Regional District of Columbia Shuswap
Golden and AREA 'A'
Mosquito Control Program
2024 Year-End Report

Prepared by:
Morrow BioScience Ltd.
info@morrowbioscience.com
1-877-986-3363

Executive Summary

Morrow BioScience Ltd. (MBL) has now completed the third year of a five-year contract term as mosquito control contractor for Electoral Area A and the Town of Golden within the Columbia Shuswap Regional District. The mosquito control program assesses, manages, and mitigates mosquito abundance within all areas of the project purview.

On April 1, 2024, immediately preceding the mosquito monitoring season, the snowpack in the Upper Columbia Basin contributing to the Columbia River and Kicking Horse River was measured at 66% of normal. The high elevation snowpack was augmented during April and gradually melted between early-May and early-July. Cool high elevation alpine temperatures during this time frame delayed the arrival of freshet to regional rivers, resulting in relatively late regional river peaks.

Seasonal precipitation was near average (except August), with rainfall events in May having minimal contributions to the late rise in Columbia and Kicking Horse River levels in 2024. Warmer ambient temperatures from late-June until early-July resulted in the depletion of high elevation snowpack at the Upper Columbia Basin snow station by mid-July, producing late river level peaks for the Kicking Horse River on 11 July (Golden gauge; 4.45 m), Columbia River on 11 July (Donald gauge; 3.84 m) and 14 July (Nicholson gauge; 2.68 m). The 2024 Columbia River peak was more than six weeks later than the peak water level in 2023. The longer melting period led to late and low peak regional river levels and did not trigger the hatch of compounded mosquito eggs.

Larval mosquitoes were treated between 22 April and 14 August. The total mosquito habitat treated by ground and air was 1,686 ha in 2024. No known sites were missed in ground-based or aerial treatment efforts; however, as noted in the discussion section, below, the timing of the last aerial was challenging. Aerial treatments were conducted on 28 June, 8 July, 17 July, and 18 July. These treatments book-ended the initial and primary Columbia River peak (Donald gauge). A real-time monitoring and treatment data dashboard was provided to the CSRD program manager. The dashboard enabled the manager to view up-to-date treatment information and ensure quality control.

Higher than average rainfall in August may have exacerbated mosquito annoyance, with the warm and weather combining to increase localized annoyance (non-floodwater) throughout the region.

Concern call volume from residents was lower than previous years with one call and two emails received from residents/administration. However, it was noted that floodwater mosquito annoyance was high in the southern portion of this program in late July/August.

During the West Nile Virus season, (mid-April through November), Canada conducts ongoing human case surveillance. To date, the BCCDC has reported two human travel-related cases of the virus in British Columbia.

Season Highlights

- The snowpack in the Upper Columbia Basin was 66% of normal in April, immediately preceding the floodwater mosquito season.
- El Niño Southern Oscillation (ENSO)-neutral weather patterns augmented snowpack in April before the warmer temperatures of May through August.
- The 2024 freshet peak arrived nearly 7 weeks later than the 2023 freshet peak.
- The peak in the Kicking Horse River occurred on 11 July (Golden gauge; 4.45 m).
- The peaks in the regional Columbia River occurred on 11 July (Donald gauge; 3.84 m) and 14 July (Nicholson gauge; 2.68 m).
- The 2024 Columbia River peak (Donald gauge) was approximately 0.1 m lower than the 2023 peak.
- Monthly local precipitation accumulation for the season was near average, with no high precipitation events during peak river levels.
- A higher-than-average August precipitation accumulation likely exacerbated mosquito annoyance.
- High temperature present during July and August likely contributed mosquito abundance.
- Lower larval abundance was observed in 2024 due to low peak regional river levels.
- Three aerial campaigns, on 28 June, 8 July, and 17/18 July, were required within the Area ‘A’/Golden mosquito program purview.
- Total area treated by air was 1,651.65 ha (7,917 kg granular Aquabac®).
- Total area treated by ground was 34.82 ha (139.3 kg granular Aquabac®).
- One call was received to the Mosquito Hotline in May of 2024, before mosquitoes had arrived.
- MBL staff gave one interview to one provincial media source, The Tyee. Information pertaining to personal protection and habitat reduction was relevant to Area ‘A’/Golden residents.
- The BCCDC provided an update on West Nile virus cases in the province as of 26 October, reporting two travel-related West Nile virus cases in British Columbia.
- Relatively low levels of WNv activity were reported in Washington State and Idaho State following a warm spring and summer.

