FRASER VALLEY REGIONAL DISTRICT
MOSQUITO CONTROL PROGRAM
2019 YEAR-END REPORT

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Executive Summary

Morrow BioScience Ltd. (MBL) has now completed the first year of a new five-year contract as mosquito control contractor for the Fraser Valley Regional District (FVRD). This is the 16th consecutive year providing floodwater mosquito control for the FVRD. The mosquito control program reduces floodwater mosquito abundance within all areas of the FVRD. Most control activity takes place along and within the Fraser River (i.e. the River) from Hope to Abbotsford/Mission.

Immediately preceding the start of the mosquito season the snowpack in basins contributing to the Fraser River were lower-than-normal. A regional warming trend in early May within contributing snow basins led to the start of the mosquito season. The Fraser River rose consistently and relatively slowly. The peak of the Fraser River at the Mission gauge occurred on June 4 (4.40 m) and was the lowest since 2016. The lack of compounded eggs abundance in mosquito development sites and the lower water levels resulted in a reduced requirement for treatment. No known sites were missed in 2019. Accordingly, complaint calls and emails from residents were considerably low. Adult trap numbers were also low, with the abundance mirroring the unimodal curve of the Fraser River levels with a week delay. Within BC, one human-case of West Nile virus was reported in the Okanagan in 2019. The person was likely infected out-of-province.

Between May 8 and June 24, a total of 605 hectares were treated by ground and helicopter. Treatment efficacy was assessed as high. Five aerial events targeted the foreshore areas, islands of the Fraser River and Stave Lake. A real-time monitoring and treatment data dashboard was provided to the FVRD program manager this year. The dashboard enables managers to view up-to-date treatment information and ensure quality control.

Communications with in-program First Nations bands and residents remains a priority for MBL. MBL staff participated in Earth Day and BC Rivers Day river clean-up events, including maintaining MBL's section of the Vedder River. The public engagement event at the Abbotsford Farmer's market was well-attended. One interview was given to Black Press on April 4 forecasting the 2019 mosquito season, which ran in various newspaper outlets throughout the province. The relatively minimal press for the mosquito program was likely due to the considerably low adult mosquito nuisance issues. The reach of social media posts continues to increase annually, meaning that more residents around the FVRD are aware of mosquito abatement efforts.

Season Highlights

- The peak Fraser River level at the Mission gauge occurred on June 5 at 4.40 m.
- The peak was the lowest since 2016 and occurred approximately 1 week earlier-than-average.
- The snowpack in basins contributing to the Fraser River ranged from 72-94 % of normal in April, immediately preceding the onset of the mosquito season.
- A region-wide warming event within contributing basins prompted considerable low and mid-elevation snow melt conditions in early May, increasing Fraser River levels beyond 3 m, and prompted site treatments.
- Five (5) aerial treatments were required throughout the FVRD region in 2019. Events ranged from May 27 – June 8 and were clustered around the freshet affecting the Fraser River.
- Combined, ground and aerial Aquabac® treatments totalled 4,609 kg (605 ha).
- Adult mosquito trap data and hotline calls/emails were considerably low, likely due to the low River levels and increased management efforts on River islands.
- Trail maintenance efforts on Matsqui Island further improved access to inner-island sites.
- MBL's real-time data management and mapping portal provided MBL managers with improved ability to target areas and gave quality control assurance for clients.
- Education outreach events included hosting an Abbotsford Farmer's Market booth.
- MBL staff volunteered for Earth Day and BC Rivers Day/World Rivers Day clean-up events within FVRD communities in April and September.

Introduction

Morrow BioScience Ltd. (MBL) is the longest-operating mosquito control firm in British Columbia, having conducted mosquito control in this province for nearly four decades. MBL has been the mosquito control provider for the Fraser Valley Regional District (FVRD) since 2004. The 2019 mosquito season marked MBL's 1st year in a new 5-year contract term.

The considerable habitat involvement, program reach, and inter-annual freshet oscillations make the FVRD mosquito control program particularly complex. However, MBL staff has acquired thorough knowledge of the program regarding site locations and effective treatment timing. Numerous improvements have been made to the program since its inception, including: Fraser River island site survey and site addition, trending decrease in complaint calls, the addition of a real-time data collection and review portal, increased public engagement both through social media and through in-person events, and improved environmental awareness through annual carbon offset purchases. MBL's goal is to continue to provide effective mosquito control to the FVRD residents, while remaining socially and environmentally responsible.

Carbon Offsets

The spatial reach and scope of the FVRD mosquito program is such that driving is an inevitable requirement. The accumulated mileage over the course of 2019 was approximately 30,000 km (ground transportation only).

As an estimation, the driving requirements for this program result in the production of approximately 8.7 tonnes of CO_2 emissions. To offset this addition of CO_2 to the environment, MBL has committed to purchasing carbon offsets. To fulfill this commitment, carbon offsets are purchased through the West Kootenay EcoSociety[1]. When the carbon offsets are purchased, a proof of purchase and certificate from the offset provider will be delivered to the FVRD.

Methodology

Floodwater mosquito larvae are the primary target of the FVRD mosquito program. Female floodwater mosquitoes (e.g. *Ae. vexans*, *Ae. sticticus*) deposit their eggs on damp substrate along the Fraser River corridor. When the high water caused by the freshet and/or significant localized precipitation floods these areas, the result is large-scale mosquito egg hatching. If numerous seasons have passed between high-water years, then high river levels may produce a compounded number of mosquito larvae.

MBL field technicians begin monitoring all known mosquito development sites within the FVRD prior to rising Fraser River levels in the spring (Image 1). When River levels start rising, monitoring efforts increase. Communication with the public assists staff in locating new sites.

[1] https://www.ecosociety.ca

Image 1. MBL field technician checking dipper for mosquito larvae

Larval mosquitoes in sufficient number (i.e. >4/dip) are treated by ground applications of a microbial larvicide product called Aquabac®. This product has the active ingredient *Bacillus thuringiensis israelensis* (Bti) and is carried in a corncob formulation. The mode of action for Bti is relatively simple and with a rather high degree of species specificity. Receptors within the mid-gut region of the mosquito larvae are specific to the toxin proteins that are produced alongside each bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs because of cleavage of the protoxins by mid-gut proteases. This event causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert 2000).

As the season progresses and more mosquito development sites become flooded, it becomes increasingly difficult to treat sites by ground due to inaccessibility and concurrent site activation. At this point, a helicopter is used to conduct aerial treatments. The aerial campaign uses the same pesticide as ground applications, although with a higher application rate to permeate canopy cover. Aerial treatments take approximately two days per campaign, due mostly to the level of flooding involvement on the Fraser River islands.

It is important to time treatments according to the correct stage of larval development (3rd and 4th instar). If treatments are applied too early, the larvae will not have reached their highest feeding rate yet and if applied too late, the larvae molt into pupae (i.e. non-feeding stage). Both circumstances may result in the development of adult mosquitoes. Additionally, by waiting until mosquito larvae are in the 3rd and early 4th instar stages, early instar larvae are available as food sources in their ecosystem.

Sites are treated when a standard dip (350ml) collects 5 or more late instar (3rd or 4th instar) larvae per dip. When flooding commences and ambient temperatures rise, many dips easily exceed this threshold. Larval densities within the range of 200-500 per dip (observed as high as 1,000 per dip) are commonly detected. All sites are checked within one or two days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted.

Environmental Conditions

The three primary environmental conditions that affect the Fraser River levels throughout the mosquito season (e.g. April – June) are: 1) ambient temperature in snow basins contributing to the Fraser River, 2) local precipitation, and 3) the snowpack in basins contributing to the Fraser River. Local ambient temperature is also of interest due primarily to how local ambient temperature affects mosquito egg hatching and development rates. As such, all noted conditions are tracked throughout the season.

Snowpack

Floodwater mosquito abundance within the FVRD is primarily governed by regional Fraser River water levels. In turn, the water levels of that systems are governed primarily by the freshet released from the Fraser, Thompson, and Nechako Plateaus. When snowpacks exceed 100 percent of normal, higher-than-average Fraser River levels are expected during the mosquito season.

In April, immediately preceding the 2019 mosquito season, all seven of the basins contributing snowmelt to the Fraser River freshet were below average (Table 1). Comparable to previous seasons, very little late-season snow was received to the basins following the 1 April Snow Survey and Water Supply Bulletin. Given the lower-than-average snowpack in the Fraser River catchment, the 2019 River peak was not expected to be high.

Table 1. Snow basin indices (April Average, 2019 Average) for basins that directly affect the Lower Fraser River flood plain, determined by the 1 April 2019 Snow Survey and Water Supply Bulletin. Values reported are considered percent of normal.

Basin	Average April Snowpack (2012-2018)	2019 April Snowpack
Upper Fraser East	109	89
Upper Fraser West	117	94
Lower Fraser	97	71
Middle Fraser	99	85
North Thompson	104	89
South Thompson	106	75
Nechako	102	72

While the weather in 2019 within influential basins was generally accepted as normal, a warming trend in the southern portion of the province, including the Fraser and Thompson Plateaus, depleted almost all snow below 1600 m by 1 May[2]. A secondary warming trend in early May caused a large amount of snow to melt in basins across the province, resulting in significantly decreased snowpacks.

Continued warming trends in early June further depleted snowpacks in basins that contribute snowmelt to the Fraser River, such that majority of basins were depleted of the remaining estimated SWE by mid-June. By the end of June, all contributing basins had been completely depleted of snow[3].

Local Precipitation

Significant temporally and spatially concentrated precipitation accumulation may elevate Fraser River levels. Local precipitation can also temporarily increase seepage site levels, where considerable mosquito development habitat is located. Thus, tracking local

[2] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2019_may1.pdf
[3] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=c15768bf73494f5da04b1aac6793bd2e

precipitation accumulation can aid MBL field staff with determining how long mosquito development sites may require management. The Fraser River gauge at Mission provides weather information allowing for the comparison of current-year environmental conditions with historical conditions. This comparison allows for some level of prediction regarding larval mosquito development rate and treatment timing requirements.

With the exception of April, the precipitation received to the Mission West Abby weather station (ID: 1105192) during the 2019 mosquito season was below average (Figure 1). Specifically, precipitation received in April exceeded the station average (1981-2010) by approximately 35 mm (Figure 1). Over a third of that accumulation was received to the area on 18 April, immediately preceding the initial rise in the local Fraser River. Thus, it is likely that precipitation did augment local river levels in April and likely created mosquito development sites.

