Columbia-Shuswap Regional District, Mosquito Control Program for Electoral Area 'A'/Town of Golden, B.C.

2018 Final Report

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Executive Summary

The 2018 season is the 7th season that Morrow BioScience Ltd. (MBL) has conducted floodwater mosquito control operations for Electoral Area 'A'/Golden within the Columbia Shuswap Regional District (CSRD). Continuing efforts include the identification of new mosquito development sites at varying regional water levels, increasing the number of staff that focus on monitoring and treatment, and increasing public engagement opportunities. The increased monitoring and treatment of areas north of Golden, including the Golden Golf Course, North Bench, Moberly, and Blaeberry, further improved floodwater/snowmelt mosquito control in those locations.

For the second year, heat maps (monitoring, treatments) were created based on larval abundance data gathered using MBL's refined real-time data collection system. The maps provide another tool for field managers and technicians to use when determining areas within which to increase larval mosquito operations in the future. New in 2018 was a dashboard platform that was provided to the CSRD mosquito program manager. The dashboard showed a map of real-time monitoring and treatment data.

The 2018 season began with a higher-than-average snowpack in the Upper Columbia snow survey basin associated with the regional Columbia River and Kicking Horse River. Snow accumulated in the Basin affecting the Columbia River and Kicking Horse River near Golden through early April. The freshet began in late April with a regional spike in ambient temperatures, which brought out a considerable amount of low and mid-elevation snow. A secondary spike in the local ambient temperature in mid-May brought out the rest of the mid-elevation snow along with some high-elevation snow. The mid-May spike in temperature lead to the Kicking Horse River (at Golden) on 26 May (4.55 m), the Columbia River (at Donald) on 29 May (4.42 m), and the Columbia River (at Nicholson) on 31 May (3.475 m). Higher-than-normal precipitation recorded in May likely augmented regional river levels, as well.

Snowmelt mosquito development sites along the mountain benches became active in late April in 2018. Ground treatments started on 23 April at snowmelt sites and an aerial of those sites was required on 2 May. The bulk of ground treatments took place in April and May; the final ground treatment took place on 29 June. When regional Columbia River and Kicking Horse River levels increased to peak levels in late May, aerial treatments were required to treat sites that became active concurrently and those that were challenging to access by ground. Four additional aerial treatment events were required to treat river-associated sites between 18 May and 1 July. The Visitor Services Manager with Tourism Golden accompanied MBL staff on one aerial event to assess areas that had been of concern to Tourism Golden.

The total ground treatments amounted to about 128 ha (i.e. 511 kg) and the total aerial treatments amounted to approximately 1,608 ha (i.e. 9,391 kg). An additional six (6) sites were located in 2018. All new and existing sites were successfully treated in 2018.

MBL regularly updates our Facebook and Twitter accounts to reflect up-to-date mosquito and treatment related information for MBL's contract areas. To provide residents with a further avenue of contact, MBL has a toll-free Mosquito Hotline (888-733-2333) that is checked daily during the mosquito season. A total of four (4) complaint calls were made to the Mosquito Hotline and two complaint emails were received. It is believed these were a result of high water and increased potential mosquito development habitat. All calls and emails were returned within 24 hours of receipt and follow-up site visits were often made.

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Cover photo credits
Main photo: Columbia River near Golden during April aerial treatment (2018, Jeff Jackson)

Introduction

Morrow BioScience Ltd. (MBL) became the mosquito control contractor for Electoral Area 'A' and the City of Golden within the Columbia-Shuswap Regional District (CSRD) in 2012. The contract was renewed for another five (5) years in 2017. This year, 2018, marks the 7th consecutive year that MBL has provided mosquito control for Area 'A' and Golden.

It is MBL's goal to reduce floodwater and snowmelt mosquito nuisance within the contract areas for each of our control programs. The general reduction in mosquito annoyance since the commencement of this contract is due, in large part, to the thorough monitoring and timely treatments conducted by MBL field technicians. Since 2012, MBL field technicians have gained a strong knowledge of mosquito development site locations and hatch timing within low and high-water years. As each season presents a unique combination of environmental variables, new seepage sites are still discovered. In 2018, field technicians further cemented site knowledge in another considerably high-water year. Local residents have played a large part in seepage site and standing water identification in high-water seasons.

Integrated Pest Management (IPM) principles are pillars of MBL's corporate philosophy and mosquito management strategy. Ultimately, the objectives of an effective floodwater mosquito control program coupled with maintaining a low environmental impact for all field activities are achieved by adhering to a strict IPM Plan. MBL employs a frequent site-monitoring regime, allowing for accurate and effective ground treatments, with a reduced dependence on aerial treatments, thus reducing the environmental impact of treatment activities. The success of this program is further supported by the fact that site visits can occur with little notice, since MBL's head field technician resides in Golden.

Program Development

- Since earning the contract, MBL ground-verified historical sites in low and high-water seasons, created GPS waypoints of each site, and mapped all areas of the program.
- Electronic data files based on the GPS waypoints have been supplied to the CSRD each year of the contract and have been annually updated with new sites.
- More than 30 new sites have been identified within the Area 'A'/Golden mosquito program since 2012, providing increased mosquito control to Area 'A'/Golden residents.
- In 2017, MBL further improved the mosquito control program by launching a real-time online data collection and management portal. This novel tool allows field technicians to update mosquito development site profiles, add larval/adult abundance data, update treatment information, take relevant photos, and create a daily site monitoring strategy in real-time.

- In 2018, the real-time online data collection and management portal was further refined to include a client-accessible dashboard summarizing current larval abundance and treatments by site.
- In 2017, the program was expanded to include a portion of the Parsons area.
- In 2018, the program was expanded again to include the Golden Golf Course.
- A second certified mosquito control technician was added to the program in 2017 and 2018. The addition of another certified technician allowed for more time to augment mosquito development site profiles, treat larger areas by ground, and time to actively seek out potential new sites.
- Since 2012, an increased number of education outreach and public engagement events have taken place, including: Farmers Market booth attendance, community meetings at the Eco Ranch, regular meetings with Tourism Golden, volunteering with local invasive plant groups (Columbia Shuswap Invasive Species Society, Wild Sight)

Relevant Regional Environmental Conditions

Snowpack

Snowpack in basins influential to Area 'A'/Golden rivers (i.e., Columbia River and Kicking Horse River) is an important environmental variable to track, as it can reveal how severe the freshet may be at varying points in the season. Following the real-time snowpack levels will also indicate when the freshet has ended. As the freshet is the primary factor affecting floodwater mosquito development, it is a benefit to the overall success of the program to understand the snowpack and freshet variations throughout the season.

The main basin that influences the Columbia River and Kicking Horse freshet in the Area 'A'/Golden area is the Upper Columbia snow survey basin (Figure 1). Immediately preceding the mosquito control season (i.e. 1 May), the snowpack in the Upper Columbia basin was reported to be 116 percent of normal[1]. Cool temperatures and unsettled weather patterns across southern British Columbia occurred in April, resulting in an increase in snow accumulation. This value is similar to the snowpack assessment made at the same time in 2017 (i.e. 115 percent of normal).

