be properly identified and mapped, and pilot studies conducted to ascertain correct dose and downstream distance of the larval control (carry).

Advantages of VectoBac Compared to Other Mosquito and Black Fly Larvicides

- Controls 1st through early 4th instar larvae
- Efficacy can be evaluated one day after application.
- Can be used in IPM programs (not harmful to beneficial predators, i.e. fish, insects)
- No residues and exempt from pesticide residue tolerance requirements
- VectoBac has shown no adverse effects to applicators, non-target wildlife, and domestic animals
- Can be applied to any water sites except treated finished drinking water
- Applications to irrigation water are permissible
- Can be applied easily with standard equipment
- Biodegradable
- Can be used in almost any aquatic habitat with no restrictions.
- Manufactured under highest standards, to pharmaceutical-grade production protocols.
- Backed by dedicated researchers and supported by experienced field staff.

Valent BioSciences' researchers are continuing to develop microbial products that provide efficacious mosquito and black fly control with a sensitivity to preserving delicate aquatic ecosystems.

D.G. Regan & Associates Ltd.
#100-2605 Clarke Street
Port Moody, B.C.
V3H 1Z4

VALENT BIOSCIENCES CORPORATION

Creating Value Through Technology and People™

For more information regarding use and application, please refer to product specimen labels and technical bulletins which are available on request from your Valent BioSciences representative or your distributor.

AG5361

870 Technology Way
Libertyville, IL 60048
1 800 323-9597
www.valentbiosciences.com

VectoBac granular formulations are covered by U.S. Patent No. 4,650,792

Front page picture: Jocelyn Moffet

Valent BioSciences

VectoLex® WSP

Biological Larvicide

Water Soluble Pouches

ACTIVE INGREDIENT:

Bacillus sphaericus Serotype H5a5b, strain 2362
Technical Powder (670 BsITU/mg) 7.5%

OTHER INGREDIENTS 92.5%

TOTAL 100.0%

Potency: This product contains 50 BsITU/mg or 0.023 Billion BsITU/lb.

The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

EPA Reg. No. 73049-20

EPA Est. No. 33762-IA-001 List No. 5722

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0 FIRST AID

If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Harmful if absorbed through the skin. Causes moderate eye irritation. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling.

2.2 ENVIRONMENTAL HAZARDS

Do not contaminate water when disposing of equipment washwaters or rinsate.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Once the foil bag containing Water Soluble Pouches is opened, use pouches within one day.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Do not contaminate water when disposing of equipment washwaters.

Pesticide Storage: Store in a cool, dry place.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Dispose of empty outer foil bag in trash.

5.0 APPLICATION DIRECTIONS

MOSQUITO CONTROL

I. For control of mosquito larvae species* in the following non-crop sites:

Habitat	Rate Range
Stormwater/Drainage Systems: Storm drains, catch basins, retention, detention and seepage ponds.	1 pouch/50 sq.ft.[1]

[1]Treat on basis of surface area of potential mosquito breeding sites by placing one (1) VectoLex Soluble Pouch per 50 square feet of treatment area. Re-apply as needed after 1 to 4 weeks.

* Mosquito species effectively controlled by VectoLex WSP:

Culex spp.
Aedes vexans
Ochlerotatus melanimon *(Aedes melanimon)*
Ochlerotatus stimulans *(Aedes stimulans)*
Ochlerotatus nigromaculis *(Aedes nigromaculis)*
Psorophora columbiae
Psorophora ferox
Ochlerotatus triseriatus *(Aedes triseriatus)*
Ochlerotatus sollicitans *(Aedes sollicitans)*
Anopheles quadrimaculatus
Coquillettidia perturbans

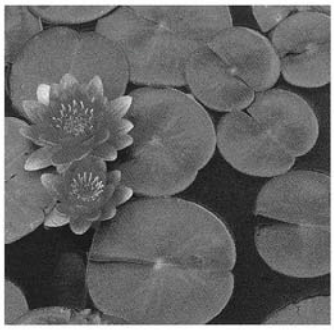
6.0 NOTICE TO USER

SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS OR OTHERWISE CONCERNING THE USE OF THIS PRODUCT OTHER THAN AS INDICATED ON THE LABEL. USER ASSUMES ALL RISKS OF USE, STORAGE OR HANDLING NOT IN STRICT ACCORDANCE WITH ACCOMPANYING DIRECTIONS.