Table of Contents

Executive Summary 1
Season Highlights 2
Introduction 5
Carbon Offsets 5
Methodology 6
Environmental Conditions 8
Snowpack 8
Local Precipitation 9
Ambient Temperature 10
Upper Columbia Basin Temperatures 11
Area ‘A’/Golden Temperatures 11
River Levels 13
Larval Control 15
Ground Application Summary 17
Ground Application Annual Comparison 18
Aerial Application Summary 18
Community Feedback (Studies) 20
Discussion 21
RPAS (Drone) Update 22
Public Relations 22
Phone Calls and Emails 22
Direct Communications 23
Social Media 24
MBL Website 25
West Nile Virus Summary 26
Zika Virus Summary 27
2025 Program Recommendations 28
References 29
Project Contacts at Morrow BioScience Ltd. 30

Cover Image: Electoral Area ‘A ’floodwater mosquito development site (May 2023)

Figures/Tables

Figure 1.Snow Water Equivalent (SWE; mm) data from the Colpitti Creek snow survey (station ID: 2A30P) within the Upper Columbia Basin (green line). 9
Figure 2 Precipitation values (rainfall and snow accumulation; mm) recorded at the Golden Airport weather station (ID: 1173220) for 01 April – 31 August 2024 (Red) and average station precipitation values (2016-2023; blue gradient) and overall average (2016-2024; green) 10
Figure 3 Maximum daily ambient temperatures (C) as recorded at the Golden Airport Station (ID: 1173220) 01 April – 31 August, 2024. 12
Figure 4 Columbia River (Donald gauge - ID: 08NB005, Nicholson gauge - ID: 08NA002) levels (m) from 1 April – 31 August 2024. Note that the higher levels at Donald primarily reflect the input from the Kicking Horse. 14
Figure 5 Columbia River (Donald gauge - ID: 08NB005) levels for 2014 – 2024 from 1 May – 11 August. Note that 2024 was the latest peak in the previous 10 seasons and 48 days later than the peak in 2023. 15
Figure 6 Columbia River levels (m; Donald gauge and Nicholson gauge) with total mosquito development area treated by ground (ha) from 1 April – 31 August 2024. Note ground treatments (ha) are recorded on the alternate y-axis. 17
Figure 7 2024 ground-treated and aerially-treated area (ha) by month from April – August. Note that Aerial is on the right axis and Ground is on the left, also note the very different scales. 18
Figure 8 Comparison of annual treatment records (2018-2024). 18
Figure 9 Columbia River levels (m; Donald and Nicholson gauges) with total mosquito development area treated aerially (ha) from 1 April – 31 August 2024. Note aerial treatments (ha) are recorded on the alternate y-axis. 19
Figure 10 Historic Treatment levels relative to peak river levels (Donald). Note that larval treatment amounts were at or near normal for the river levels (compared to 2011, 2013, 2014, 2018, etc.) 20

List of Appendices (see Attached)

Appendix I. 2024 mosquito larval densities at sample locations throughout the Area ‘A’/Golden

Appendix II. 2024 treatment data (kg, ha) by site and date for all ground (A) and aerial (B) treatments

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 Electoral Area A – Town of Golden (Area ‘A’/Golden) within the Columbia Shuswap Regional District (CSRD) since 2012. In 2024, MBL started the third year of a five-year contract to provide mosquito control to the residents of Area ‘A’/Golden.

The extensive mosquito habitat, program reach, and inter-annual regional river peak variations make the Area ‘A’/Golden mosquito control program complex. However, throughout MBL’s contract tenure with this program, MBL staff has acquired thorough knowledge of the area and how Area ‘A’/Golden-specific environmental conditions affect mosquito development sites. In addition to having built a program knowledge base, numerous improvements have been made to the program since its inception, including:

- comprehensive site survey along floodplain benches,
- identification of new mosquito development sites,
- the addition of a real-time data collection and review portal,
- increased public engagement through social media, radio and in-person events,
- improved environmental awareness of program impacts through annual carbon offset purchases, and
- increased community involvement through MBL volunteer commitments.

MBL’s goal is to continue to provide effective mosquito control to the Area ‘A’/Golden residents, while remaining socially and environmentally responsible.

Carbon Offsets

The spatial reach of the CSRD mosquito program is such that driving is an inevitable requirement. The accumulated mileage over the course of 2024 was approximately 12,000 km (ground transportation only).

As an estimation, the driving requirements for this program results in the production of approximately 2.25 tonnes of CO_2 emissions. To compensate for this addition of CO_2 to the environment, MBL has committed to purchasing carbon offsets. In fulfillment of this commitment, carbon offsets are purchased through the Neighbours United – formerly West Kootenay EcoSociety[1]. When the carbon offsets are purchased, a proof of purchase and certificate from the offset provider can be delivered to the CSRD.

[1] https://neighboursunited.org

Methodology

As large areas of the Area ‘A’/Golden purview are within the Columbia River and Kicking Horse River flood plains, the primary targets of the Golden/Area ‘A’ mosquito control program are floodwater mosquito larvae. Female floodwater mosquitoes (e.g., *Aedes vexans*, *Ae. sticticus*) deposit their eggs on damp substrate that experiences flooding. Within Area ‘A’/Golden, floodwater mosquito development sites primarily exist along the flooding corridor of the Columbia River and Kicking Horse River, including associated seepage sites. When water floods these sites, due to the freshet and/or significant localized precipitation, the result is large-scale floodwater mosquito egg hatching. If more than one season has passed between high-water years, then high river levels may trigger a compounded number of mosquito eggs to hatch, resulting in a compounded number of mosquito larvae. While study results vary, Breeland and Pickard (1967) estimate that *Aedes vexans* eggs can remain viable for up to four (4) years while they await environmental hatching cues.