[1] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2018_may1.pdf

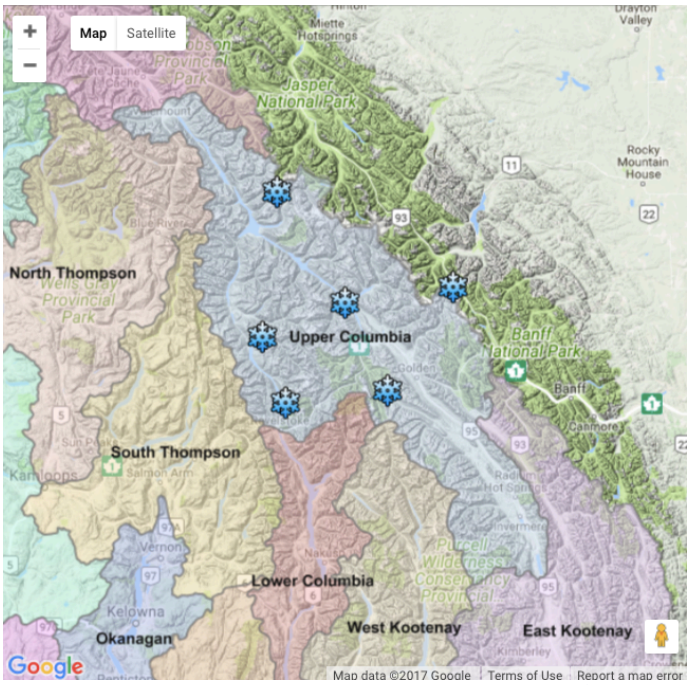

Figure 1. Upper Columbia snow survey basin area delineations with snowflake-pinned snow survey stations. The snowpack in this basin most influences the Columbia River and Kicking Horse River at Area 'A'/Golden (http://bcrfc.env.gov.bc.ca/data/asp/realtime/index.htm).

The late-season snow accumulation across most of the province caused a slight delay in the timing of the freshet. For the Golden area, specifically, the snowpack in the Upper Columbia basin stations didn't start to melt in earnest until late April. By late June, the snowpack in all Upper Columbia basin stations had been depleted[2]. It is reasonable to assume that by mid-July, the freshet contribution to the regional Columbia River and Kicking Horse River levels was insignificant. Regional Columbia River and Kicking Horse River level fluctuations within the mosquito season that occurred after mid-July would have been caused by precipitation input only (see 'Precipitation' for more information).

Ambient Temperature Records

Regional Columbia River and Kicking Horse River levels can be indirectly affected by ambient temperature spikes occurring in snow basins associated with these river systems in the early part of the mosquito season (i.e., April – June). When the Columbia River and Kicking Horse River (i.e. the Rivers) levels increase dramatically in the early Spring, the ground along the Rivers' edges are wetted. The ground immediately adjacent to these Rivers contains floodwater mosquito eggs. Mosquito eggs remain dormant until ideal hatching conditions are present, which include water, low dissolved oxygen levels, and sufficiently high ambient temperatures. Typically, these floodwater conditions present themselves within the month of May.

[2] http://bcrfc.env.gov.bc.ca/data/asp/realtime/index.htm

Image 1. Snowmelt ditch site (Golden, BC; 2018)

Local snowmelt sites are directly affected by ambient temperature spikes occurring in the early part of the mosquito season. When ambient temperatures spike, localized snowpack melts and pools in low-lying areas (e.g. ditches) or existing lakes that freeze (Image 1). These areas can then become prime environments for snowmelt mosquito development. Mosquito eggs laid in the previous summer remain dormant until ideal hatching conditions are present, which include cool water from recently melted snow and slowly increasing ambient temperatures (Becker et al. 2010). Typically, these conditions present themselves within the month of April along the mountain benches in Area 'A'/Golden.

Ambient temperatures more strongly influence sites that are shallow, relatively stagnant, and land-locked. The majority of the mosquito development sites within the Electoral Area 'A'/Golden monitored by MBL technicians are shallow and relatively stagnant. Thus, as the ambient temperatures begin to rise, water temperature more quickly reflect ambient temperatures, creating an ideal environment for mosquito development.

When comparing the previous three mosquito seasons (i.e. 2015-2017), the maximum ambient temperature data in 2018 are generally similar (Figure 2). However, early-April ambient temperatures in 2018 are lower-than-normal. This trend is consistent with the BC River Forecast Centre's 1 May report[3] stating that temperatures were 1°C – 2°C below normal for most of southern BC in April. Temperatures began to increase steadily in late April and remained high for numerous days (Figure 2). Not surprisingly, in late April through early May, the average temperatures across the majority of the province were 5°C – 10°C above normal, with record high ambient temperatures noted across the southern portion of the province[3]. Accordingly, notable snowmelt began to occur at the same time, creating high regional River levels (see 'Regional Columbia River and Kicking Horse River Levels' section). Consistently high temperature spikes in May led to the peaks in regional Rivers in late-May.

The relatively high ambient temperatures recorded in July and August likely also created localized annoyance due to container mosquito emergence and dispersal. Container mosquito habitats near residential homes can be continually created throughout the summer due to local watering practices. MBL field technicians regularly inform residents

[3] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2018_may1.pdf

that adult container-bred mosquitoes can be greatly reduced around their homes by ensuring potential container mosquito environments are either free of water or refreshed frequently.

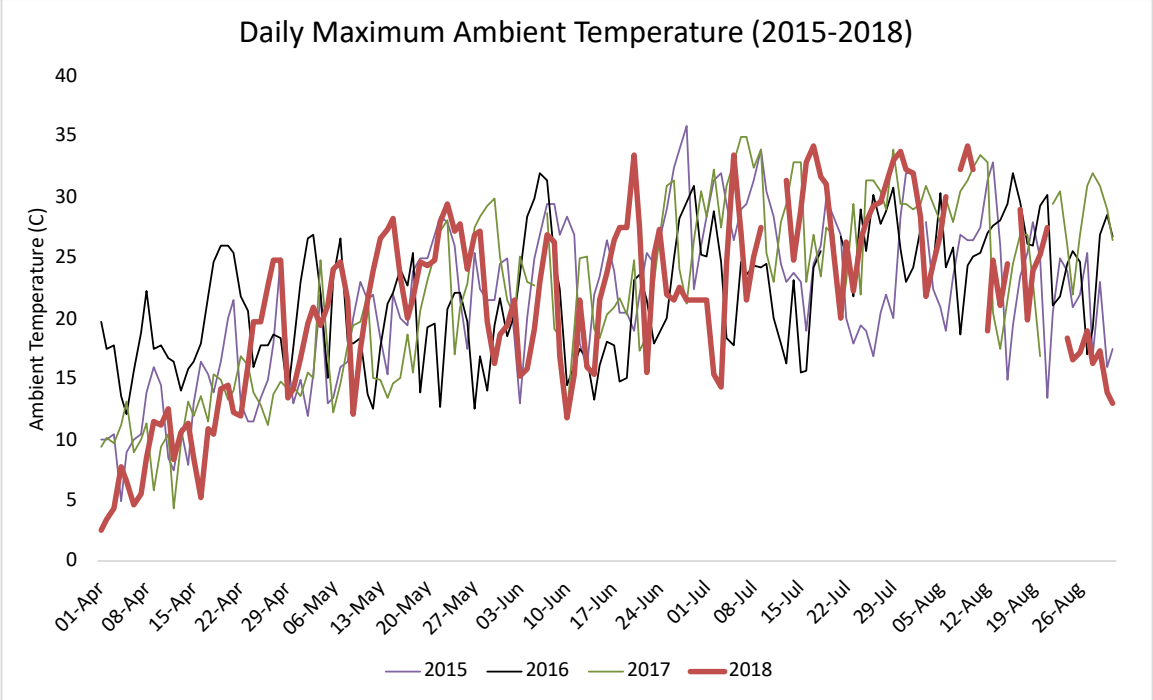

Figure 2. Maximum daily temperature (°C) as recorded at the at the Golden, BC Airport (Climate ID: 1173220) between 1 April – 31 August, 2015-2018. Gaps in the data represent days wherein the monitoring station was not functioning properly.