VALENT BIOSCIENCES® CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048—800-323-9597

04-4364/R2

 VID 3.17.04


VectoLex® WSP

Technical Use Bulletin

VectoLex WSP is a Water Soluble Pouch containing VectoLex CG. (Bacillus sphaericus strain 2362; potency = 50 BsITU) Each 10-gram packet treats up to 50 square feet of mosquito breeding water. The formulation is ideal for treatment of catch basins and other small breeding sites. The product is applied by placement and is very useful for control of West Nile Virus (WNV) vectors in urban and suburban areas.

B. sphaericus is a naturally occurring, spore-forming bacterium found throughout the world in soil and aquatic environments. At the time of sporulation, *B. sphaericus* produces a d-endotoxin which is toxic to many species of mosquito larvae upon ingestion. Early development of *B. sphaericus* for mosquito control focused on strains isolated and maintained by the Pasteur Institute, WHO collaborating Center, Paris, France. VectoLex is based on strain 2362, which was isolated in Nigeria.

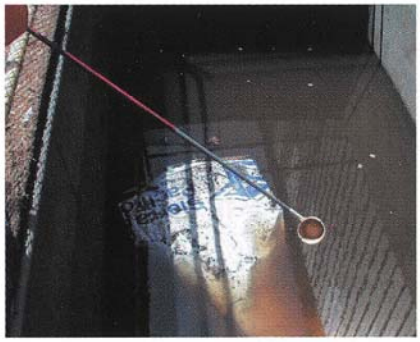
VectoLex WSP was developed at the request of Mosquito Control Professionals. With the spread of West Nile Virus in the United States, Valent BioSciences Corporation was asked by mosquito abatement programs to develop a VectoLex formulation that could be easily applied to catch basins for control of mosquito larvae. VectoLex CG was already popular with these agencies because of its favorable environmental profile and residual activity, but when faced with the challenge of treating hundreds of catch basins each day, an improvement to the delivery system was needed. In 2001, VectoLex WSP was introduced to fill this need.

Benefits of VectoLex WSP

- Effective
- Economical
- Environmentally Friendly
- Easy to apply (malleable, slips into tight spots, clean)
- Does not get hung up in debris or buried in sludge at the bottom of a catch basin

Once placed in water, VectoLex WSP dissolves in 2-5 minutes, releasing the VectoLex granules. The corncob carrier disperses on the water surface and in the water column, distributing *Bsph* to the larval feeding zone.

Preliminary tests indicated that more than 30 days control could be expected from application of one pouch to a catch basin. Later field studies confirmed that in fact control could last much longer. This product has been used successfully nationwide, with results consistently supporting an estimated 30 day treatment interval.



Mode of Action

The d-endotoxin of *B. sphaericus* is only toxic to the larval stages of mosquitoes. It must first be ingested by the larvae, then partially digested before it becomes activated. The toxin's mode of action is similar to *Bti*, causing disruption of the midgut epithelium.

However, activity of the d-endotoxin of *B. sphaericus* differs from that of *Bti* in several important ways. The toxin is attached to the bacterial spore, while *Bti* toxins are not attached to the spore. The toxins of *B. sphaericus* and *Bti* bind to chemically different receptor sites on cells. They are not related immunologically, and are thought to have completely different molecular modes of action.