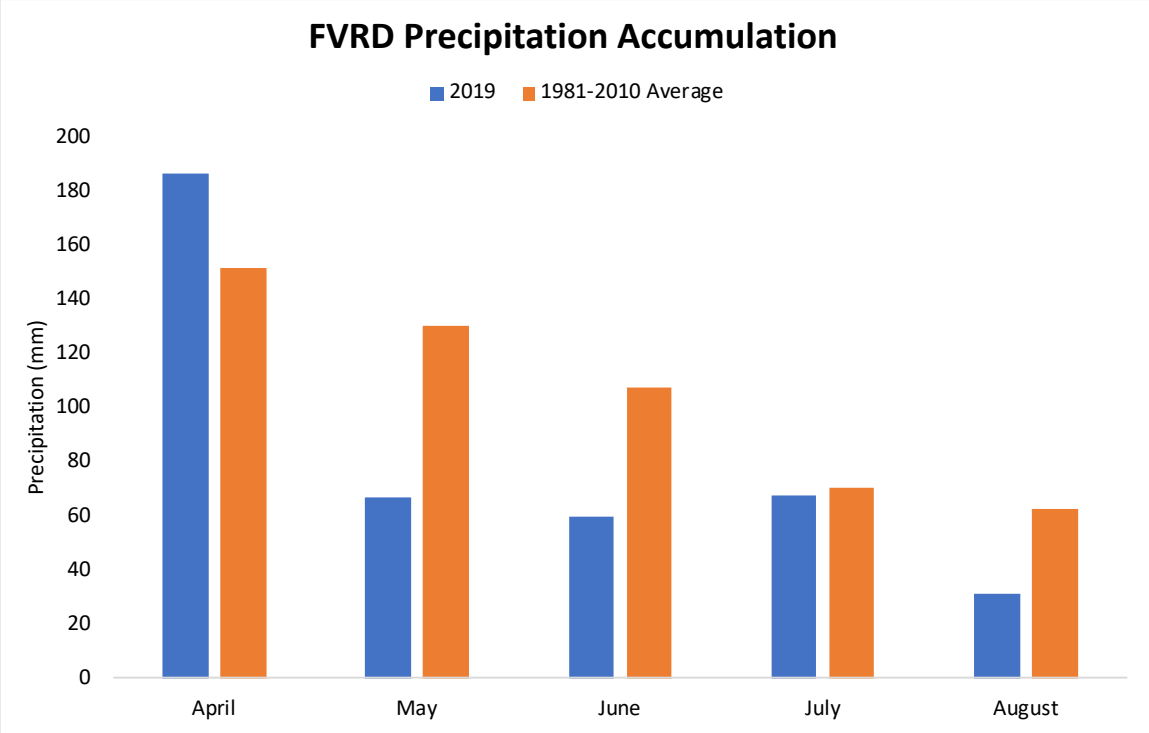


Figure 1. 2019 precipitation values (rainfall and snow accumulation; mm) recorded at the Mission West Abby Station (ID: 1105192) for 01 April – 31 August (blue). Average station precipitation values (1981-2010) are shown in orange.

May and June precipitation accumulation was approximately half of the average accumulation for those months (Figure 1). Given these data, it is reasonable to determine that local precipitation did not measurably augment Fraser River levels in May or June. As the peak in the Fraser River occurred in early June, precipitation data suggest that the rise and peak for the Fraser River was due primarily to the freshet.

Local July precipitation was similar to the average value, while the August accumulation was well-below average (Figure 1). By this time in the season the Fraser River and associated seepage site levels had receded well below the threshold for mosquito egg hatch trigger. However, it's possible that precipitation received in July and August created habitat

for container mosquito breeding. Thus, adult mosquito presence toward the end of the season was likely due to container mosquito hatches, not floodwater species.

Local Ambient Temperature

From April through August, local ambient temperature fluctuations can affect mosquito egg hatching and larval development rates. If the ground proximate to the Fraser River contains floodwater mosquito eggs and if hatching conditions are present (i.e. low dissolved oxygen, higher ambient temperatures), then mosquito egg hatching will commence (Mohammad and Chadee, 2011).

Trpis and Horsfall (1969) exposed submerged eggs of a common univoltine floodwater mosquito species, *Aedes sticticus*, to various constant air temperatures and recorded hatching success. Results revealed that eggs began to hatch at 8°C, although larval development was slow. Eggs held at 21°C provided the most optimal temperature, of the five temperatures tested, for hatching and larval development (Figure 2). While *Ae. sticticus* are not the sole floodwater species present in BC, they serve as representative species for our purposes and provide general developmental benchmarks.

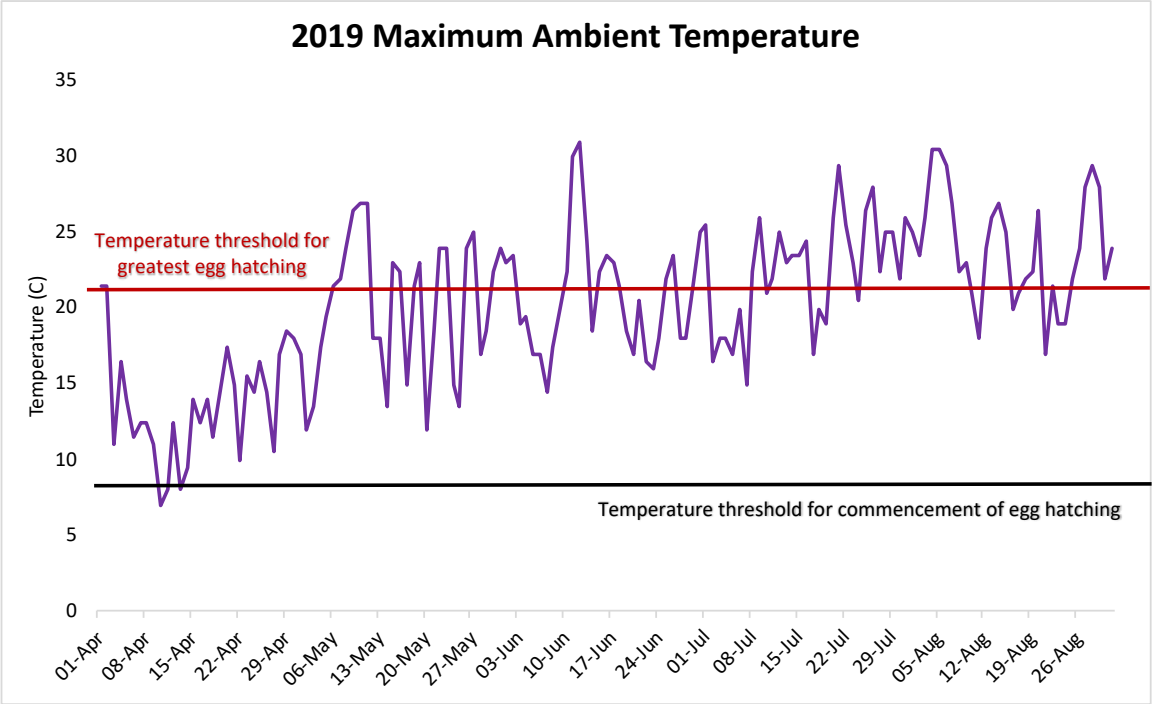


Figure 2. Maximum daily ambient temperatures (C) as recorded at the Mission West Abby Station (ID: 1105192) 01 April – 31 August 2019. Lower black line illustrates threshold at which *Ae. sticticus* eggs commence hatching; upper red line illustrates threshold at which most *Ae. sticticus* eggs hatch.

The 2019 season began with seasonal ambient temperatures for April. The monthly average for April (13.7 °C) was just 0.1°C higher than the station average for April this season (i.e. 13.6°C). Given that April temperatures were well above those noted as being sufficient for hatching, floodwater mosquito eggs within the FVRD were likely activated within April if exposed to flooding conditions (Figure 2). It is important to note that while there were likely sufficient hatching cues for mosquito eggs in April, the larval development at those

temperatures would have been notably slow (Trpis and Horsfall 1969). The potential for larval development in April is the primary reason for annual site monitoring commencement during that month.

Local ambient temperatures in May and June were relatively warmer and more consistent with the most favourable larval development conditions (Figure 2). As expected, hatching and larval development rates increased significantly within those months. Appropriately, larval treatments were concentrated in the latter half of May through early June when ambient temperatures and the Fraser River levels were more consistently high (Figure 2).

Ambient temperature does not directly relate to floodwater larval mosquito abundance after the Fraser River levels measurably and consistently recede, due to lack of water as a cue for hatching. However, ambient temperature does increase development rates for larval and adult mosquitoes (Ciota et al. 2014). Thus, any floodwater mosquitoes that successfully emerged would have had a reduced lifespan with the heightened ambient temperatures into late August (Figure 2).

Although floodwater mosquito annoyance reports reduced as August progressed, localized annoyance due to container mosquito presence may have occurred. Container mosquito habitats near residential homes can be created throughout the summer whenever water occurrence is coupled with high ambient temperatures. MBL technicians regularly inform residents that adult container-bred mosquitoes can be reduced around homes by ensuring container mosquito environments are either free of water or refreshed frequently.

River Levels

Within the FVRD, the majority of floodwater mosquito development sites are found along the flooding corridors of the Fraser River and associated seepage sites. As the presence of water is a hatching cue for floodwater mosquito eggs, tracking the Fraser River levels provides predictive capabilities with regards to mosquito larval development.

A small pulse of water came through the system in early April. With ambient temperatures in contributing snow basins increasing in May, the Fraser River (Mission gauge; 08MH024) levels also increased consistently (Figure 3). Following a provincial warming trend in mid-May, the Fraser River peaked on June 5 (Figure 3). The peak was recorded at 4.40 m, approximately 1.50 m lower than the peak in 2018 and 1.25 m lower than that recorded in 2017 (Figure 3). The last time this level was reached occurred in 2016.

Figure 3 shows Fraser River levels during the mosquito season from 2016-2019 along with a horizontal black line. The black line denotes the Fraser River height threshold (i.e. 3 m) at which mosquito development sites within the FVRD have been observed to become active. In 2019, the Fraser River reached that point on 15 May. While treatments began approximately 1 week earlier, about 99 percent of treatments took place after 15 May (See ‘Larval Control’ section below).

The Fraser River rose at a relatively slow, consistent rate in 2019. When the River rises in this manner, floodwater mosquito eggs laid on substrates at various river levels have optimal environmental hatching cues. When river levels rise at high rates in the early portion of the season, the typically cool highly oxygenated water moving through the system makes it more challenging for mosquito eggs to hatch. However, because the Fraser River began increasing and peaked just slightly earlier-than-normal in 2019, temperatures were warm enough to trigger mass mosquito hatching events.