Precipitation

While not the major contributor to overall levels in the local Columbia River or Kicking Horse River, precipitation can impact levels when the ground is saturated in influential basins or when considerable precipitation is received locally. Significant precipitation can augment mosquito development sites associated with local Rivers, boost river levels, and create snowmelt sites when precipitation is received as snow.

There was a moderate amount precipitation accumulation throughout the 2018 mosquito season (i.e. April – August; Figure 3). Of the months monitored, the greatest amount of precipitation accumulation was received in June (Figure 3; 44.4 mm). Regional River levels had just peaked in late-May and those levels were still considerably high when the precipitation was received. It is possible that the precipitation received in June elongated seepage site occurrence, but unlikely that the precipitation drastically increased already high Columbia and Kicking Horse River levels, as precipitation events were dispersed throughout the month.

Precipitation received to the area from June through August likely did create container breeding mosquito habitat. Container mosquito species (e.g. *Culex* spp.) require sites that

have stagnant, warm water for breeding and maturation. Specific sites include flat roofs, rain gutters, old tires, tree holes, birdbaths, and rain barrels, to name a few. It is possible that container mosquitoes emerged from localized sites and were a nuisance to residents into August. While MBL's mandate does not include controlling container mosquitoes, field staff help concerned residents reduce potential container mosquito breeding sites on their property by advising them to remove or replace standing water regularly.

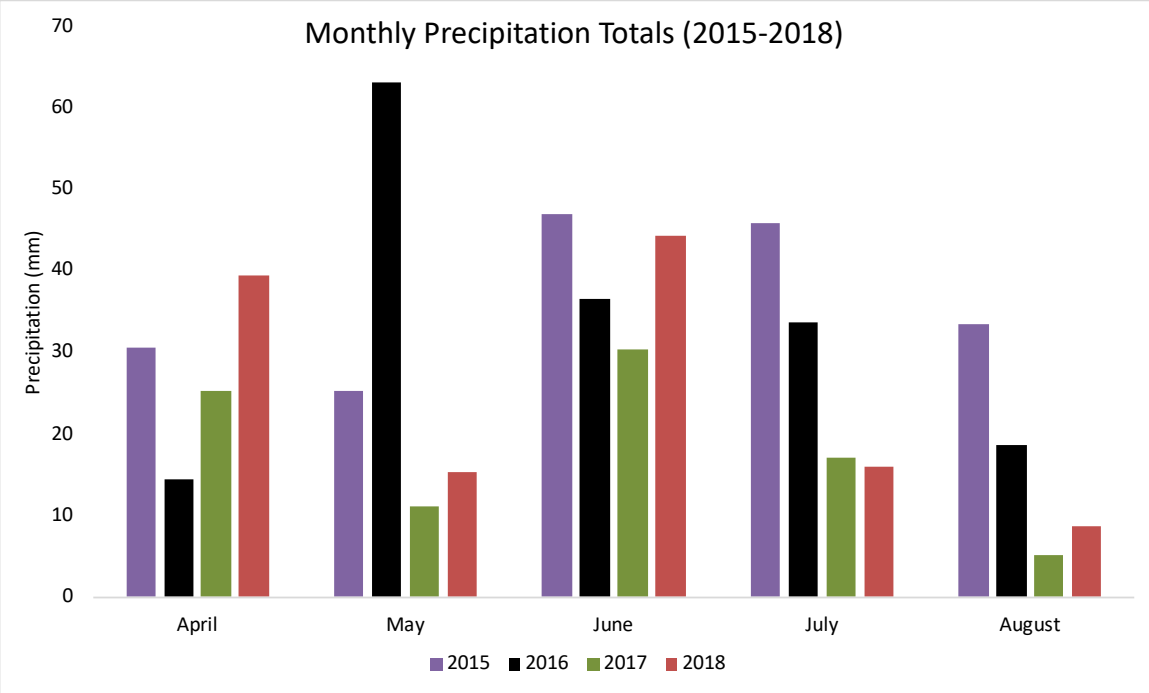

Figure 3. Monthly total precipitation accumulation (mm) as recorded at the at the Golden, BC Airport (Climate ID: 1173220) between 1 April – 31 August, 2015-2018.

Regional Columbia River and Kicking Horse River Levels

The Columbia River and the Kicking Horse River primarily affect the floodwater mosquito abundance in the area around Area 'A'/Golden. The water levels of both river systems are governed by two main influences: 1) local snowmelt and 2) the freshet from the Upper Columbia basin (Figure 1). Frequent and large amounts of precipitation can also affect River levels, though typically to a lesser degree than the primary factors listed above.

It is likely that the Columbia River affects the program disproportionally. Thus, the regional Columbia River levels are followed at two gauges: Donald (08NB005) and Nicholson (08NA002). To a large degree, the Columbia River at both gauges and Kicking Horse River mirror one another in level fluctuations (Figure 4).

A spike in regional ambient temperatures in late April melted a measurable amount of low and middle-elevation snow within contributing snow basins. This resulted in distinctive increases in both Kicking Horse and Columbia River levels (Figure 4). Consistently high temperatures in early and mid-May led to the resulting large amounts

of middle and high-elevation snow melting in contributing basins. The large pulses of snowmelt moving through the systems led to a peak in the Kicking Horse River (at Golden) on 26 May (4.55 m), the Columbia River (at Donald) on 29 May (4.42 m), and the Columbia River (at Nicholson) on 31 May (3.475 m; Figure 4). Because the peak in the regional rivers occurred at a relatively warm time of the mosquito season, environmental cues were present for successful mosquito larval development, requiring treatments that started in April (see 'Larval Treatment' section; Image 2).

The peak regional River levels in 2018 were lower than those of 2017, but not significantly so (Figure 5). Because river levels were not higher than those of 2017, fewer mosquito eggs would have amassed in the interim period between flooding (i.e. hatch cueing) events. Thus, mosquito larval treatment needs were lower than those of 2017.

After their respective peaks in late May, both regional river levels began slowly declining (Figure 4). Regional river levels decreased more slowly in 2018 likely due to moderate precipitation input in June, extending mosquito development seepage sites by longer. Rivers were all consistently declining by mid-August (Figure 4).