Operationally, the most important differences between the toxins of *B. sphaericus* and *Bti* are speed of action and persistence in the larval habitat. *B. sphaericus* toxin is much slower acting than *Bti* toxin. Larval mortality can take several days, but is usually expressed within 48 hours of ingestion. *B. sphaericus* toxin is also much more persistent in the larval habitat than *Bti*. This persistence is thought to be the result of the stability and slower settling rate of the *B. sphaericus* toxin, as well as the unique ability of *B. sphaericus* spores to germinate, grow and produce toxin in cadavers of mosquito larvae treated with the material. This process is known as recycling.

VectoLex WSP is labeled for the control of the following mosquitoes:

Culex (all species)
Aedes vexans
Ochlerotatus stimulans
Ochlerotatus nigromaculis
Ochlerotatus melanimon
Coquillettidia perturbans
Psorophora columbiae
Psorophora ferox
Ochlerotatus sollicitans
Aedes quadrimaculatus
Ochlerotatus triseriatus

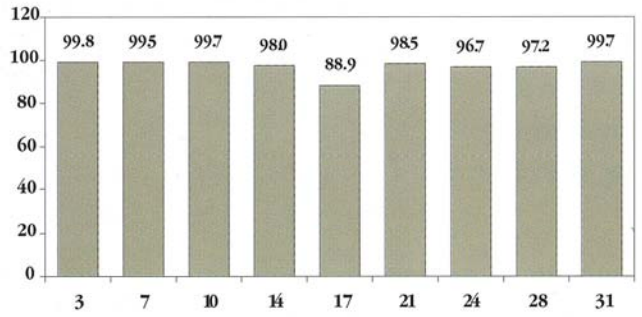
Habitats	Rate Range
Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, retention, detention and seepage ponds	1 pouch/50 sq. ft (1)

(1) Treat on the basis of surface area of potential mosquito breeding sites by placing one (1) VectoLex WSP pouch per 50 square feet of treated area. Re-apply as needed after 1-4 weeks. Research indicates that the average catch basin and feeder lines' surface area is 50 square feet.

VectoLex WSP Performance

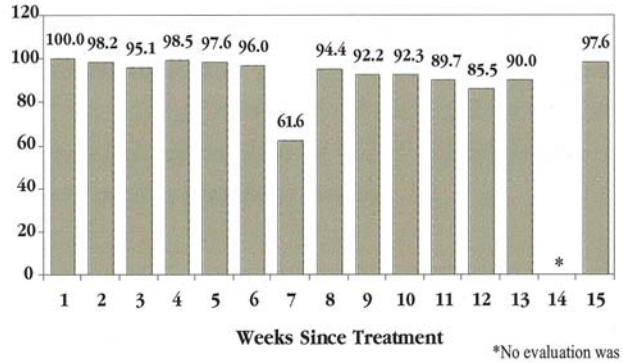
Percent Control of *Culex* Larvae (L_{3-4})

Study Location: Key West, Florida
Habitat: Street Catch Basins



Species: *Culex quinquefasciatus*
Sampling: sweep net
Replications: 4 treated; 4 UTC – Whole study repeated 4X
Data Source: Shannon James

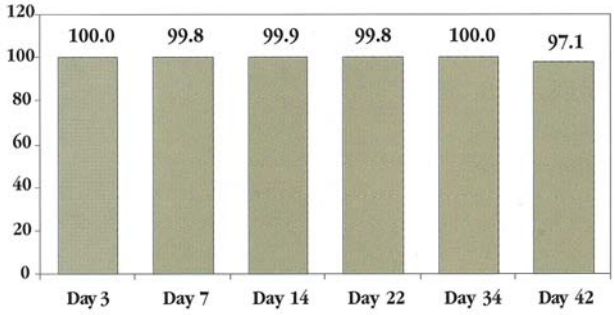
Study Location: Newton, Massachusetts
Habitat: Street Catch Basins



*No evaluation was made on Week 14

Species: *Culex pipiens*
Sampling: Landers ladle (specially designed dipping device)
Replications: 40 treated; 40 UTC
Data Source: Doug Bidlack, David Henley – East Middlesex MCP