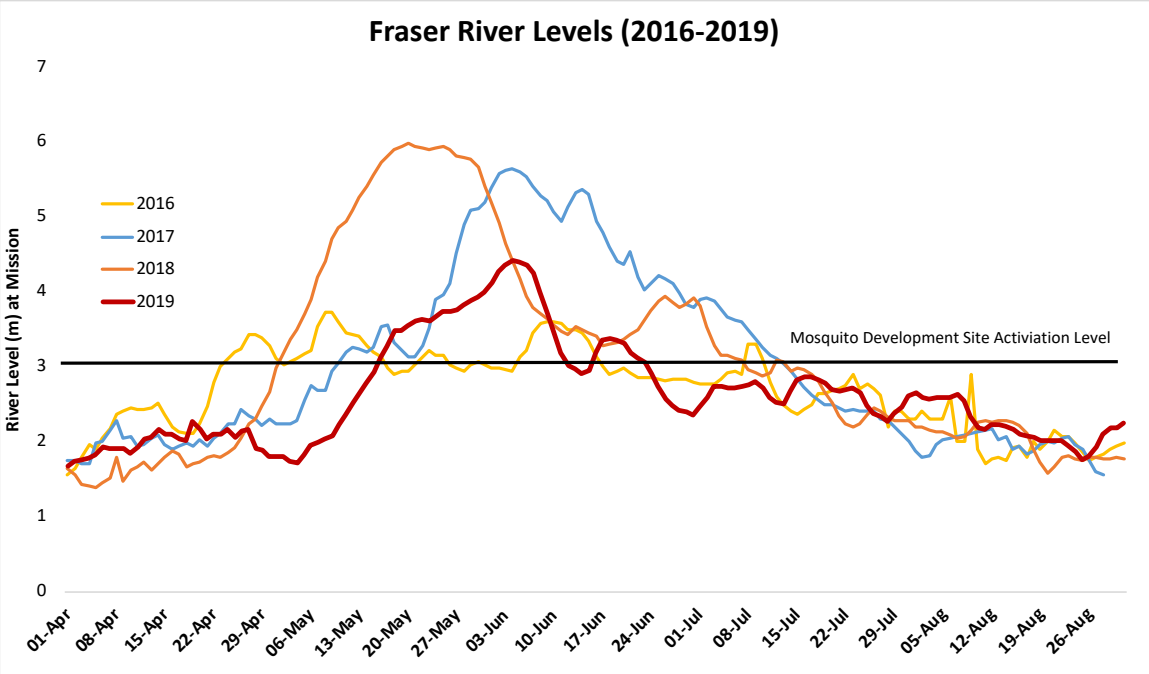


Figure 3. 2019 river Levels (m) as recorded at the Fraser River (Mission gauge, 08MH024; Blue), as reported by the River Forecast Centre. Horizontal black line indicates level at which River-associated mosquito development sites become active.

The Fraser River's peak height relative to recent seasons is a predictive variable that may help explain an associated year's larval abundance. If the current year's regional river levels far exceed that of preceding seasons, mosquito eggs laid between the high-water mark of both years could have remained dormant until current-year flood waters trigger their hatching. Because the peak of the Fraser River was far lower than the preceding two seasons', it is unlikely that the 2019 peak level triggered many dormant eggs to hatch. As such, a lower-than-normal larval abundance was noted in 2019.

By late June 2019, all the snow basins contributing to the Fraser River were depleted of snow[4]. This depletion corresponds with a marked decline in the Fraser River levels by early July at the Mission gauge (Figure 3). When the Fraser River levels consistently remain below 3 m, associated seepage sites reduce quickly. Thus, by late June many of the mosquito development sites were dry.

[4] http://bcrfc.env.gov.bc.ca/data/asp/realtime/

Larval Control

Monitoring within the FVRD began in late April. Appendix I shows a map of larval densities found throughout the 2019 season. Larval abundance is assessed in the field using a system of ranges (0, 1-4, 5-49, 50+) for early and late instar mosquito larvae. In order to transfer these data to a frequency map (Appendix I), data are ultimately summarized and assigned to a hexbin representing an area of 21.65 ha. Only wet sites were included in the analysis. An intensity value representing the relative number and life stage of the larvae are assigned to each single sample. For each sample, late instar larvae ranges are weighted more heavily than early instar larvae ranges to indicate targeted life stage and treatment urgency. In this way, each sample is assigned an intensity value from 0 to 1. All sample intensity values are then averaged by hexbin. Thus, each hexbin is assigned an average intensity value from 0-1. The intensity value thresholds within Appendix I denoting 'low', 'moderate', 'high', and 'very high' were assigned based on biological significance and operational urgency.

Hexbins are used to aggregate point data, making general data trends visible at large scales. The primary drawback and disclaimer to hexbin analysis is that generalizations must be made. In general, hexbins denoted as 'None Detected' (i.e. white) or 'Low' (i.e. light sandy colour) indicate the average sample contained < 5 larval mosquitoes per dip. In most cases, hexbins with a moderate frequency (0.2875 - 0.525 intensity value; light orange colour) or greater indicate those which had an average of > 5 mosquito larvae per dip. Hexbins can contain one or greater sample point, may contain sample points that lie directly on hexbin borders, or contain treatment area associated with a point that is officially housed within a neighbourng hexbin; each of these circumstances may create skewed results.

In certain cases, hexbins denoted as 'Non-Detected' or 'Low' do have treatments associated with them (Appendix II). In these cases treatments may have been triggered by the larval activity of a representative site. Typically, sites that are located on Fraser River islands or those that are difficult to access may be associated with representative sites. Historically, when representative sites become active the other sites in the area have proven to also be active. Thus, sites with a previous designation of 'Non-Detected' or 'Low' may require a later treatment due to representative sites' activity level without the need to sample. Of note, the areas with highest recorded larval abundance amongst known sites are Crescent Island, Matsqui Island, Kilby/Harrison Mills, Vedder River and Fraser River confluence, Agassiz, and Laidlaw (Appendix I A-C).

The first ground treatment occurred on May 8 (Figure 4). Most ground treatments took place between late-May and early-June with the rise of the Fraser River beyond 3 m (Figures 4, 5). Aerial treatments were also concentrated within the same timeframe (Figure 5). Five aerial treatments occurred within the FVRD in 2019, including one at Stave Lake (27, 28 May and 5, 6, and 8 June; Figure 6). Appendix II (A-C) is a map depicting where and how frequently treatments took place in 2019.

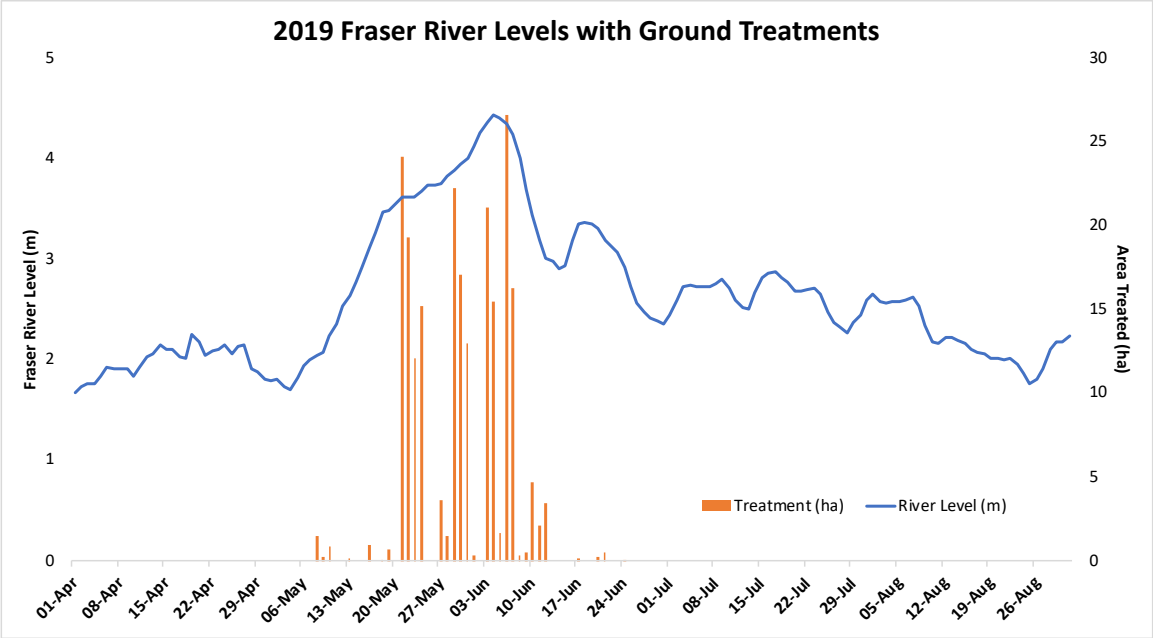


Figure 4. Fraser River levels (m; Mission gauge) and total mosquito development area treated by ground (ha) from April 1 – August 31, 2019.

Relative to the high-water year of 2018, mosquito habitat was significantly decreased in 2019 due to low Fraser River levels. The Fraser River peaked during a period of high ambient temperatures which created ideal mosquito hatching environments. River levels started to recede in early June; by early July mosquito development areas were considerably reduced or dry. Thus, ground treatments tapered-off towards the end of June (Figures 4, 5, and 6). The final ground treatment took place on June 21 (Figure 4).