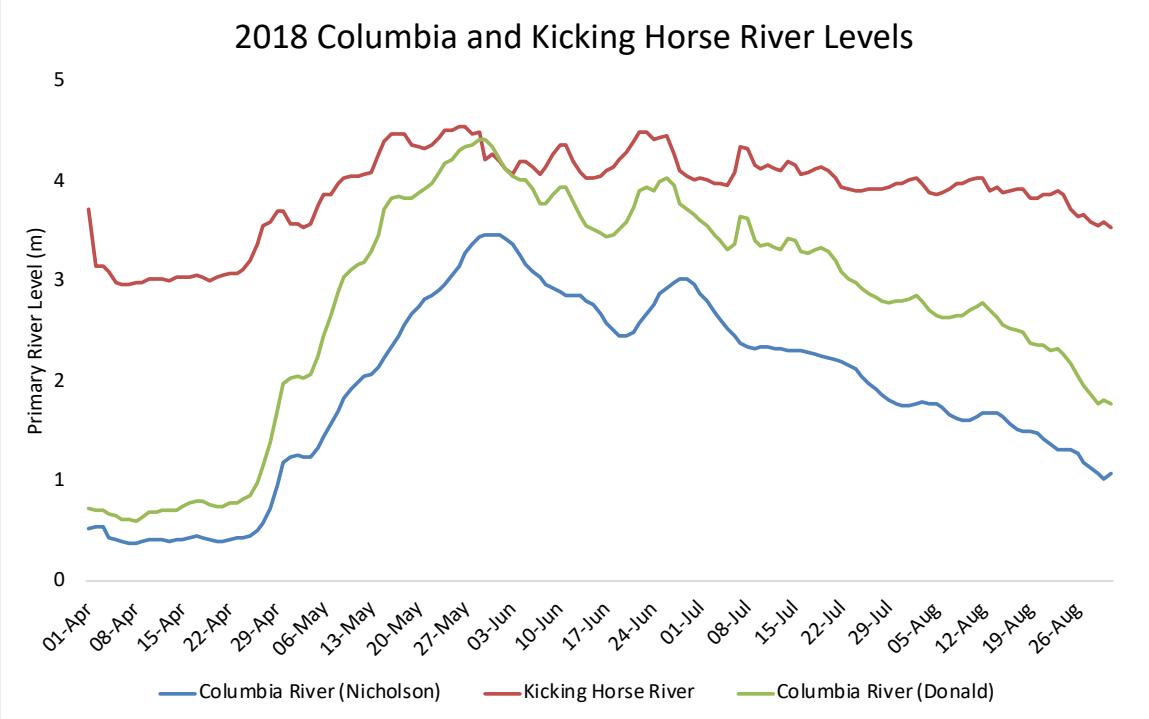

Figure 4. 2018 Columbia River and Kicking Horse River levels (m), 1 April – 31 August. Columbia River measurements were taken from the 'Columbia River at Donald' (08NB005) and 'Columbia River at Nicholson' stations (08NA002). Kicking Horse River measurements were taken from the 'Kicking Horse River at Golden' station (08NA006).

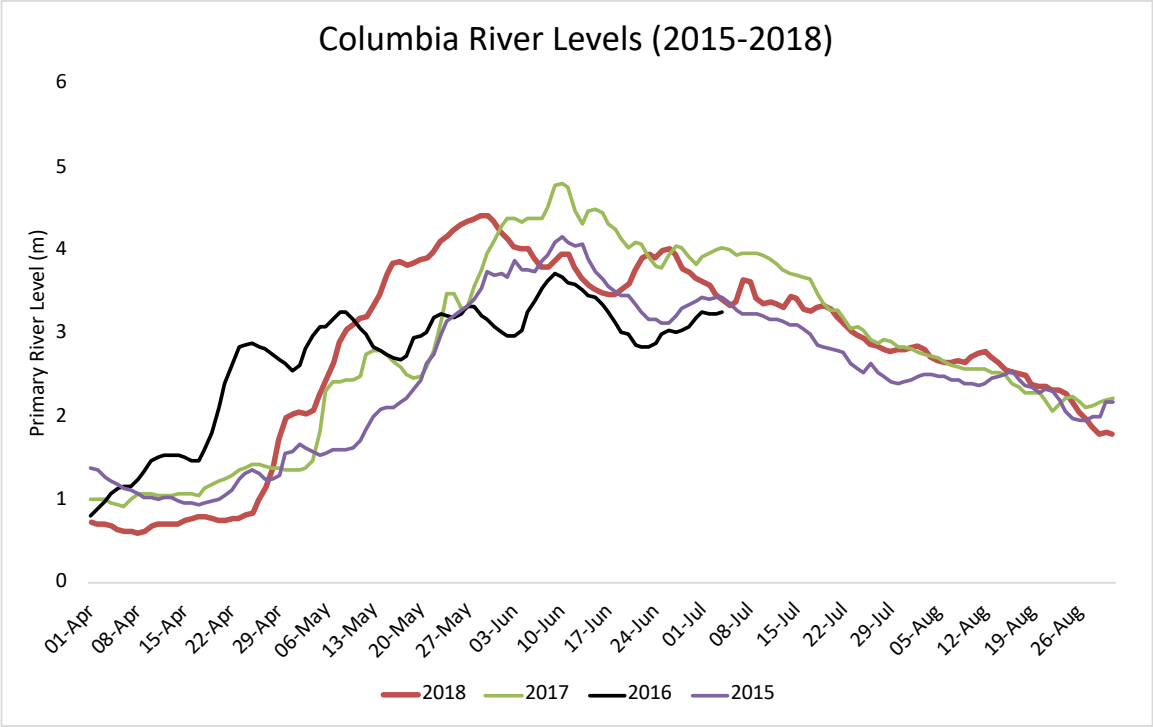

Figure 5. Columbia River levels (m), 1 April – 31 August (2015 – 2018). Measurements taken from the 'Columbia River at Donald' station (08NB005).

Monitoring Methodology

Aedes. vexans and *A. sticticus* mosquitoes are the most common floodwater nuisance mosquitoes within Area 'A'/Golden. Floodwater mosquitoes lay their eggs on damp substrate in areas with a high flooding potential. If the floodwater is sufficiently warm, contains a low enough dissolved oxygen (DO) content, and is organically rich (which contributes to a decreased DO content), hatching will commence (Gjullin et al. 1950).

The mosquito control program for Electoral Area 'A'/Golden involves monitoring mosquito development sites within regional Columbia River and Kicking Horse River floodplain areas to target floodwater mosquito hatching. In 2017, additional area in the Parson community was added to the program to manage extensive mosquito habitat along the Columbia River corridor. In 2018, additional monitoring efforts took place north of Golden at the Golden Golf Course, North Bench, Moberly, and Blaeberry areas. The reach of the Area 'A' and Golden program has expanded considerably since acquiring the contract in 2012.

In 2018, there were 110 sites monitored within Area 'A'/Golden. Increased reconnaissance efforts in 2018 led to the discovery of six (6) additional mosquito development sites (i.e. 3 bench sites and 3 wetland sites). All sites were discovered in time to successfully treat developing mosquito larvae.

To address early-season mosquito larval hatching on the mountain benches, weekly monitoring begins in early April. Monitoring increases to twice a week when regional ambient temperatures increase markedly and when Kicking Horse and Columbia rivers rise. Frequent monitoring takes place until seepage sites and higher-elevation foreshore sites become dry. Monitoring typically decreases to once weekly in August, unless there is a significant precipitation event, in which case monitoring increases.

Image 2. MBL field technician assessing mosquito larval abundance at a mosquito development site.

Larval mosquitoes in sufficient number (i.e. >4/dip) are treated using a microbial larvicide product (i.e. 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).