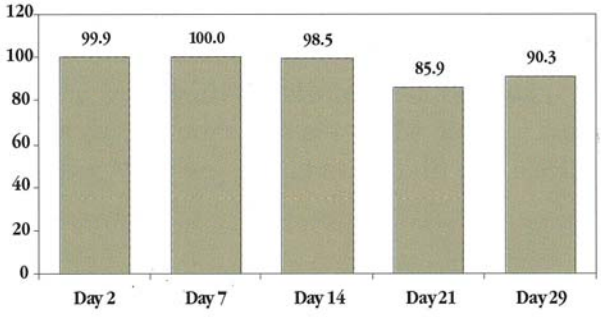
Study Location: Portland, Oregon
Habitat: Street Catch Basins



Species: *Culex pipiens*
Sampling: sweep net
Replications: 7 treated; 2 UTC
Data Source: Peter DeChant, VBC/Glenn Bissell, Alpine Pest Mgmt.

VectoLex WSP – 1 pouch per basin

Study Location: Corpus Christi, Texas
Habitat: Simulated Catch Basins



Species: *Culex quinquefasciatus*
Sampling: Dipper
Replications: 8 treated; 8 UTC
Data Source: Daniel Sprenger, Nueces County Health

VectoLex WSP – 1 pouch per basin

Biological Larvicide

VectoLex® CG

Granules

ACTIVE INGREDIENT:
Bacillus sphaericus Serotype H5a5b, strain 2362 Technical Powder (670 BsITU/mg) 7.5%
OTHER INGREDIENTS 92.5%
TOTAL 100.0%

Potency: This product contains 50 BsITU/mg or 0.023 Billion BsITU/lb.

EPA Reg. No.73049-20
EPA Est. No. 33762-IA-001 List No. 5722

INDEX:

KEEP OUT OF REACH OF CHILDREN
CAUTION

1.0 FIRST AID

If in eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-877-315-9819 (24 hours) for emergency medical treatment and/or transport emergency information. For all other information, call 1-800-323-9597.

2.0 PRECAUTIONARY STATEMENTS

2.1 Hazards To Humans and Domestic Animals
CAUTION

Harmful if absorbed through the skin. Causes moderate eye irritation. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling.

Mixers/loaders and applicators not in enclosed cabs or aircraft, must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can cause allergic sensitizations.

2.2 Environmental Hazards

Do not contaminate water when disposing of equipment washwaters or rinsate.

3.0 DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Do not contaminate water when disposing of equipment washwaters.

Pesticide Storage: Store in a cool, dry place.

Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Completely empty bag into application equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or if allowed by State and local authorities, by burning. If burned, stay out of smoke.

5.0 APPLICATION DIRECTIONS

MOSQUITO CONTROL

I. For control of mosquito larvae species* in the following non-crop sites:

Habitat	Rate Range
Wastewater: Sewage effluent, sewage lagoons, oxidation ponds, septic ditches, animal waste lagoons, impounded wastewater associated with fruit and vegetable processing.	5-20 lbs/acre**
Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, retention, detention and seepage ponds.	5-20 lbs/acre**
Marine/Coastal Areas: Salt marshes, mangroves, estuaries.	5-20 lbs/acre**
Water Bodies: Natural and manmade aquatic sites such as lakes, ponds, rivers, canals and streams.	5-20 lbs/acre**
Dormant Rice Fields: Impounded water in dormant rice fields. (For application only during the interval between harvest and preparation of the field for the next cropping cycle.)	5-20 lbs/acre**
Waste Tires: Tires stockpiled in dumps, landfills, recycling plants, and other similar sites.	20-80 lbs/acre(1)

(1) 0.5-2 lbs/1000 sq. ft.

CONTINUED

II. For the control of mosquito larvae species* in agricultural/ crop sites where mosquito breeding occurs:

Habitats:	Rate Range
Rice, pastures/hay fields, orchards, citrus groves, irrigated crops.	5-20 lbs/acre**

Apply uniformly by aerial or conventional ground equipment. Reapply as needed after 1 to 4 weeks.