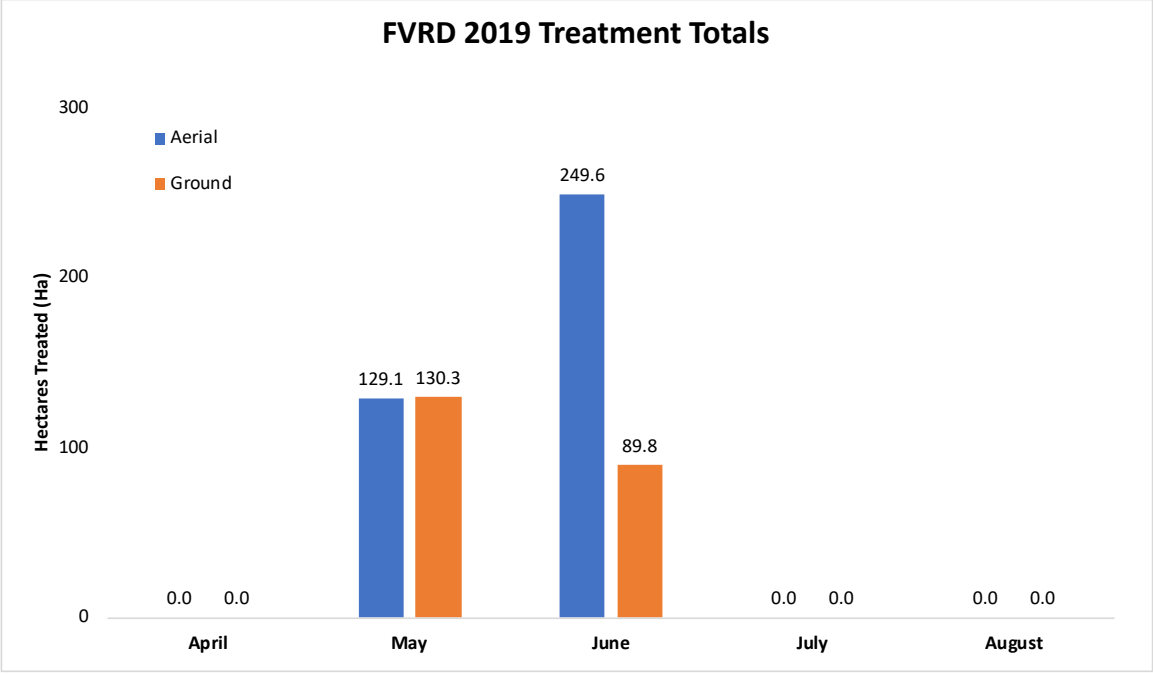


Figure 5. 2019 treated area (ha) by method (i.e. ground vs. aerial) and month from April – August.

Ground treatments were applied at a rate of 4 kg/ha. A total of 227 ha was treated by ground, equating to a total of approximately 896 kg of Aquabac® used (see Fig. 7 for context). Typically, sites only require one treatment per season unless additional mosquito larvae are pushed into the site due to the movement of water. If additional treatments at a site are required they occur at increased water levels, hence the treatment overlap is minimal.

To compensate for increased canopy cover, aerial treatments were applied at a rate of approximately10 kg/ha. Lower rates were used for areas like Stave Lake, where canopy cover is not as dense as on the Fraser River islands. A total of 379 ha was treated by air, equating to a total of 3,713 kg of Aquabac® used (Figures 6, 7). No sites were missed in 2019 and no new sites were discovered, beyond those located on Matsqui Island. Appendix III shows more specific information about site, treatment timing, and extent of treatment.

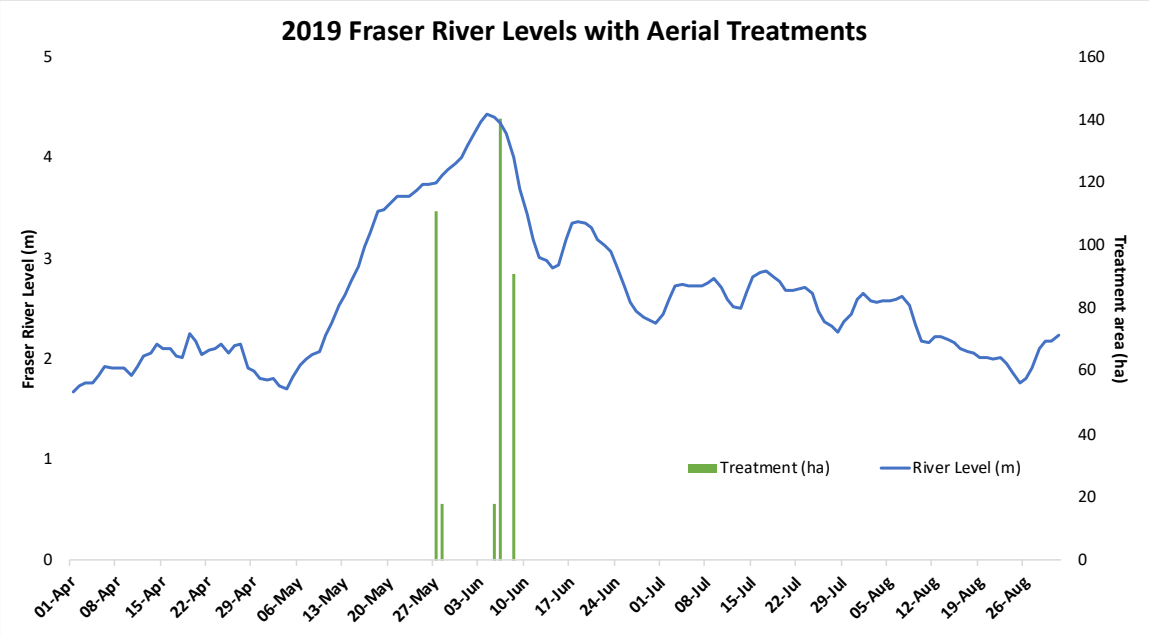
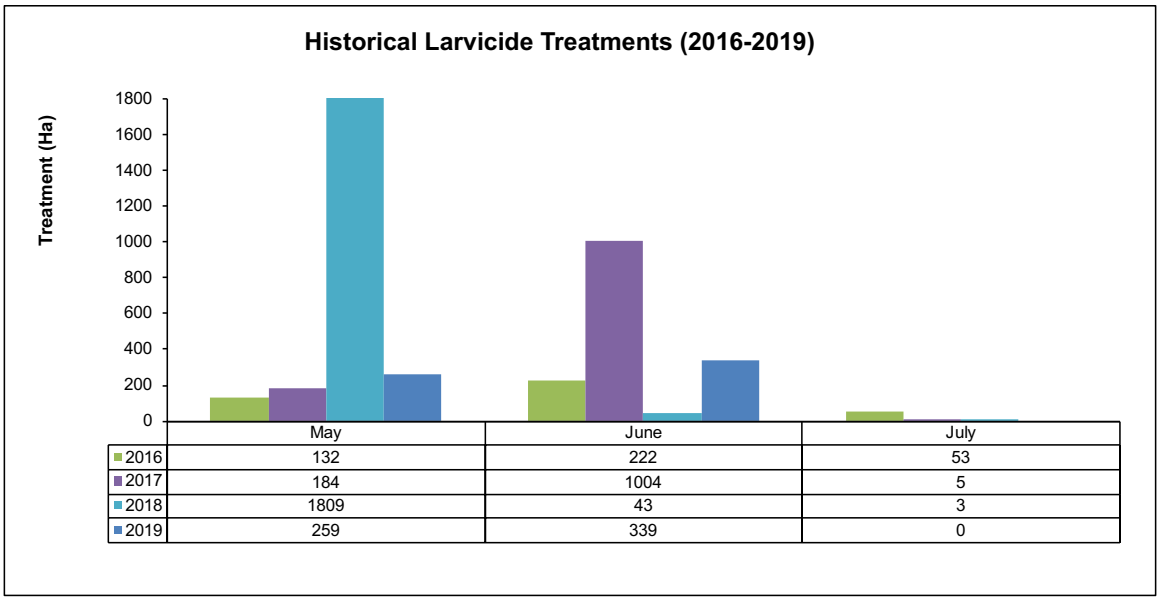


Figure 6. Aerial application events (green lines; ha) and Fraser River levels (blue line; m) as recorded at the Mission gauge from April 1 through August 31, 2019.

In comparing treatment areas since 2016, a year with similar peak River levels to 2019, the total treated area was most like that of 2016 (Figure 7). The lower treatment amount in 2019 is due to the lower-than-average snowpack in contributing basins, along with average local precipitation accumulation. As the peak in the Fraser River was unimodal, treatments were not required in July (Figure 7).



	May	June	July
2016	132	222	53
2017	184	1004	5
2018	1809	43	3
2019	259	339	0

Figure 7. Historical Aquabac® treatments (ha) for May, June, and July (2016-2019). Treatments include ground and aerial applications.

2019 Focal Mosquito Program Areas

The FVRD mosquito program includes the largest number of islands of any program in BC. There are 22 island groups between Abbotsford and Hope. Depending on water levels in the Fraser River, these islands can be split by various channels into approximately 88 islets totalling approximately 3,200 ha of treatable area. These islands are accessible only by water or air and, as a result, are challenging and expensive to monitor. Canopy cover and plant density on certain islands (e.g. Matsqui, Comrey) further complicates site management. Adult mosquitoes coming from the Fraser River islands can disperse to nearby municipalities and are likely the cause of nuisance issues approximately three weeks after the Fraser River peaks.

On less densely covered islands (e.g. Herrling, Carey), the MBL river boat has been integral to the identification and treatment of mosquito habitat. Monitoring these sites with the use of the riverboat is more effective and cost efficient in comparison to monitoring with a helicopter prior to treatment. Previous years' efforts to investigate the islands within the riverboat program have resulted in the discovery of a considerable amount of potential mosquito habitat.

Carey Island and Herrling Island were cleared for tree-farming purposes in late 2017 and 2018. These efforts make identifying mosquito development sites on the islands easier. Aerial applications are now more straight-forward on these islands and require a lower treatment rate because the Aquabac® can reach its target site without being impeded by foliage.

Matsqui Island

Matsqui Island is located near the communities of Abbotsford and Mission. Adult mosquitoes that disperse from Matsqui Island directly affect residents of those communities and residents in smaller communities nearby. Dense foliage on Matsqui Island has largely prohibited monitoring or treatment of the interior area until recently.

Image 2. Matsqui Island trails required considerable maintenance in 2019. MBL staff re-cut trails on the Island from 27-29 August.

In 2018, MBL partnered with Matsqui First Nations and the FVRD to build a network of trails throughout the island. A total of approximately 2 km of trails was created in 2018. Crews returned to the previously established trails on 27-29 August 2019. While the general imprint of the trails was still evident, the trails required considerable maintenance (Image 2). Following MBL staff efforts, the 2 km of trails on Matsqui Island were re-established to good condition. The trail improvements will enable continued access to sites in 2020.

Stave Lake

Stave Lake is a reservoir located in Electoral Area 'F' and at the northern end of the District of Mission. BCHydro manages the hydroelectric project connected to the Stave Lake reservoir, which is contained by the Stave Lake Dam. When Stave Lake levels increase sufficiently in the spring months, suitable mosquito development habitat adjacent to the lake north of Hatzic Valley is flooded. MBL has monitored Stave Lake for larval mosquito habitat since 2015 and treated that habitat since 2016.

Based on Stave Lake levels, river boat monitoring took place on five (5) days in 2019 between mid-May and early July. An aerial treatment was required on May 28, with high control efficacy. No known complaints were received by Stave Lake residents.

Adult Mosquito Trapping

This year is the 8th consecutive year in which adult mosquito trapping stations have been set-up throughout the FVRD. The primary intention of the adult mosquito trapping program is to determine adult mosquito abundance, which will act as a quality assurance/quality control measure for larval mosquito control activities conduct by MBL technicians. Additionally, the trap data allows MBL to compare intra and inter-annual nuisance levels.