Larval Treatment

Ground (Hand/Blower) Treatment Summary

Whenever possible, MBL field technicians conduct ground treatments. Early in the mosquito season, field staff access sites by foot or canoe. In addition to reducing the environmental impact of field activities, ground treatments allow for the identification of new sites and access points to sites that are commonly shrouded by canopy-cover when conducting all activities by air.

Monitoring snowmelt mosquito development sites began in early April. Appendix I shows a map of varying larval densities found throughout the 2018 season. All sites with larval densities with a moderate or greater abundance rating were treated with Aquabac®, as long as larvae were in the 3rd and/or 4th instar stage. In 2018, MBL field technicians applied 511 kg of Aquabac® by ground (i.e. hand/blower), at a rate of approximately 4 kg/ha in

the Area 'A'/Golden area. Thus, approximately 128 ha, in total, were treated by ground, with most of the ground treatments occurring in April and May (Table 1). Appendix II shows the area and frequency of ground treatments for Area 'A'/Golden in 2017.

Table 1. 2018 Area 'A' and Golden, BC ground and aerial treatments (ha) from April – August.

	April	May	June	July	August
Ground	11.37	105.79	10.52	0.00	0.00
Aerial	0.00	958.53	485.33	163.80	0.00

Ground treatments at snowmelt mosquito development sites started on 23 April (Figure 6). All snowmelt sites had already become active and were successfully treated by the middle of May. Ground treatments at sites associated with the Columbia River and Kicking Horse River were treated starting on 1 May and were consistent with the initial spikes in the regional rivers. Despite the high water, certain foreshore sites were accessible throughout the mosquito season. After mid-June, ground treatments began to taper off as local Columbia River and Kicking Horse River levels peaked; the final ground treatment took place on 29 June (Figure 6).

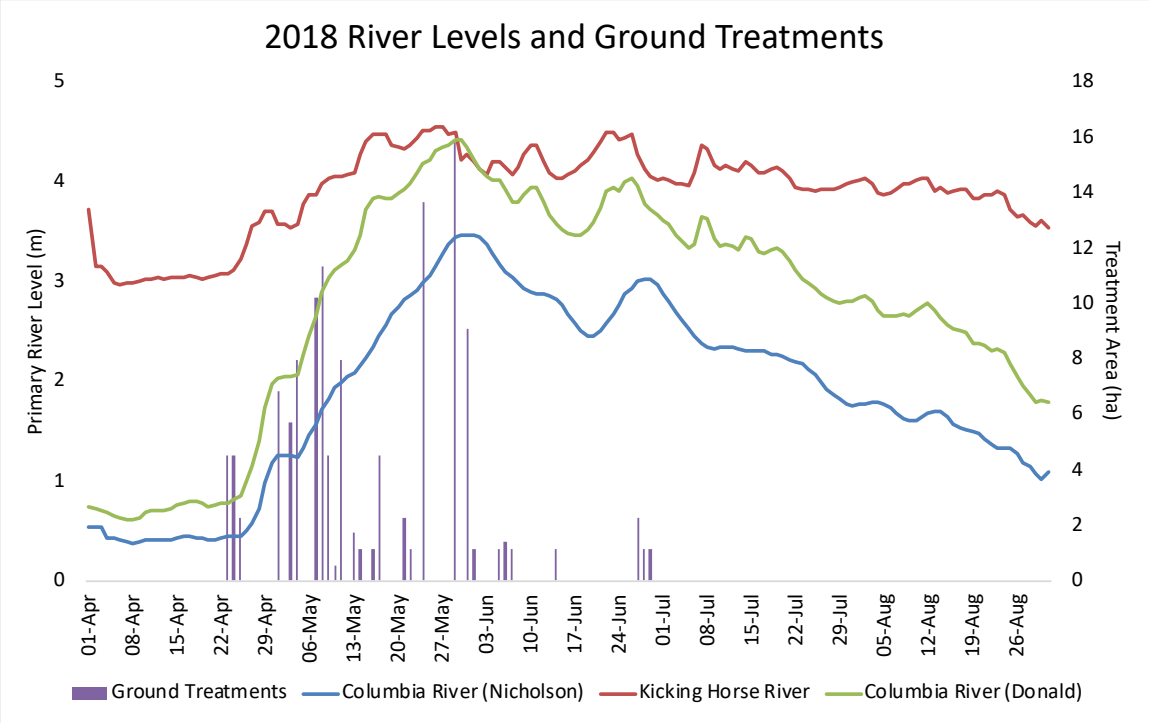

Figure 6. Ground (hand/blower) treatments (ha) with respect to the daily peak of the Columbia River at Donald (08NB005, green), Columbia River at Nicholson (08NA002, blue) and Kicking Horse River at Golden (08NA006, red) for the 2018 mosquito season.

Peak regional river levels required a shift toward aerial treatments due to drastically increased and concurrent mosquito development site productivity. Fewer treatments were required in 2018 in comparison to 2017, due to fewer and smaller seepage sites being flooded (Figure 7). Appendix III provides more specific information about site, treatment timing, and the extent of treatment.

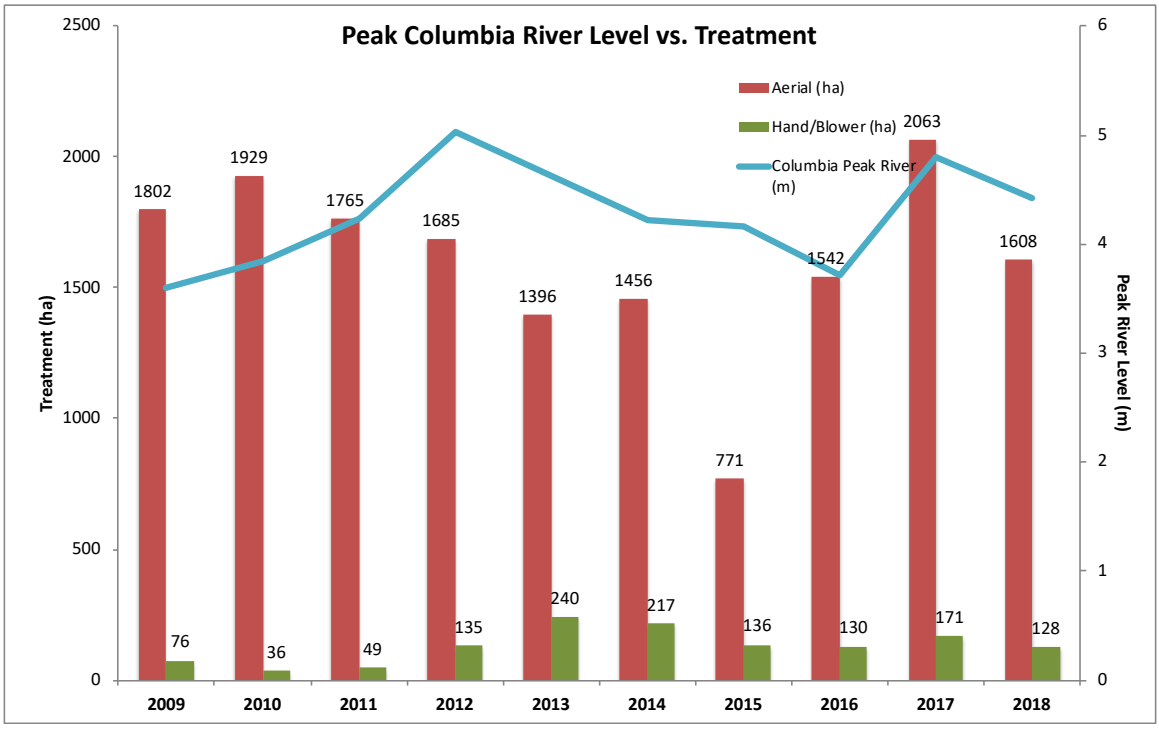

Figure 7. Peak Columbia River level (m) at the Donald station, along with the corresponding total aerial and hand treatment area (ha) for 2009 – 2018.