* Mosquito species effectively controlled by VectoLex CG:

Culex spp.	
Aedes vexans	
Ochlerotatus melanimon	*(Aedes melanimon)*
Ochlerotatus stimulans	*(Aedes stimulans)*
Ochlerotatus nigromaculis	*(Aedes nigromaculis)*
Psorophora columbiae	
Psorophora ferox	
Ochlerotatus triseriatus	*(Aedes triseriatus)*
Ochlerotatus sollicitans	*(Aedes sollicitans)*
Anopheles quadrimaculatus	
Coquillettidia perturbans	

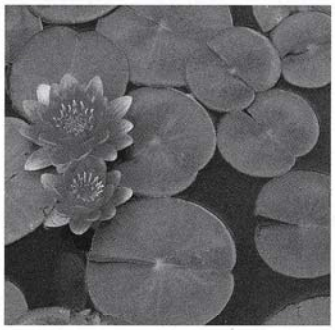
**Use higher rates (10 to 20 lbs/acre) in areas where extended residual control is necessary, or in habitats having deep water or dense surface cover.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determine the potential for spray drift. The applicator and the treatment coordinator are responsible for considering all these factors when making desicions.

6.0 NOTICE TO USER

SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS OR OTHERWISE CONCERNING THE USE OF THIS PRODUCT OTHER THAN AS INDICATED ON THE LABEL. USER ASSUMES ALL RISKS OF USE, STORAGE OR HANDLING NOT IN STRICT ACCORDANCE WITH ACCOMPANYING DIRECTIONS.

VALENT BIOSCIENCES CORPORATION
870 TECHNOLOGY WAY
LIBERTYVILLE, IL 60048 - 800-323-9597


VectoLex® CG
Technical Use Bulletin

VectoLex CG is the granular formulation of Bacillus sphaericus(strain 2362). It is designed for application to mosquito larval habitats. The product has a potency of 50 BsITU/mg (B. sphaericus International Units/mg). It is available in 40 pound bags.

History

B. sphaericus is a naturally occurring, spore-forming bacterium found throughout the world in soil and aquatic environments. At the time of sporulation, *B. sphaericus* produces a d-endotoxin which is toxic to many species of mosquito larvae upon ingestion. Early development of *B. sphaericus* for mosquito control focused on strains isolated and maintained by the Pasteur Institute, WHO collaborating Center, Paris, France. VectoLex is based on strain 2362, which was isolated in Nigeria.

All tested species of *Culex* larvae are susceptible to *B. sphaericus*. Many species of *Aedes, Ochlerotatus, Psorophora, Coquillettidia, Mansonia* and *Anopheles* are also very susceptible. However, susceptibility of species within these genera is variable.

B. sphaericus has demonstrated the ability to provide residual control of mosquito larvae in a great variety of aquatic habitats. It is also the only biological larvicide capable of providing residual control in highly organic environments, including sewage, waste lagoons, animal waste ponds, septic ditches etc.

Bioassay

A standardized bioassay, similar to that developed for Bti H-14 has been developed for determining the potency of *B. sphaericus* preparations. The bioassay utilizes 3rd-4th instar larvae of *Culex quinquefasciatus.*

Mode of Action

The d-endotoxin of *B. sphaericus* is only toxic to the larval stages of mosquitoes. It must first be ingested by the larvae, then partially digested before it becomes activated. The toxin's mode of action is similar to *Bti*, causing disruption of the midgut epithelium.

However, activity of the d-endotoxin of *B. sphaericus* differs from that of *Bti* in several important ways. The toxin is attached to the bacterial spore, while *Bti* toxins are not attached to the spore. The toxins of *B. sphaericus* and *Bti* bind to chemically different receptor sites on cells. They are not related immunologically, and are thought to have completely different molecular modes of action.