The same five trap locations were used in 2019 as were used in the previous seasons. Specifically, Hope Wastewater Plant, Abbotsford Wastewater Plant, Kent Wastewater Plant, Mission Raceway, and Chilliwack Wastewater Plant. Adult counts include male and female specimens (Table 2).

Table 2. 2019 adult mosquito count by trap location and date.

	17-May	31-May	10-Jun	26-Jun	09-Jul	26-Jul	19-Aug
Hope Wastewater Plant	3	20	29	2	8	0	0
Abbotsford Wastewater Plant	3	9	27	12	2	1	0
Kent Wastewater Plant	7	15	30	18	4	2	0
Mission Raceway	1	13	31	11	2	0	1
Chilliwack Wastewater Plant	6	21	23	5	9	0	6

A New Jersey Light trap was placed at each location and connected to a timer. These traps rely on mosquitoes being attracted to the heat and intensity of the light. A fan is attached to the trap, as well, which draws in mosquitoes that have been attracted to the light. The timer for the light was set to go on just before dusk and off just after dawn, capturing the time of the day when mosquitoes are most active. Instead of the standard light used in the light traps, a grow-light was used to increase trap counts.

Traps were monitored every 2-3 weeks throughout the season beginning on May 17 and ending on August 19 (Table 2). Each time, adult mosquito specimens were counted and trap function was checked. All traps were performing normally at each monitoring event.

Historically, adult mosquito trap abundance appears to have been directly related to the height of the lower Fraser River levels. While 2018 total trap abundance was inversely related to the peak of the Fraser River, 2019 total trap abundance was more in-line with previous observations. Trap abundance from 2018 may have been an anomaly or may have been due to trap malfunctioning issues present that year. The total adult specimens collected in 2019 were 321, which is similar to the total collected in 2016, the most recent season with a comparable Fraser River peak.

The trend in 2019 adult trap abundance followed a bell curve, with the most adults collected at the June 10 event (Table 2). The high abundance on that date is likely due to early dispersal from near-peak River level emergence. Typically, adult mosquitoes begin to disperse at least 2-3 weeks after the peak in the regional Fraser River levels. Depending on wind direction and velocity, the dispersal may be accelerated or decelerated.

Adult specimens were not collected in 2019. It is expected that the general species distribution did not differ significantly from that of 2018, as historic trap locations were the same and the general trend in peak adult mosquito abundance as it relates to Fraser River peak were similar (Sternberg 2018). It is expected that floodwater species (e.g. *Aedes* spp.) comprised the majority of specimens from late-May through June and container species comprised a more prominent portion of the species composition from July through August. Adult mosquito identification will be conducted in 2020 to assess species composition in FVRD traps.

Public Relations

Maintaining positive public relations remains a high priority for MBL. Public relations occur on several levels: in-person communication with members of the public, the mosquito hotline, presentations to staff and politicians, responding to e-mails, and continuing our social media presence. MBL continues to look for new areas to expand this aspect of our program and to improve our communication techniques.

Phone Calls and Emails

The total number of complaint calls and emails received in 2019 was four (4) (Figure 8; Appendix IV). The exceptionally low number of complaint calls is likely due to relatively low Fraser River levels and improved monitoring and treatment on the Fraser Islands. An additional three (3) calls were classified as inquiry calls from residents requesting information about the upcoming mosquito season. Two (2) complaint emails were received from the Popkum area. Notably, the number of calls and emails received in the 2019 season was the lowest recorded, to date.

The highest number of complaint calls and emails (3) were received from the Chilliwack/Popkum area. One email and one call from Popkum were received in mid-July, well after the dispersal from floodwater mosquitoes would have concluded. Thus, it's likely the mosquitoes reported from the Chilliwack/Popkum area were container mosquitoes. The other email received from a Chilliwack resident was likely due to the adult mosquitoes dispersing from Comery and/or Queens Island, which are densely forested and challenging to treat. All complaint and inquiry calls and emails were returned within 24 hours.

Direct Communications

Direct communication between MBL staff and the public can occur in many circumstances. The most common direct interfacing with the public occurs when technicians are in the field. While conducting site visits, MBL technicians are often asked questions by landowners or residents. These encounters provide an excellent opportunity for public relations. The fact that technicians are visibly monitoring and treating assures residents that attention is being given to mosquito abatement efforts. Additionally, an important outcome of these interactions can be the identification of new sites and larval mosquito activity by involved residents.

MBL contact information is disseminated when field technicians have direct communication with the public. Contact information for MBL includes the website address, an email, phone number, and social media sites (Twitter, Facebook). By providing the public with these resources and avenues of communication, it also enables community members a platform for question follow-up.

Social Media

This year, 2019, is the 8th consecutive year in which MBL has maintained a social media presence. There are five main goals for MBL's social media presence: 1) provide timely and up-to-date information regarding conditions pertinent to mosquito production, 2) relay MBL's current efforts to control mosquitoes, 3) inform the public about MBL's efforts at social sustainability, 4) provide the community with opportunities to get involved with related public events, and 5) offer a platform for mosquito-related discussion amongst program residents and the MBL team.

Facebook (facebook.com/morrowmosquito) remains the primary avenue for MBL to disseminate mosquito-related information. Regular updates on mosquito abundance began in mid-April advertising the annual Chilliwack/Vedder River Clean-Up Day. In addition to volunteer opportunities, post topics also included mosquito management efforts, outreach efforts conducted by MBL staff members (i.e. Farmer's Market booths). Whenever possible, photos of staff working within the FVRD were also posted.

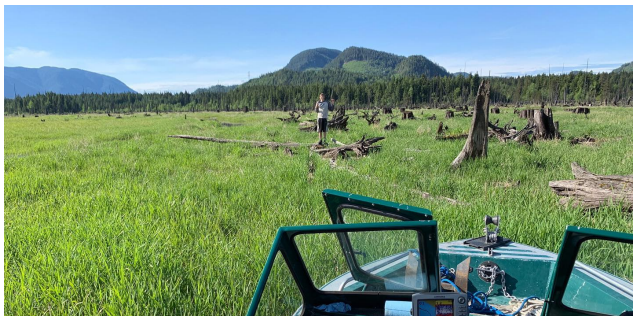


Image 3. Stave Lake monitoring event posted on Facebook (19 May 2019).

The total number of followers on the MBL Facebook page is currently 305. This number has increased by 25 since October 2018. Another way to gauge how many people are looking at or responding to MBL's posts is by considering MBL's post "reach". Specifically, each time a follower interacts with the MBL page a subset of their "friends" is exposed to the information that the original follower commented on or "liked". The maximum reach in 2019 was 336 on May 19 and was in response to a posting about monitoring activities at Stave Lake (Image 3).

MBL Website

The MBL website (**www.morrowbioscience.com**) was launched in 2015. This site was developed to allow clients and the public to have access to information about MBL's background, activities, outreach, and staff members. The website is continually being refined as MBL further develops our programs.

Currently, the site contains information about MBL's philosophy, staff background, and current projects. The site outlines MBL's services and relevant news, including a blog updated throughout the mosquito season. Of importance is the 'Contact' tab which allows a person to directly send a message to MBL. Additionally, there are links to MBL's Facebook account and Twitter feed, so interested individuals may have real-time updates on MBL's activities.

Public Engagement Opportunities

As part of MBL's commitment to social sustainability, MBL adopted a portion of Vedder River in 2015. As such, MBL is responsible for ensuring that our section is clean throughout the year and that it is attended to during organized river clean-up days. On Chilliwack/Vedder River Clean-Up Day and BC Rivers Day in 2019, MBL employees and their families helped clean up MBL's section of the Vedder River. Our hope is that MBL helps promote a healthy ecosystem for animals and humans that utilize the area.

MBL staff hosted an information booth at the Abbotsford Farmer's Market on June 15. Staff shared information pertaining specifically to the mosquito abatement program, addressed frequently asked questions about Aquabac®, and disseminated pamphlets with tips for reducing mosquito abundance around the home. The market was well-attended and the information presented was timed appropriately to assist residents with personal protective measures and mosquito abundance reductive tips prior to the majority of adult mosquito dispersal and container mosquito emergence.

Image 4. MBL staff attend an Abbotsford Farmer's Market outreach booth on June 15, 2019.

One interview was requested of MBL staff by Black Press. MBL's head biologist gave the interview on April 4, with specific attention paid to the forecast for mosquito annoyance in 2019. While this request and interview were not specific to the FVRD, the article was published in various news outlets throughout British Columbia. Appendix V includes the Chilliwack Progress's interpretation of the Black Press Media interview. The relatively low number of interview requests was likely due to the low water year and related low adult mosquito annoyance.

West Nile virus Summary

Along with its partners, the Government of Canada conducts on-going surveillance of West Nile virus (WNv) cases in humans between mid-April and the end of October. As of October 9, there was one confirmed human case of WNv reported in BC. It's suspected that the person in the Okanagan was infected outside the province. It should be noted that Health Canada includes any WNv human cases that are deemed probable or confirmed. Cases may include WNv neurological syndrome, WNv non-neurological syndrome, and WNv unclassified/unspecified.

Mosquito pools, horses, and birds within BC have also been tested. To date, no mosquito pools have tested positive for WNv in BC, nor have any birds. One horse tested positive for WNv in BC[5]. It is believed that the horse was infected outside of the province.

As Washington State shares a border with British Columbia, it is important to follow WNv activity in that area, as well. As of October 15, there were 6 human cases of WNv in Washington State; five of the cases were acquired in-state in a county in the middle of the state[6]. Additionally, 27 mosquito pools and 2 horse/other mammals tested positive for WNv. No birds tested positive for WNv in 2019. The Washington State county that borders the FVRD is Whatcom County. Within that county, no human, bird, horse/other mammal, or mosquito cases were reported.

Program Reminders

A number of important issues must be addressed at the start of each season:

- Notify the Ministry of Environment of the FVRD intent to treat mosquitoes in 2020 under the FVRD Pest Management Plan. Notification should take place 2 months before the start of the season (the end of February at the latest).
- It is important to attach copies of all the mosquito development site maps with the Notice of Intent to Treat (NIT). NOTE: all sites have been re-mapped. This new data should be used to reprint maps for the purposes described above.