Aerial Treatments

Aerial treatments are necessary whenever access to mosquito development sites is not possible by foot or canoe, when there is a significant amount of mosquito larval activity, and when larval development is occurring too quickly to treat all sites by ground. Thus, the total number of aerial treatments conducted within a given year is dependent upon the amount of water moving through or adding to the system and the larval mosquito development rate.

In 2018, MBL field technicians applied a total of approximately 9,391 kg. Aerial treatments were applied at a rate of approximately 6 kg/ha, thus, the total area treated by helicopter was 1,608 ha (Table 1; Figs 7, 8). Five measurable mosquito hatching events were noted in 2018. Specifically, aerial treatments took place on 2, 18, and 28 May, 4 June, and 1 July (Figure 8). The 2 May aerial event was necessary due to a high abundance of larval snowmelt mosquitoes along the mountain benches. The following three aerial events

were necessary due to the rise in the Columbia and Kicking Horse rivers. The final aerial on 1 July was specific to the Parsons area and necessary due to rising water table levels in the vicinity. Appendix III provides more specific details about treatments.

Image 3. Loading helicopter with larvicide for aerial treatment (Golden, 2018)

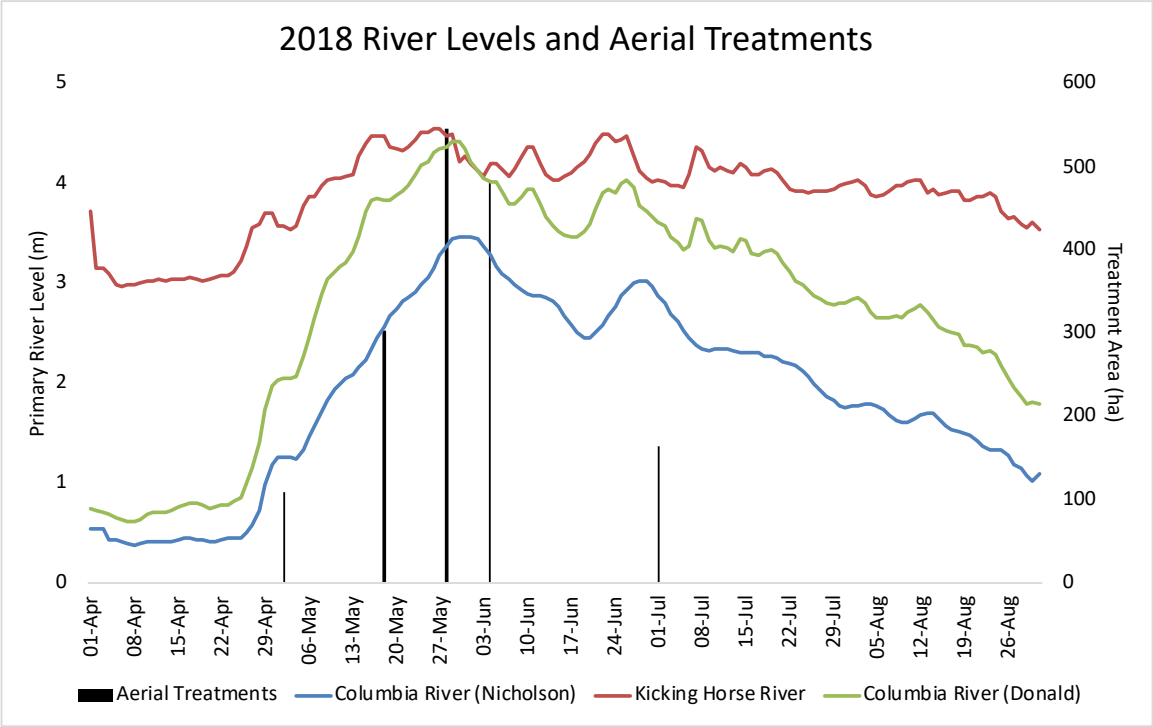

Figure 8. Aerial treatments (ha) with respect to the daily peak of the Columbia (at Donald, Nicholson) and Kicking Horse (at Golden) rivers for the 2018 season.

The efficacy of all aerial treatments was checked one day post-application. In all cases, efficacy was good, with few mosquito larvae noted, if any. If necessary, ground-based applications were made during the follow-up monitoring to address mosquito larvae presence around the edge of treatment zones.

Public Engagement

Direct communication between MBL staff and the public can occur under many circumstances. The most common direct interfacing with the public occurs when technicians are in the field. While conducting site visits, MBL field technicians are often asked questions by landowners or bystanders. These encounters provide an excellent opportunity for public relations. The fact that technicians are visibly monitoring and treating shows residents that attention is being given to mosquito abatement efforts. 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 an email, phone number, and social media sites (Twitter, Facebook). Another resource for public queries is the MBL website (morrowbioscience.com).

MBL field staff volunteered at two Columbia-Shuswap Invasive Species Society (CSISS)/Wildsight invasive plant events. During these events, MBL staff had the opportunity to discuss what a healthy ecosystem looks like from the macro-invertebrate perspective. Additionally, MBL maintained close communications with Tourism Golden throughout 2018. In May, MBL took Alycia Weir (Tourism Golden, Visitor Services Manager) on an aerial tour of specific mosquito development sites which Ms. Weir had been concerned about. MBL staff were able to provide a more detailed perspective on the mosquito abatement program activities and specific challenges faced in those areas. The information was subsequently passed along to interested visitors or residents who contacted Tourism Golden.

Hotline Calls and Emails

A total of six (6) calls were made to the Mosquito Hotline and the regional program manager in 2018. Of those, four (4) calls were determined to be complaint calls. In those cases, residents provided their general addresses and reported that the adult mosquitoes were abundant. The other two (2) calls were inquiry calls. No emails were received either via the MBL website contact form or through MBL field technicians. As per company policy, all calls received were returned within 24 hours. Often, MBL field technicians made site visits as well.

In comparison to the 2017 complaint call volume, the number in 2018 was reduced by eight (8). No complaint emails were received in 2018, in comparison to two received in 2017. The reduction in complaint calls and emails is likely due to increased surveillance and treatment efforts, lower regional river levels in 2018, the addition of six (6) new sites to the monitoring regime, and consistent communication with residents and local businesses.

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

Social Media

This year, 2018, is the 7th consecutive year in which MBL had 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 involved citizens 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 early April noting the kick-off of the freshet around British Columbia. In addition to field updates, post topics also included volunteer, outreach efforts conducted by MBL staff members (i.e. Farmer's Market booths). Whenever possible, photos of staff working within Area 'A'/Golden were also posted.

The total number of followers on the MBL Facebook page is currently 282. This number has increased by 100 since October 2017. 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". In this way, the maximum reach for the Area 'A'/Golden region was on 21 May and was in response to a posting about monitoring activities near Golden. Resident responses to the post included encouragement for the efforts and questions regarding where treatments were taking place and what larvicide product would be used. Both the reach and responses encourage the future dissemination of local mosquito control articles on this site.