The secondary target of the Area ‘A’/Golden mosquito program is snowmelt mosquitoes. Snowmelt mosquitoes hatch early in the spring (i.e., April in 2024) within the area. Snowmelt mosquito habitats consist of smaller depressions in the landscape where snowmelt mosquito eggs were laid the previous summer. The smaller depressions collect water in the fall and freeze. Just as the site begins to thaw, snowmelt mosquito eggs hatch. These species typically hatch early to ensure their development habitat remains wet from hatching to emergence and to reduce inter-species habitat competition as they develop (Clements 1992). Certain snowmelt mosquito species begin to hatch at a water temperature of approximately 4°C and can complete development to adult emergence at 10°C (Clements 1992). Snowmelt mosquito development sites are mainly located along the mountain benches within Area ‘A’.

MBL field technicians begin monitoring all known mosquito development sites within Area ‘A’/Golden as the snowmelt sites begin to show signs of thawing. Mosquito development sites are adaptively managed, meaning that the regional river levels and environmental conditions largely dictate frequency of visits, as opposed to a prescribed monitoring schedule. At the height of the mosquito season, MBL staff may monitor highly productive sites multiple times a week. Adaptive management techniques allow MBL staff to most accurately time treatments, if necessary. Prescribed monitoring methods increase the risk of missing optimal treatment windows due to accelerated mosquito development rates with rising temperatures (Read and Moon 1996). Hence, as regional river levels and ambient temperatures begin to rise consistently, monitoring efforts increase.

Image 1. Standard dip (350 ml) with 3rd and 4th instar floodwater mosquito larvae.

Larval mosquitoes in sufficient number (i.e., >4/dip; Image 1) are treated by applications of a microbial larvicide product, Aquabac®. This product has the active ingredient *Bacillus thuringiensis* var. *israelensis* (Bti). In 2023, only the granular formulations of Aquabac® was used, which is carried on a corncob mixture. The mode of action is relatively simple and with a high degree of target species specificity. Receptors within the mid-gut region of the mosquito larvae are compatible with 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. This event causes 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 either flooded or thawed, it is increasingly difficult to treat sites by ground due to access challenges and concurrent site activation. At this point, a helicopter is used to conduct aerial treatments. The aerial treatments use the same pesticide as ground applications, although typically with a higher application rate to permeate canopy cover. High water years may require 2-day aerial treatment campaigns (treatment of the entire Area ‘A’/Golden region). All sites are checked within 1 or 2 days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted.

It is important to time treatments according to the correct stage of larval development (i.e., 3rd and 4th instar). If treatments are applied too early, the larvae will not have advanced to 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 within the ecosystem. When flooding commences and ambient temperatures rise, many dips easily exceed this threshold. Larval densities within the range of 200-500 per dip are commonly detected (Image 1).

Environmental Conditions

The four primary environmental conditions that affect floodwater or snowmelt mosquito larval production throughout the mosquito season (i.e., April – August) within Area ‘A’/Golden are: 1) local ambient temperature 2) ambient temperature in the snow basin contributing to either the Columbia River or Kicking Horse River, 3) local precipitation, and 4) the snowpack in the Upper Columbia Basin. Each condition provides insights regarding floodwater or snowmelt mosquito egg hatching onset, development rate, and success. As such, all noted conditions are tracked throughout the season.

Snowpack

Floodwater mosquito abundance within Area ‘A’/Golden is largely governed by the regional Columbia River, measured at the Donald (ID: 08NB005) and Nicholson (ID: 08NA002) gauges. The Kicking Horse River (ID: 08NB006) also contributes water to the Columbia River near the Town of Golden, affecting down-stream flows. The water levels of those systems are governed by the snowmelt released from Upper Columbia Basin. When snowpack within the Upper Columbia Basin exceeds 100 percent of normal, higher-than-average Columbia River and Kicking Horse River levels are expected during the mosquito season. Similarly, high ambient temperatures within contributing basins can compress the melt timeline, resulting in high regional river levels even if the snowpack in those basins does not exceed 100 percent.

On 1 April, immediately preceding the 2024 Area ‘A’/Golden mosquito monitoring season, the snowpack within the Upper Columbia Basin was 66% of normal. The lower-than-normal snowpack was likely a result of the El Nino weather pattern that was in place during the winter of 2024. The 2024 snowpack heading into the mosquito season was much lower than the high snowpack year of 2023, with cool high elevation temperatures helping to delay freshet to regional river systems until early-July. Subsequent warm weather depleted high elevation by mid-July, followed by a significant drop in regional river levels.

The Colpitti Creek snow survey station (ID: 2A30P) is the closest station to the program purview (Figure 1). It serves as a representative site for the regional snowmelt trajectory. Over-all, the Snow Survey data show the slow melt rate of high elevation snow at the station from early-May until late-June in 2024. Other snow survey stations throughout the Upper Columbia Basin show similar trends[2].

Data have been recorded at this site since 1976. Record Snow Water Equivalent (SWE) was recorded from December 2023 – July 2024 (Figure 1). By mid-July, any fluctuations

[2] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=c15768bf73494f5da04b1aac6793bd2e

in the regional Columbia River and Kicking Horse River levels were likely not due to regional snowmelt contributions.