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[6] http://www.doh.wa.gov/DataandStatisticalReports/DiseasesandChronicConditions/WestNileVirus

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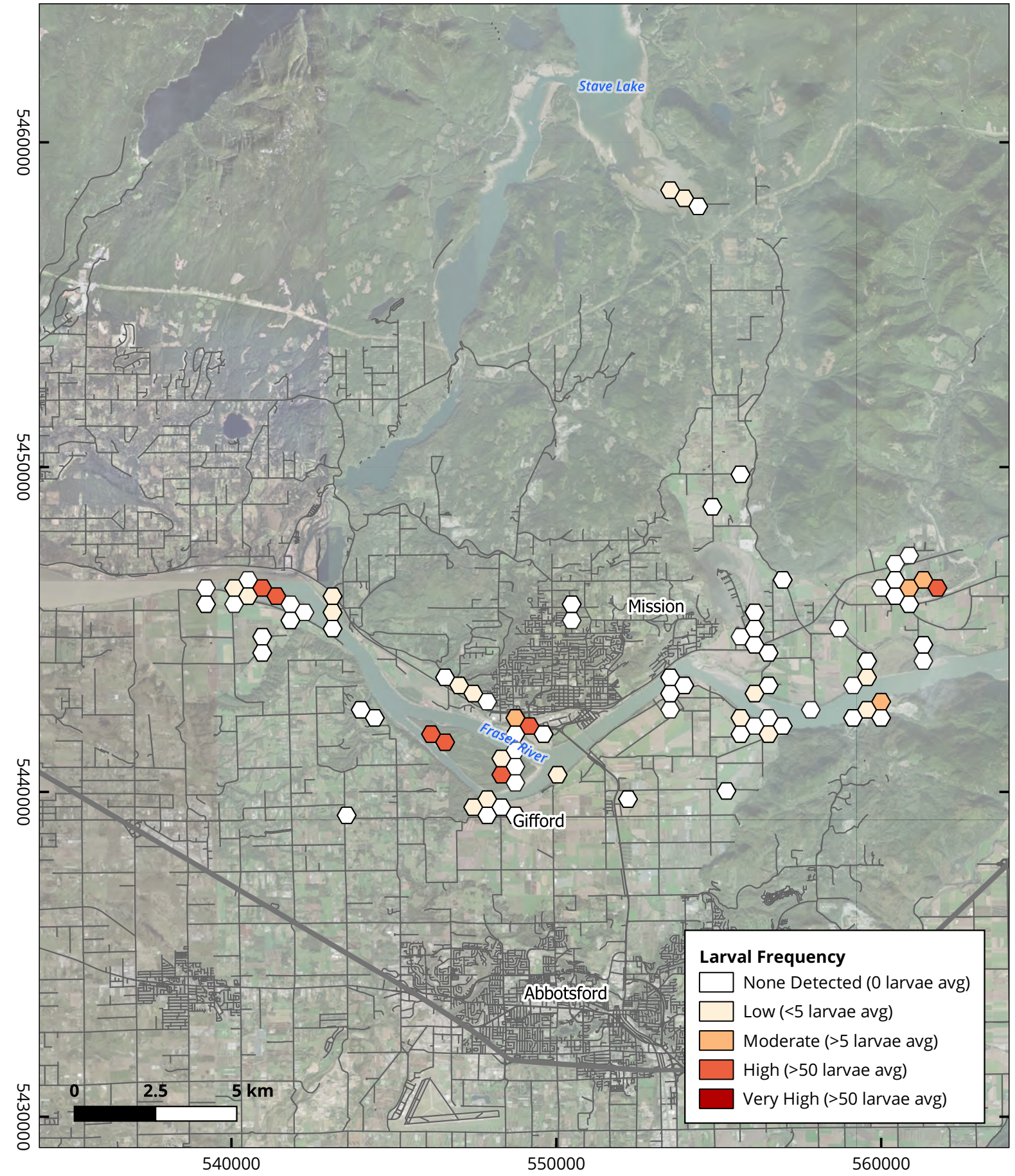
Mosquito Larval Densities at Sample Locations (1/3)

Appendix I-A

2019

Morrow BioScience Ltd
PO Box 1013 Rossland, BC V0G 1Y0
gis@morrowbioscience.com 1(877)986-3363

Scale = 1 : 150,000 CRS = NAD83 UTM Zone 10N



Mosquito Larval Densities at Sample Locations (2/3)

Appendix I-B

2019

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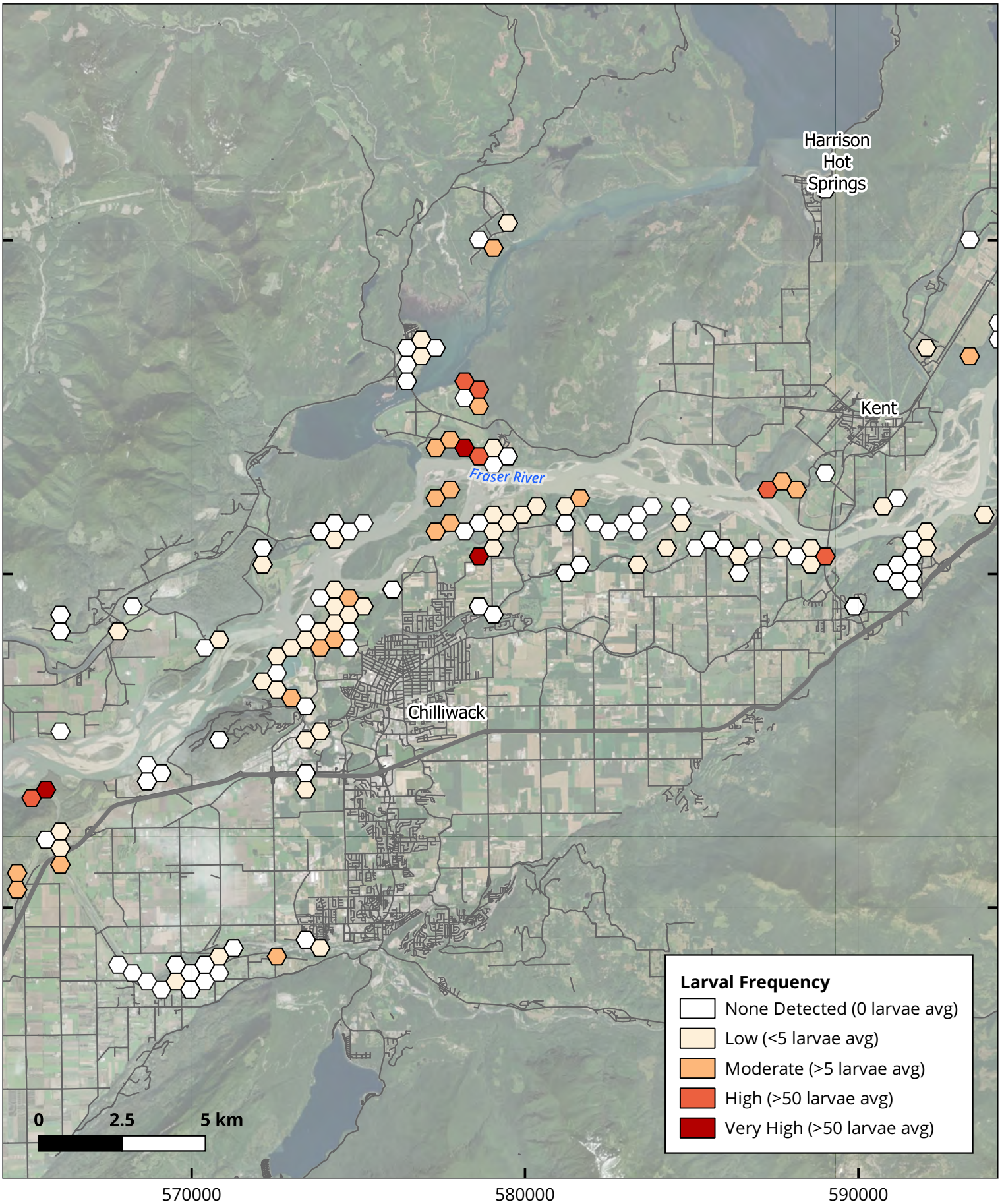

Mosquito Larval Densities at Sample Locations (3/3)

Appendix I-C

2019

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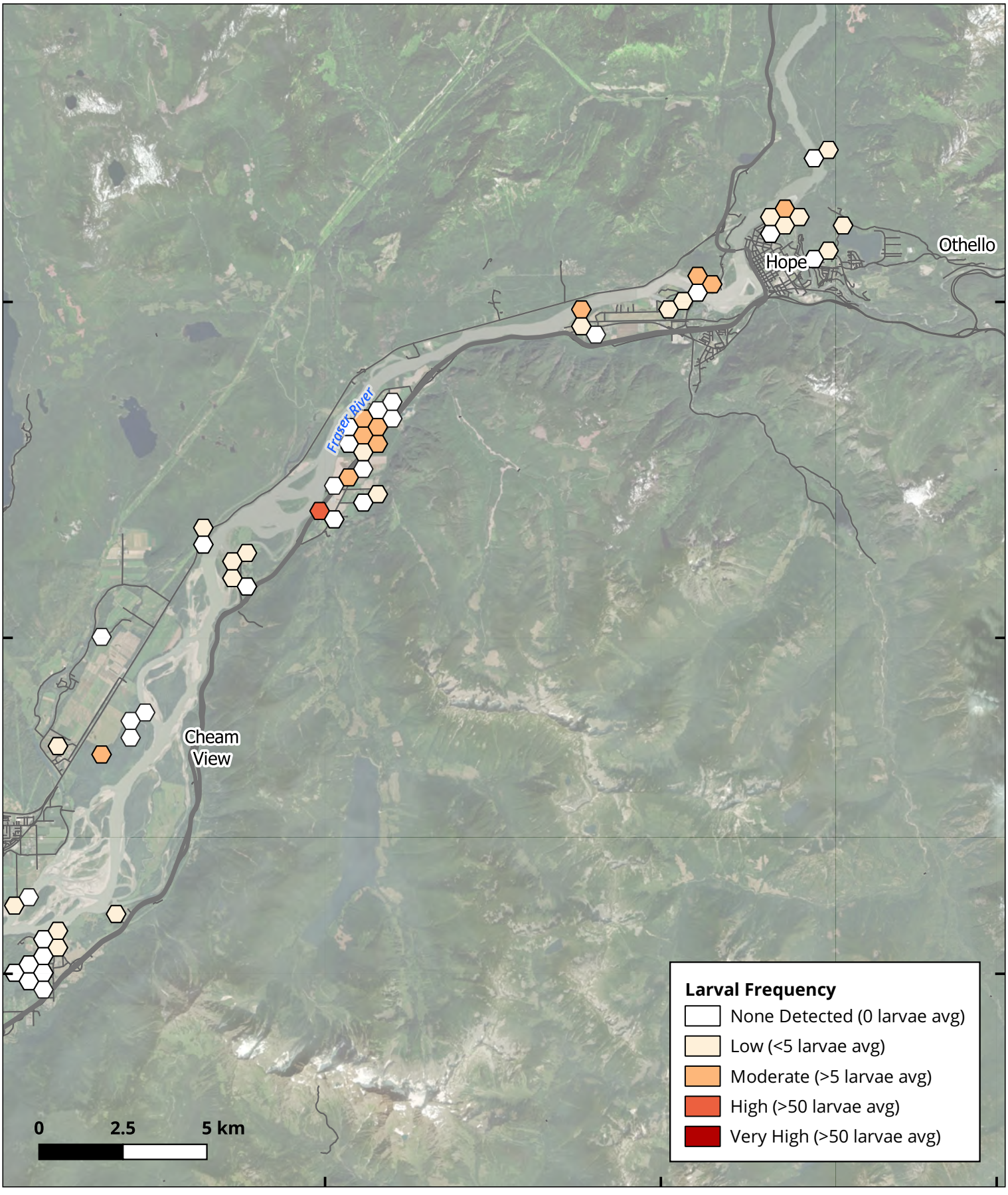