Another aspect to MBL's social media outreach strategy is the use of Twitter (@morrowmosquito). Utilizing Twitter allows the opportunity for community members to follow, in real-time, our activities and updates relating to mosquito control issues. An average of one "tweet" a week is sent out throughout the mosquito season. Some of these "tweets" were forwarded from other sources if those messages were mosquito-related.

To date, the maximum number of followers on Twitter is 140, which is an increase from October 2017. Part of the reason for the increase in followers through this method is the

link between the Twitter account and the Facebook account. Each time a "tweet" was sent out via Twitter, it was also posted to the Facebook page. This way the Twitter feeds reached as many people per day as did the Facebook posts. Twitter and Facebook accounts are also linked to the Morrow BioScience website, enabling visitors to easily connect with each account. Notable Twitter followers include local municipalities and media.

MBL Website

The MBL website (**www.morrowbioscience.com**) was launched on March 26, 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.

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 8 October there were no confirmed human cases of WNv reported in BC. 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 horses. On 22 August two wild birds in Kimberly, BC tested positive for the virus. Given the proximity of these positive cases to Area 'A'/Golden, future education outreach events will also include information about how to report cases of dead, wild birds for WNv testing. MBL field technicians are aware of the potential for WNv-infected animals and mosquito pools. Staff utilize personal protective measures and are on alert for the occurrence of dead, wild birds in the area.

Future Work

Future work within Electoral Area 'A'/Golden will continue include reconnaissance efforts for new sites and monitoring adult mosquito populations within the new program reach. Additionally, MBL would like to continue the current community engagement strategy by volunteering for wetland-focused events and visiting a Farmer's Market event in 2019.

MBL endeavours to improve aerial treatment mapping. Specifically, helicopters should be equipped GPS technology that will help inform specific treatment paths of the helicopters. This will not only enable more informative treatment maps, but will also provide the opportunity to capture aerial footage of the treatments.

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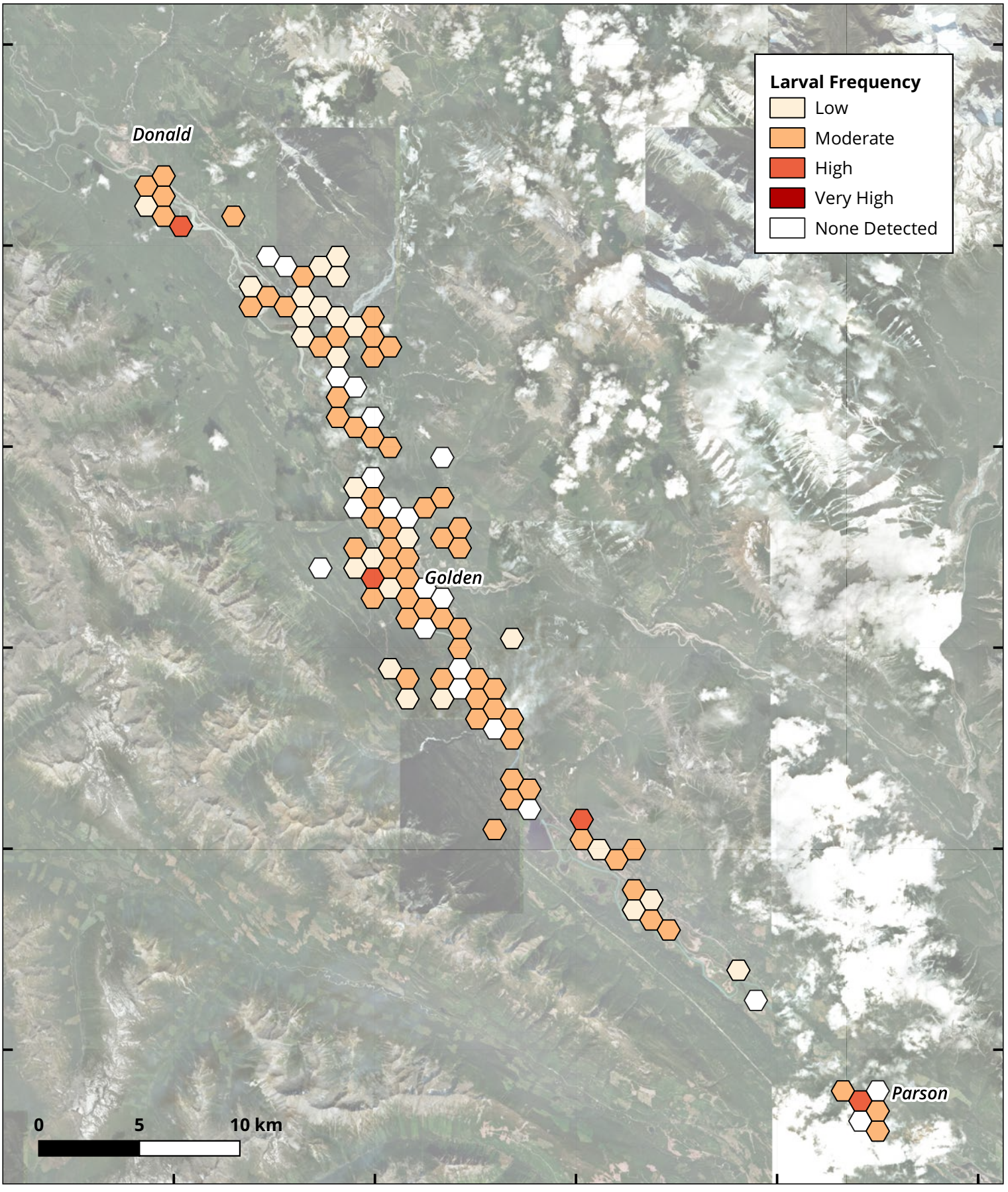
2018 Mosquito Larval Densities at Sample Locations