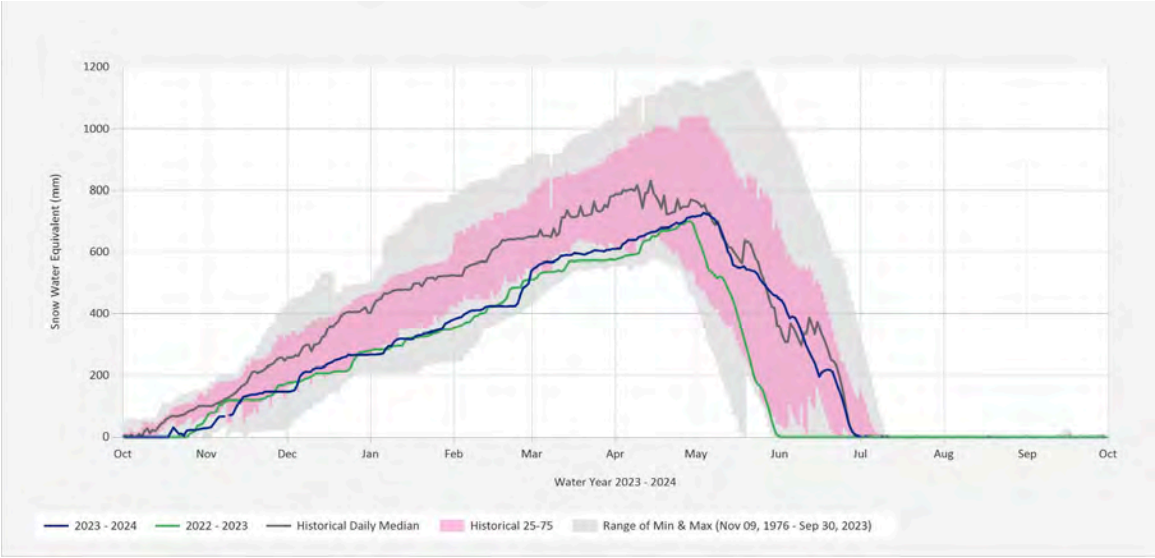


Figure 1.Snow Water Equivalent (SWE; mm) data from the Colpitti Creek snow survey (station ID: 2A30P) within the Upper Columbia Basin (green line).

In normal years, most of the snowpack has melted within the Upper Columbia Basin by mid-June. In 2024, however, cool high elevation ambient temperatures in May and June delayed the commencement of the Upper Columbia Basin snowpack melt until early-May. Consequently, the freshet was delivered gradually over seven weeks, two weeks later-than-average. The 15 June snow basin index for the Upper Columbia Basin was 53% of normal[4]. This relatively low value reflects the abnormality of the low snowpack and slight reduction in snowpack between 1 April and 15 June. Warm ambient temperatures within the basin continued through June with regional rivers dropping significantly after mid-July.

Rainfall events in May briefly increased Columbia and Kicking Horse River levels but did not provide environment cues to associated mosquito development habitat, with many sites remaining dry. The 2024 Columbia and Kicking Horse River freshets were set apart in two ways: 1) low snowpack within the Upper Columbia Basin and, 2) delayed delivery of freshet by approximately two weeks over average (almost 7 weeks later than 2023). Overall, these two factors led to average and late regional water peaks, resulting in approximately two large mosquito larvae hatching events in late-June and mid-July.

Local Precipitation

Substantial temporally and spatially concentrated precipitation accumulation may elevate regional Columbia River and Kicking Horse River levels and increase seepage site levels. Tracking local precipitation accumulation can aid MBL field staff in determining how long mosquito development sites may require management. The Golden Airport weather station (ID:1173220) provides both historical precipitation accumulation averages (i.e., 1981 – 2010) and current-year totals, allowing for the comparison between the two. This

comparison facilitates some level of prediction regarding larval mosquito hatching and treatment timing requirements. When more than average precipitation is received within peak hatching months, seepage site levels may be higher or sustained for longer. Both scenarios may lead to additional floodwater mosquito egg hatches.

The precipitation received to the Golden Airport weather station (ID: 1173210) from May through July was similar to the monthly station average (2016-2024; **Figure 2**). A precipitation event on 16 May (18.2 mm) did impact Columbia and Kicking Horse River levels, but not seepage sites, as regional water were below levels needed to activate many associated sites in mid-May. It is unlikely that this specific precipitation event augmented river levels beyond those that would have been observed due to freshet alone.