Operationally, the most important differences between the toxins of *B. sphaericus* and *Bti* are speed of action and persistence in the larval habitat. *B. sphaericus* toxin is much slower acting than *Bti* toxin. Larval mortality can take several days, but is usually expressed within 48 hours of ingestion. *B. sphaericus* toxin is also much more persistent in the larval habitat than *Bti*. This persistence is thought to be the result of the stability and slower settling rate of the *B. sphaericus* toxin, as well as the unique ability of *B. sphaericus* spores to germinate, grow and produce toxin in cadavers of mosquito larvae treated with the material. This process is known as recycling.

VectoLex CG is labeled for the control of the following mosquitoes:

Culex (all species)
Aedes vexans
Oc. melanimon
Oc. stimulans
Oc. nigromaculis
Coquillettidia perturbans
Psorophora columbiae
Psorophora ferox
Oc. triseriatus
Oc. sollicitans
Anopheles quadrimaculatus

Several other species of mosquitoes are susceptible to VectoLex, but have not been listed on the label. Use for control of such species in the absence of a listed species is therefore not advised. Check with your state agency responsible for FIFRA enforcement if further interpretation is desired.

Habitats	Rate Range
Crops and Dormant Fields: Pastures/hay fields, citrus groves, irrigated crops, orchards, rice, impounded water in dormant fields	5-20 lbs/acre
Marine/Coastal Areas: Salt marshes, Mangroves estuaries	5-20 lbs/acre

Stormwater/Drainage Systems: Storm sewers, catch basins, drainage ditches, retention, detention and seepage ponds	5-20 lbs/acre
Wastewater Sewage effluent, sewage lagoons, oxidation ponds, sewage treatment plants, septic ditches, animal waste lagoons, impounded wastewater associated with fruit and vegetable processing	5-20 lbs/acre
Water Bodies Natural and manmade aquatic sites such as lakes, ponds, rivers canals, wetlands and streams	5-20 lbs/acre

Use higher rates (10-20 lbs/acre) in habitats having deep water, high organic loading, high larval populations or dense surface cover.

Application

VectoLex CG is available in 10/14 mesh. The granules are designed to be applied by ground or aerial application. The size, shape and density of the granules lessens the potential for off-target application due to aerial drift and enables good penetration of dense vegetation. The presence of both floating and sinking granules helps ensure the distribution of the active ingredient throughout the larval feeding zone.

Bulk Density

Bulk density should be measured with multiple lots and data included (this varies somewhat with RH and each batch).

Ground Applications

VectoLex CG granular treatments can be made with many types of ground equipment designed for granule application. These include manually or mechanically driven devices relying on a whirling disk (e.g. Cyclone® seeder, Ortho Whirlybird seeder) and air-blast applicators (Buffalo® turbine, Maruyama® or Stihl® power backpacks.) VectoLex CG is suitable for Horn seeder applications.

When using VectoLex granules, it is important to properly calibrate application equipment. Granule output at a given setting should be determined as well as swath width and required speed or travel. (Please refer to "Successfully Calibrating Applications of VectoBac and VectoLex Mosquito Control Products" AG5293)

Aerial Applications

VectoLex granules can be applied aerially with conventional fixed-wing aircraft or helicopter granule application equipment. Each application unit should be calibrated and the swath characterized using VectoLex granules before being used operationally. The variety of equipment in use precludes specific instructions on settings, airspeed, etc. As an example: ram-air type of applications used on most fixed-wing aircraft usually requires a simple adjustment of the baffle plate or gate to decrease the granule flow rate. Most aerial treatment rate will be in the range of 5 to 10 pounds of VectoLex granules per acre (5 to 10 kg of VectoLex per hectare).

The following table can be used as a guide in determining rates of VectoLex CG application:

Number of Granules Per F2 or Per M2

Rate in Pounds/Acre VectoLex CG (Kilograms/Hectare) 10/14 Mesh

	Ft2	M2
5.0 (5.6)	19	202
7.5 (8.4)	28	303
10.0 (11.2)	38	404

361 granules = gram

Residual Activity

Based upon extensive field evaluations, residual activity of VectoLex CG has been shown to persist for 4-6 weeks after single application at labeled rates. Effective treatment intervals of three or more weeks are typical from single applications to most habitats. Both persistence of the toxin in the water column and recycling of the bacteria contribute to the extended control.