Appendix I

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

Scale = 1 : 250,000 CRS = NAD83 UTM Zone 11N



2018 Mosquito Larvicide Treatment Locations

Appendix II

Morrow BioScience Ltd
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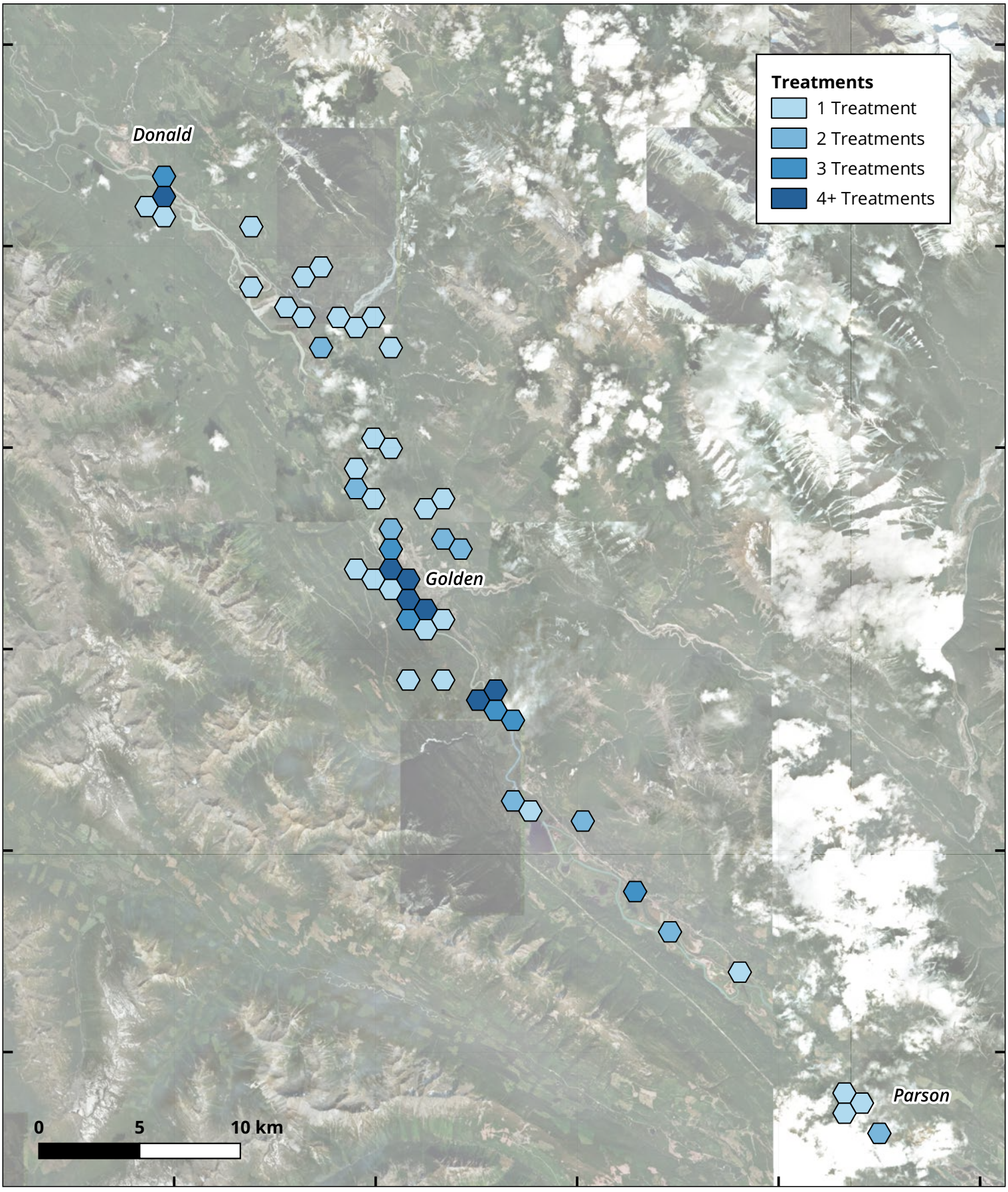
Scale = 1 : 250,000 CRS = NAD83 UTM Zone 11N



Appendix III. 2018 treatment data (kg, ha) by site and date for all ground (A) and aerial (B) treatments within Area 'A'/Golden.

III-A: Ground Treatments

Date	Site	Treatment Amount (kg)	Treatment Area (ha)
23-Apr-18	CSRD-087	4.55	1.14
23-Apr-18	CSRD-112	4.55	1.14
23-Apr-18	CSRD-102	2.28	0.57
23-Apr-18	CSRD-095	2.28	0.57
23-Apr-18	CSRD-019	4.55	1.14
24-Apr-18	CSRD-114	9.10	2.28
24-Apr-18	CSRD-089	6.83	1.71
24-Apr-18	CSRD-103	2.28	0.57
25-Apr-18	CSRD-052	4.55	1.14
25-Apr-18	CSRD-052	4.55	1.14
01-May-18	CSRD-096	18.20	4.55
01-May-18	CSRD-096	9.10	2.28
03-May-18	CSRD-011	4.55	1.14
03-May-18	CSRD-094	13.65	3.41
03-May-18	CSRD-125	4.55	1.14
04-May-18	CSRD-109	31.85	7.96
07-May-18	CSRD-021	2.28	0.57
07-May-18	CSRD-034	20.48	5.12
07-May-18	CSRD-022	13.65	3.41
07-May-18	CSRD-023	4.55	1.14
08-May-18	CSRD-132	2.28	0.57
08-May-18	CSRD-097	6.83	1.71
08-May-18	CSRD-130	13.65	3.41
08-May-18	CSRD-105	20.48	5.12
08-May-18	CSRD-058	2.28	0.57
09-May-18	CSRD-092	2.28	0.57
09-May-18	CSRD-090	2.28	0.57
09-May-18	CSRD-043	4.55	1.14
09-May-18	CSRD-093	9.10	2.28
10-May-18	CSRD-013	2.28	0.57
11-May-18	CSRD-008	11.38	2.84
11-May-18	CSRD-067	18.20	4.55
11-May-18	CSRD-007	2.28	0.57
13-May-18	CSRD-048	6.83	1.71
14-May-18	CSRD-149	4.55	1.14

16-May-18	CSRD-104	4.55	1.14
17-May-18	CSRD-063	4.55	1.14
17-May-18	CSRD-003	4.55	1.14
17-May-18	CSRD-065	9.10	2.28
21-May-18	CSRD-031	4.55	1.14
21-May-18	CSRD-075	2.28	0.57
21-May-18	CSRD-107	2.28	0.57
22-May-18	CSRD-010	4.55	1.14
24-May-18	CSRD-110	9.10	2.28
24-May-18	CSRD-045	9.10	2.28
24-May-18	CSRD-046	9.10	2.28
24-May-18	CSRD-078	4.55	1.14
24-May-18	CSRD-003	13.65	3.41
24-May-18	CSRD-065	4.55	1.14
24-May-18	CSRD-065	4.55	1.14
29-May-18	CSRD-076	4.55	1.14
29-May-18	CSRD-138	4.55	1.14
29-May-18	CSRD-075	2.28	0.57
29-May-18	CSRD-064	15.93	3.98
29-May-18	CSRD-107	4.55	1.14
29-May-18	CSRD-065	4.55	1.14
29-May-18	CSRD-139	27.30	6.83
31-May-18	CSRD-111	9.10	2.28
31-May-18	CSRD-110	4.55	1.14
31-May-18	CSRD-028	9.10	2.28
31-May-18	CSRD-003	4.55	1.14
31-May-18	CSRD-074	9.10	2.28
01-Jun-18	CSRD-065	4.55	1.14
05-Jun-18	CSRD-045	4.55	1.14
06-Jun-18	CSRD-061	1.14	0.28
06-Jun-18	CSRD-078	2.28	0.57
06-Jun-18	CSRD-076	2.28	0.57
07-Jun-18	CSRD-127	4.55	1.14
14-Jun-18	CSRD-010	4.55	1.14
27-Jun-18	CSRD-065	6.83	1.71
27-Jun-18	CSRD-107	2.28	0.57
28-Jun-18	CSRD-028	4.55	1.14
29-Jun-18	CSRD-111	4.55	1.14

III-B: Aerial Treatments

Date	Site	Treatment Amount (kg)	Treatment Area (ha)
02-May-18	Area 'A' mountain benches	655.20	109.20
18-May-18	Area 'A' & Golden	1820.00	303.33
28-May-18	Area 'A' & Golden	3276.00	546.00
04-Jun-18	Area 'A' & Golden	2912.00	485.33
01-Jul-18	Golden south; Campbell Rd. area	728.00	163.80