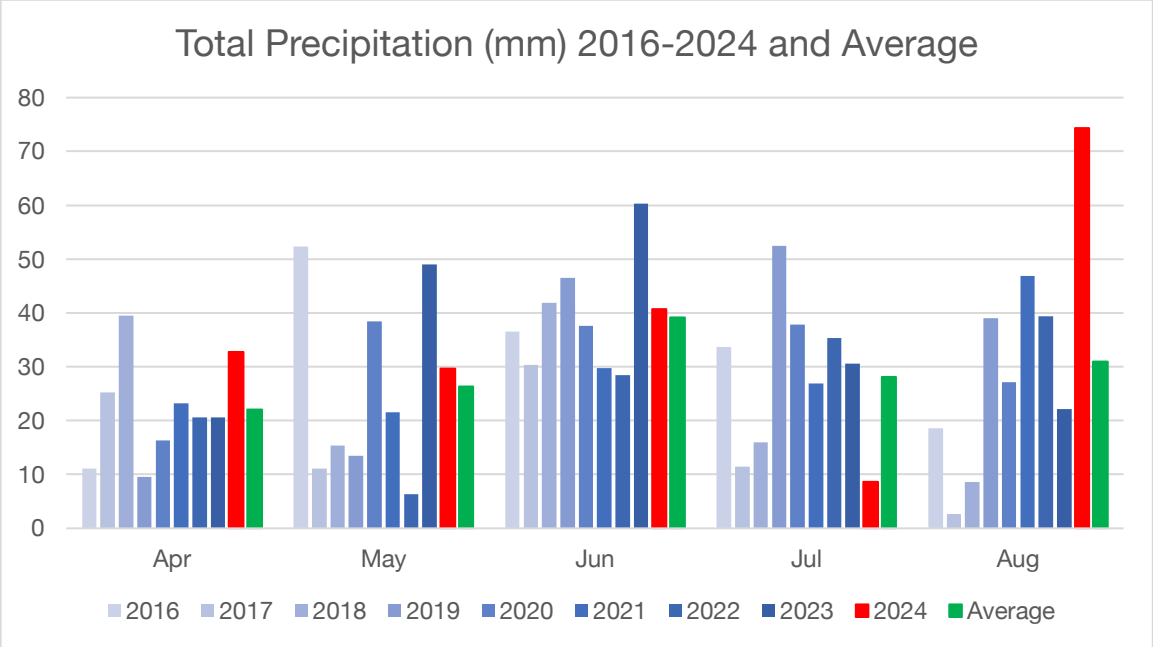


Figure 2 Precipitation values (rainfall and snow accumulation; mm) recorded at the Golden Airport weather station (ID: 1173220) for 01 April – 31 August 2024 (Red) and average station precipitation values (2016-2023; blue gradient) and overall average (2016-2024; green)

Regional precipitation received in August was well above average, but likely did not contribute to floodwater mosquito development sites due to the already subsiding Columbia River and Kicking Horse River levels. It is possible that precipitation received in August created habitat for container mosquito species to reproduce. Thus, adult mosquito presence toward the end of the season was likely due to container mosquitoes dispersing from these sites, not floodwater mosquito species in certain areas.

Ambient Temperature

Local and regional ambient temperatures within the Upper Columbia Basin are important variables to track. Local ambient temperature fluctuations from April through August can affect mosquito egg hatching, larval development rates, adult dispersal, and adult survival within Area ‘A’/Golden mosquito development habitat. Within the Upper Columbia Basin, regional ambient temperature dictates the commencement and intensity of the freshet, directly impacting floodwater mosquito development habitat.

Upper Columbia Basin Temperatures

The 2024 mosquito monitoring season began in April with above-average ambient temperatures within the Upper Columbia Basin. The weather in April was near normal across much of the province [3], with ambient temperatures ranging from 0.5°C to -0.5°C of average for the month.

The warm ambient spring temperatures in April resulted in a monthly average temperature of 13.2°C, double the historic monthly average. The warm April did not initiate snowmelt within Upper Columbia Basins due to cool high elevation temperatures and snow augmentation in April. Warm high elevations ambient temperatures from early-May to early-July gradually depleted high elevation snowpack and delivering freshet to regional rivers from mid-May until mid-July. By mid-July, the regional rivers levels were retreating as contributing high elevation snow basins were depleted of snow. Dry conditions persisted through July helping to further dry out river-associated floodwater and seepage sites.

The delayed peak of the freshet resulted in low 2024 peak levels for both the Columbia (3.84m, Donald station) and the Kicking Horse rivers which peaked between 11 and 14 July. Ambient temperatures remained warm through July and August. When snowpack is depleted, ambient temperatures within the Upper Columbia Basin do not typically impact floodwater mosquito habitat within the Area ‘A’/Golden. Ambient temperature data are consistent with 2024 automated snow station data depicting snowmelt points correlating with regional ambient temperature spikes[4].

Area ‘A’/Golden Temperatures

Local ambient temperature is a predictive tool when gauging the commencement of floodwater egg hatching. If the ground proximate to the Columbia River and Kicking Horse River contains floodwater mosquito eggs and if hatching conditions are present (i.e., low dissolved oxygen, higher ambient temperatures), then floodwater mosquito egg hatching will commence (Mohammad and Chadee 2011). Local ambient temperature data are acquired from the Golden Airport weather station (ID: 1173220).

To illustrate the effect of ambient temperature on floodwater mosquito egg hatching events, 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 and survivorship was low. Eggs held at 21°C provided the optimal temperature, of the five temperatures tested, for hatching and larval development (Figure 3). While *Ae. sticticus* is not the sole floodwater species present in Area ‘A’/Golden, it serves as a representative species for our purposes and provides general developmental benchmarks.