Duration of residual control is generally determined by habitat factors, rather than by application rate. Factors that can reduce residual activity include flushing and water movement, water depth and possibly chemical contamination. In addition, spot treatments with VectoLex CG tend to deliver less residual than treatment of whole water bodies.

Summary of Toxicological Data

Bacillus sphaericus, the technical material was not infective, pathogenic, or overtly toxic by the oral, dermal, intravenous or pulmonary routes of exposure. No mortalities or treatment-related evidence of toxicological effects were observed. The technical material is slightly irritating to the skin and is a moderate eye irritant. Oral exposure of B. sphaericus is practically non-toxic to mallard duck. No mortalities or signs of toxicity occurred following oral treatment. Birds fed diets containing the technical material experienced no apparent infective, pathogenic or overtly toxic effects after 30 days of treatment.

B. sphaericus is not infective or pathogenic and presents no hazard to aquatic freshwater or saltwater organisms.

Storage

When stored in a cool, dry place, out of direct sunlight, useful life is expected to be greater than two seasons. Precautions should be taken to provide a storage area that is dry with temperatures below 24°C (75°F) and rodent proof. In northern areas, product can be held in unheated storage facilities. Freezing will not reduce potency.

Container Disposal

Completely empty bag by shaking and tapping sides and bottom to loosen clinging particles into application equipment. Dispose of empty bag in a sanitary l,and fill or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke. *Do not contaminate potable water, food or feed by storage or disposal.*

Effects on Non-Target and Beneficial Organisms

Due to the very narrow spectrum of effect of the B. sphaericus toxin, effects of label approved applications on non-target organisms are practically nonexistent. A review of the literature (Lacey and Mulla 1990)1 showed the following:

Organism	Study Type	Result
Odonata		
Dragonflies/Damselflies		
T. corruptum	laboratory/naiads fed infected larvae	No effect
E. civile	laboratory/naiads fed infected larvae	No effect
Ephemoptera		
Mayflies		
C. pacificus	field treatment (Technical powder 0.22 kg/ha)	No effect
Heteroptera		
Corixids/Notonectids		
C. decolor	field treatment Technical powder 0.22 kg/ha)	No effect
N. Undulata	laboratory/fed infected larvae	No effect
A. bouvieri	laboratory/LC50	500x mosquito LC50
N. Undulata	field study/treated ponds	No effect
N. unifasiciata	field study/treated ponds	No effect
Buenoa sp.	field study/treated ponds	No effect
Coleoptera		
Dytiscidae	field studies	No effect
Hydrophylidae	field studies	No effect
Diptera		
Chironomidae		
C. crassicaudatus laboratory/LC50	10,000 - 250,000x	mosquito LC50
various species	mesocsom study (Technical powder 11 kg/ha)	No Effect No Effect
Crustacea		
Daphnia		
D. similis	laboratory	Effect at 15,000x mosquito rate
Fairy Shrimp		
S. dichotomus	laboratory	Effect at 27,000x mosquito rate
Crawfish		
P. Clarkii	laboratory	Effect at 1000x mosquito rate

1Lacey and Mulla (1990). Safety of Bacillus thuringensis ssp. israelensis and Bacillus sphaericus to non-target organisms in the aquatic environment. In "Safety of Microbial Insecticides" (Marshall Laird, Lawrence Lacey, and Elizabeth Davidson, eds.), Chap. 12. CRC Press, Inc. Baco Raton, Florida.

Recent unpublished laboratory studies by Ernest Ruber at Northeastern University and field studies in California rice fields by Deborah Dritz of UC Davis confirm the high level of safety of VectoLex products to nontarget organisms.

VectoLex CG has been extensively tested and is not a human health hazard when handled as instructed by the product label. VectoLex CG has a hazard classification signal wordof Caution.