Mosquito Larvicide Treatment Locations (1/3)

Appendix II-A

2019

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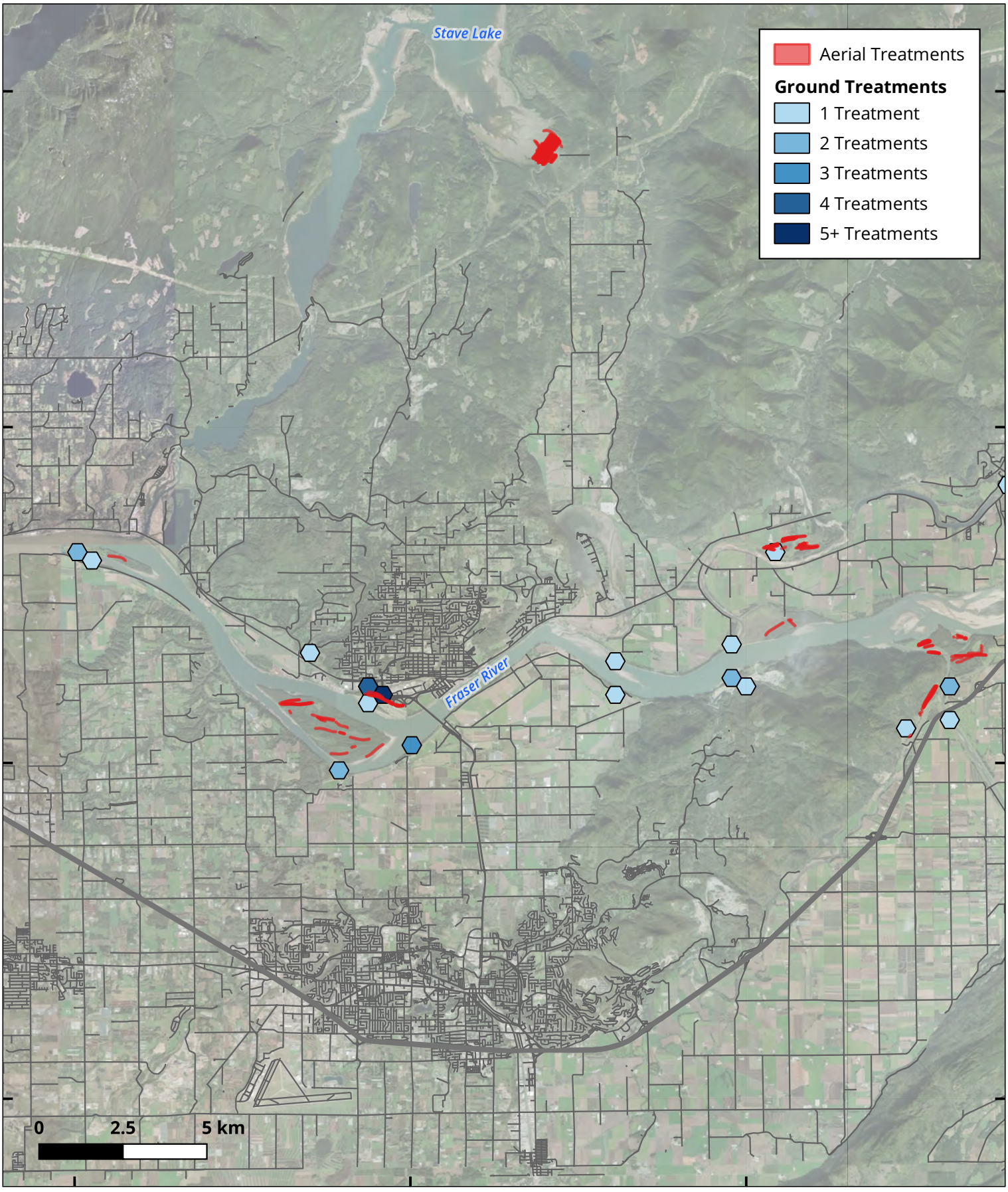
Scale = 1 : 150,000 CRS = NAD83 UTM Zone 10N



2018 Mosquito Larvicide Treatment Locations (2/3)

Appendix II-B

2019

N

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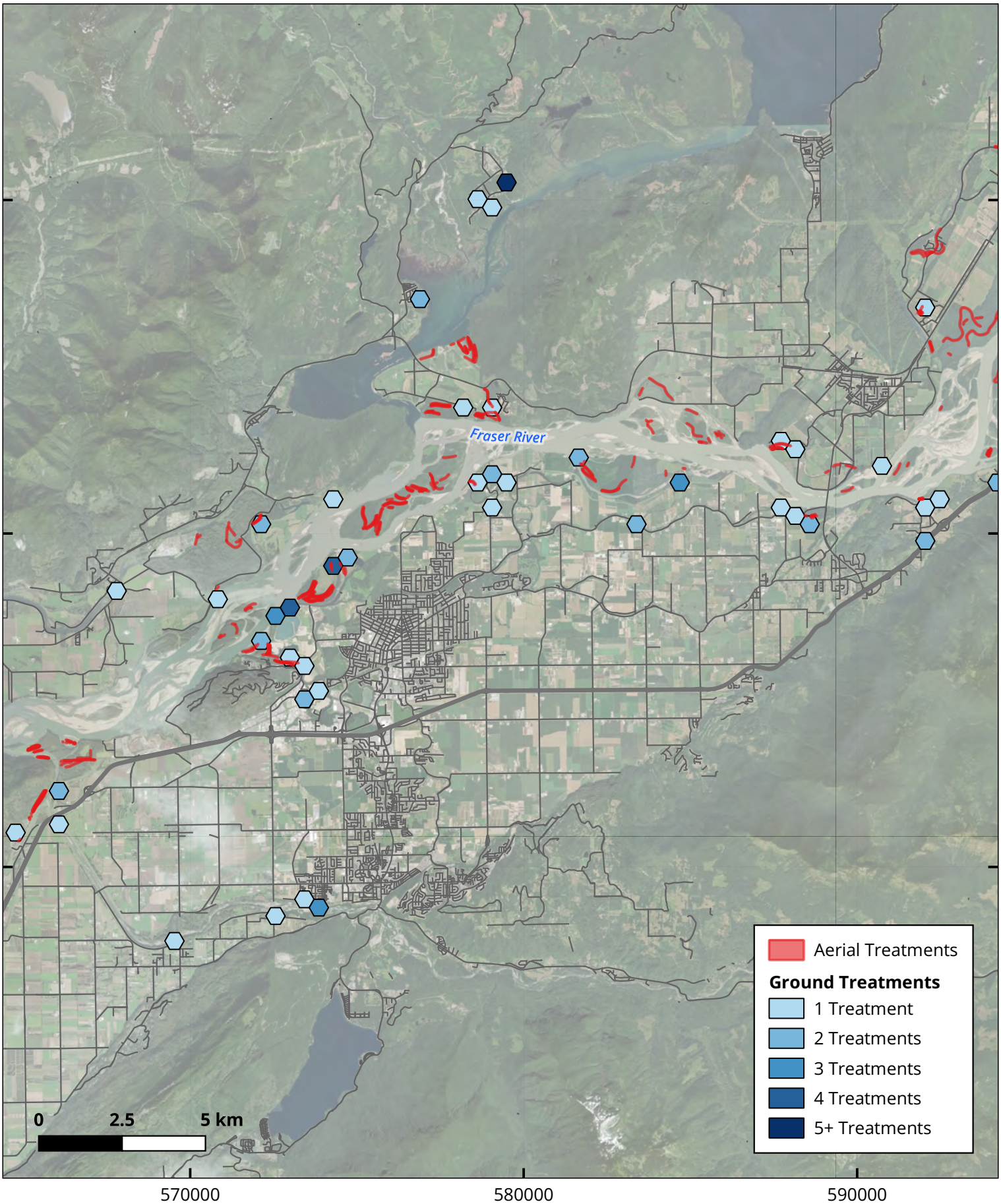

Mosquito Larvicide Treatment Locations (3/3)