[3] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2024_may1.pdf
[4] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data/automated-snow-weather-station-data

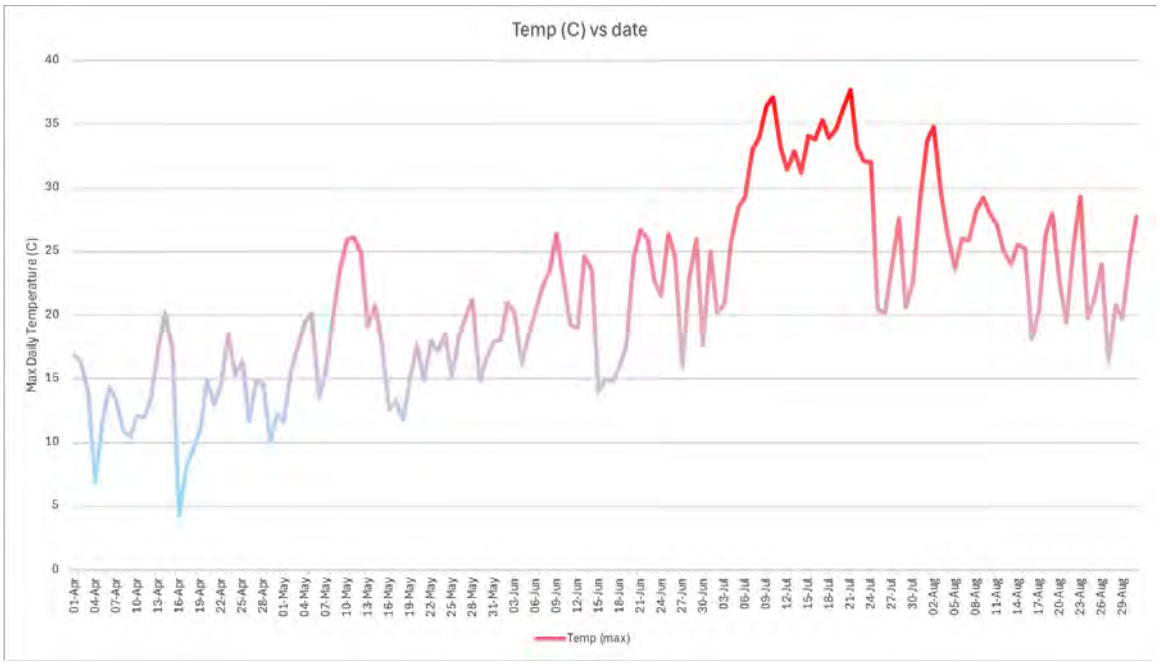


Figure 3 Maximum daily ambient temperatures (C) as recorded at the Golden Airport Station (ID: 1173220) 01 April – 31 August, 2024.

Snowmelt mosquito eggs hatch earlier than floodwater mosquito eggs. Certain snowmelt mosquito species begin to hatch at a water temperature of approximately 4°C and can complete development to adult emergence at 10°C (Clements 1992). Thus, snowmelt mosquito eggs laid along the Columbia River bench area were triggered to hatch in April as sites began to show initial melting (**Figure 3**). Of note, **Figure 3** shows ambient temperature, not water temperature. The delay in realized water temperature is likely a few days in relatively small, shallow sites, including the majority of snowmelt-influenced sites found in along the mountain benches in Area ‘A’/Golden.

Within Area ‘A’/Golden, the 2024 mosquito control season began with above average ambient temperatures for April, with seasonably warm temperatures through the month of ~6.6°C. This was above the historical station average. April temperatures provided conditions for successful floodwater mosquito egg hatching, however, floodwater mosquito eggs within Area ‘A’/Golden did not activate unitl floodwater and seepage water arrived in June. (**Figure 3**). If mosquito eggs were exposed to water during this month, the larval development at cooler temperatures would have been slow (Trpis and Horsfall 1969). In contrast, April temperatures were well within the bounds for successful snowmelt mosquito hatching in April. Numerous snowmelt mosquito sites had egg hatching events in April due to warm temperatures.

Local ambient temperatures in May were warm and well within the temperature range for favourable floodwater larval development conditions for target mosquito species (**Figure 3**). The average maximum daily temperature for May was 17.9°C, approximately 6.8°C warmer than the historical station average. Despite above average temperatures, floodwater mosquito egg hatching and larval development rates did not increase during the month of May, as nighttime ambient air temperatures in Golden averaged 4.3°C, with even cooler temperatures delaying snowmelt within high elevation snow basins. Snowmelt mosquito

larval treatments continued into May as local warm ambient temperatures melted remaining low elevation snow at associated mosquito development sites.

Ambient temperatures in June were higher than May, providing sufficient hatching cues for floodwater mosquito eggs exposed to water. Local ambient temperatures remained above seasonal average in July and favourable for floodwater and permanent water mosquito hatching events. Precipitation through August was above average; however, regional river levels were too low to activate mosquito development habitat.

Warm weather in late-June and early-July corresponded with the annual peak of the Columbia River and Kicking Horse Rivers. When river levels peak during periods of higher heat, the result is often large-scale mosquito egg hatching events and increased larval development rates, however below average snowpack resulted in low and late peak river levels, providing the necessary cues for approximately two large, hatching events around late-June and again in mid-July.

As predicted by the Temperature and Precipitation Probabilistic Forecasts for Canada, July, and August ambient temperatures were above average. Average daily ambient temperatures were 29.9°C and 25.7°C for July and August in Golden, respectively. The freshet receded below critical levels in late-July and there was minimal new floodwater mosquito larvae activity in August. Warm weather with above average precipitation later into the summer led to occasional mosquito treatments at fewer sites in August. High ambient temperatures, such as those noted during July and August, decrease the lifecycle of adult mosquitoes (Ciota et al. 2014). Thus, any mosquitoes that successfully emerged would have had a reduced lifespan with the heightened ambient temperatures through July and August (**Figure 3**).

While not a target of the Area ‘A’/Golden mosquito control program, container mosquito abundance typically increases in July and August. Container mosquito habitats near residential homes can be created throughout warmer summer months whenever the presence of water is coupled with high ambient temperatures. MBL technicians regularly inform residents that container-bred mosquitoes can be reduced around homes by ensuring conducive environments (i.e., bird baths, kiddy pools, flowerpot holders, etc.) are either free of water or refreshed frequently.

River Levels

Floodwater mosquito development sites within Area ‘A’/Golden are found along the flooding corridors of the regional Columbia River (Donald gauge - 08NB005; Nicholson gauge - 08NA002) and Kicking Horse River (Golden gauge – 08NA006) and within associated seepage sites. As the presence of water is the main hatching cue for floodwater mosquito eggs, springtime and early summer regional river levels provide predictions about the timing and extent of floodwater mosquito egg hatching.

From early-May to early-July, warming temperatures gradually melted the snowpack, resulting in the annual Columbia and Kicking Horse River freshets two weeks later than

average. By late-July, the majority of freshet had run through the regional river systems as high ambient temperatures depleted the below average Upper Columbia basin snowpack (**Figure 4**). Through late-July, the freshet continued to decline, despite above average precipitation in August. The regional rivers were below levels needed to produce new mosquito larvae activity at the majority of floodwater and seepage sites in August.

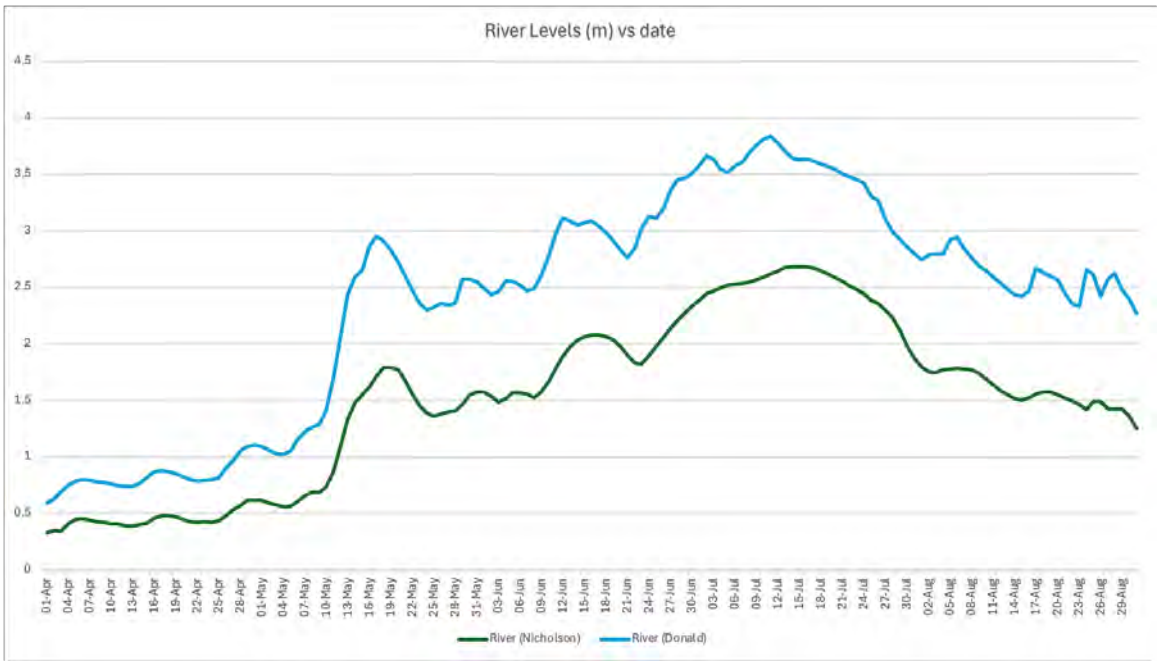


Figure 4 Columbia River (Donald gauge - ID: 08NB005, Nicholson gauge - ID: 08NA002) levels (m) from 1 April – 31 August 2024. Note that the higher levels at Donald primarily reflect the input from the Kicking Horse.