Appendix II-C

2019

Morrow BioScience Ltd

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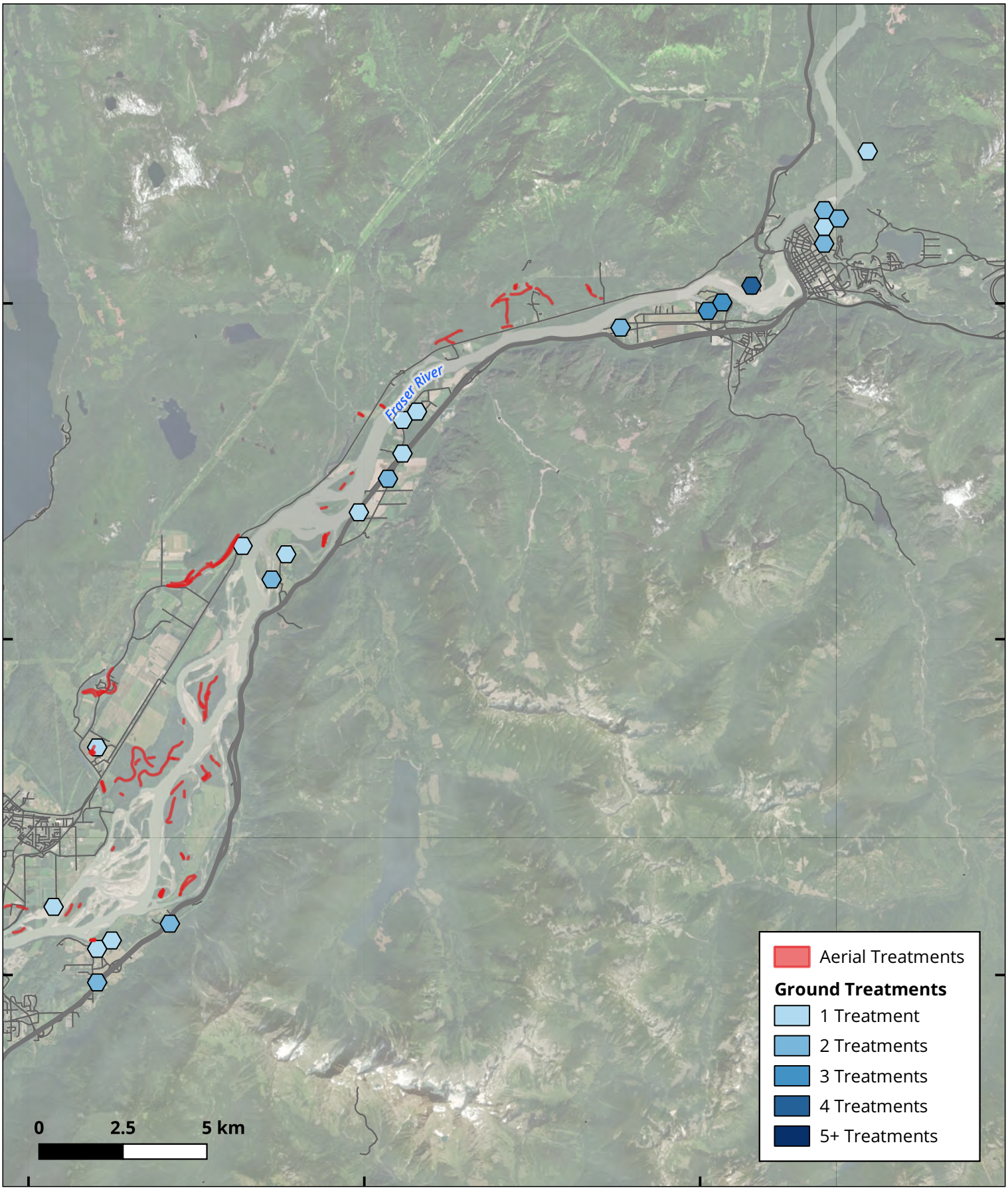
Scale = 1 : 150,000 CRS = NAD83 UTM Zone 10N



Appendix III. 2019 treatment data (kg, ha) by site and date for all ground (A) and aerial (B) treatments

III-A: Ground Treatments

Treatment Date	Site	Treatment Amount (kg)	Area Treated (ha)
08-May-19	FVRD-104	6	1.5
09-May-19	FVRD-190	1	0.25
10-May-19	FVRD-062	3.5	0.875
13-May-19	FVRD-218	0.25	0.0625
13-May-19	FVRD-218	0.5	0.125
16-May-19	FVRD-063	2	0.5
16-May-19	FVRD-099	2	0.5
18-May-19	FVRD-052	0.1	0.025
19-May-19	FVRD-002	0.1	0.025
19-May-19	FVRD-211	0.3	0.075
19-May-19	FVRD-062	2.5	0.625
21-May-19	FVRD-053	1	0.25
21-May-19	FVRD-176	1.5	0.375
21-May-19	FVRD-109	2	0.5
21-May-19	FVRD-173	6	1.5
21-May-19	FVRD-116	9	2.25
21-May-19	FVRD-171	9	2.25
21-May-19	FVRD-061	12	3
21-May-19	FVRD-194	16	4
21-May-19	FVRD-141	30	10
22-May-19	FVRD-056	0.25	0.0625
22-May-19	FVRD-142	3	0.75
22-May-19	FVRD-142	13	3.25
22-May-19	FVRD-115	13	3.25
22-May-19	FVRD-139	48	12
23-May-19	FVRD-104	0.25	0.0625
23-May-19	FVRD-063	2	0.5
23-May-19	FVRD-099	5	1.25
23-May-19	FVRD-186	6	1.5
23-May-19	FVRD-063	9	2.25
23-May-19	FVRD-058	12	3
23-May-19	FVRD-135	14	3.5
24-May-19	FVRD-226	0.5	0.125
24-May-19	FVRD-226	0.5	0.125
24-May-19	FVRD-090	4	1
24-May-19	FVRD-063	5	1.25
24-May-19	FVRD-038	6	1.5
24-May-19	FVRD-077	12	3
24-May-19	FVRD-121	12	3
24-May-19	FVRD-121	21	5.25
27-May-19	FVRD-012	2.5	0.625

2019 Mosquito Hotline Complaints

Morrow BioScience Ltd
PO Box 1013 Rossland, BC V0G 1Y0
gis@morrowbioscience.com 1(877)986-3363

Appendix IV

0 10 20 km

Scale = 1 : 150,000 CRS = NAD83 UTM Zone 10N

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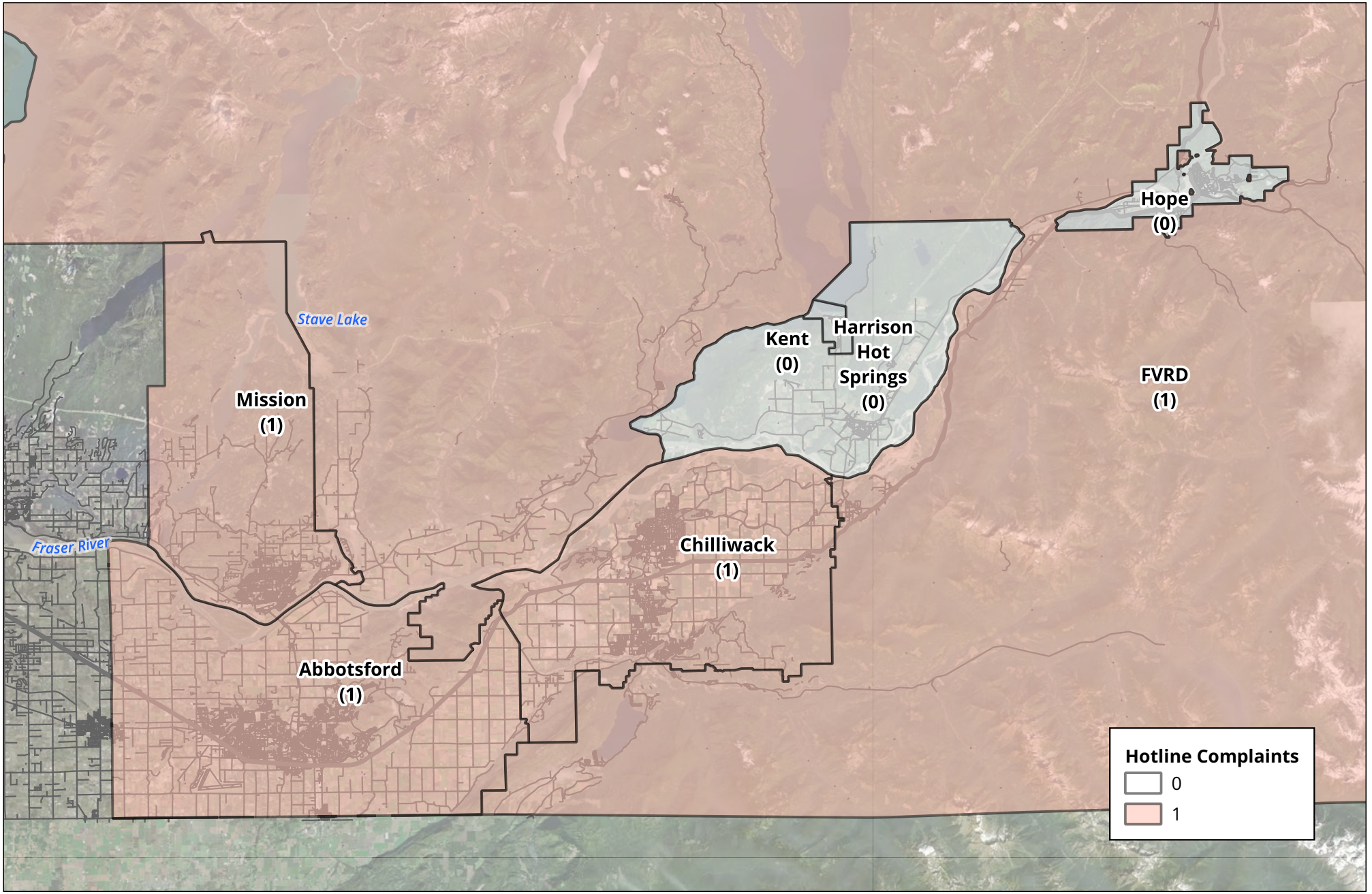

FILE - In this Jan. 18, 2016 photo, a female Aedes aegypti mosquito acquires a blood meal on the arm of a researcher at the Biomedical Sciences Institute in the Sao Paulo's University in Sao Paulo, Brazil. (AP Photo/Andre Penner, File)

B.C.'s 'mosquito guy' says dry spring could mean fewer pesky biters

Dirk Lewis works at a 'mosquito management' firm in Rossland

ASHLEY WADHWANI / Apr. 4, 2019 1:45 p.m. / NEWS

A dry April could mean fewer mosquitoes this summer, one B.C. expert says.

Last year, the pests were out in full force after more than a month of flooding was followed by extreme heat.

Dirk Lewis, known as the "mosquito guy" at Morrow BioScience, a "mosquito management" firm in Rossland, told Black Press Media it all depends on water levels this month.

"It's looking like they might come earlier, but there may also be lower flood waters than last year," Lewis said.

Female mosquitoes look to lay their eggs in soil that's protected from risks but prone to flooding, like near rivers and creeks.

They average about 1,000 eggs in a lifetime. The eggs can't hatch until they get wet, so each tiny egg can remain dormant for as long as 10 years, waiting for perfect conditions.

READ MORE: Birds from Kimberley test positive for West Nile virus

BUG SPRAY 101: Health Canada wants you to stay bite free

With floodwaters reaching historic levels last year, it was the perfect storm for plenty of pesky biters to hatch.

This season, the first batch of mosquitoes out now are fresh from the winter melt, Lewis said.

"As it is warming up, they're coming out looking for a blood meal, so they can lay their eggs," he explained. "The main ones that really bother people during barbecues later in the summer season will all be coming off of the floodwaters."

So minimal flooding means fewer eggs. That, combined with hot weather, will accelerate their demise.

"It looks like it will be a better year than last year."

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