Floodwater mosquito eggs laid on substrates at various river levels have optimal environmental cues and adequate time within which to hatch when rivers rise at a slower rate. When river levels rise at high rates, mosquito eggs typically lack sufficient environmental cues due to the cold, highly oxygenated meltwater moving through the system. Both regional rivers rose at low rates in 2024, but high-water levels were present long enough to produce approximately two floodwater mosquito hatching events. Local floodwater mosquito development sites activate mosquito larval eggs to hatch when the Columbia River (Donald station) reaches the 3 m mark (Figure 4). Thus, beginning in late-June environmental cues were present to trigger mass floodwater mosquito hatching events at rising river levels.

A provincial high elevation warming trend occurred in early-May, causing both rivers to experience seasonal peaks between 11 July and 14 July (**Figure 4**). These initial peaks presented considerable hatching cues for floodwater mosquito eggs, requiring large-scale treatments. High-elevation snowpack within the Upper Columbia Basin remained present until early-July. As a result of a high elevation warming trend, the peak of the Kicking Horse River was recorded on 11 July (4.45 m) and associated seepage sites were reduced following the recede of the river. By August many previously active mosquito development sites were dry.

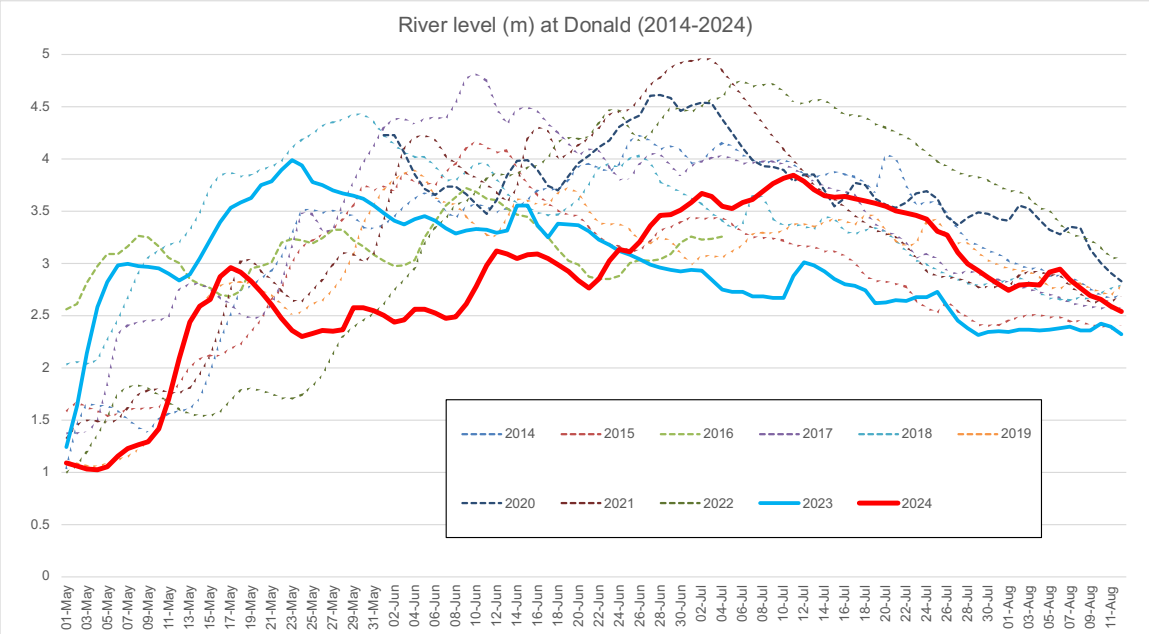


Figure 5 Columbia River (Donald gauge - ID: 08NB005) levels for 2014 – 2024 from 1 May – 11 August. Note that 2024 was the latest peak in the previous 10 seasons and 48 days later than the peak in 2023.

The Kicking Horse River feeds into the Columbia River at Golden with the Donald gauge situated downstream of this confluence. Thus, the Columbia River at Donald gauge provides data for the Kicking Horse River and Columbia River. Comparing data from the Donald gauge through various seasons provides a representative understanding of relative flooding states. The 2024 Columbia River peak at the Donald gauge was approximately 0.10 m lower than the 2023 peak (**Figure 5**) and 48 days later. Consequently, the low and delayed snowmelt of 2024 resulted in an average and late river peak that arrived during a very hot spell (Figure 3, pg. 12).

The current year’s peak in the regional Columbia River relative to those of recent seasons is another predictive variable that may help explain a current year’s larval abundance. If the current year’s peak river levels far exceed those of the preceding season, mosquito eggs laid between the high-water mark of both years could remain dormant until current-year flood waters trigger their hatching. In contrast, because the peak of the Columbia River in 2024 was lower than that of the preceding season’s, the 2024 peak level did not trigger a compounded number of floodwater mosquito eggs to hatch. As such, a lower floodwater mosquito larval abundance in comparison to 2023 was noted.

Larval Control

Snowmelt mosquito monitoring begins in the early spring when consistent local snowmelt starts. Snowmelt mosquito development site monitoring began on 22 April. Floodwater mosquito monitoring begins when spring ambient temperatures start to rise steadily in the Upper Columbia Basin, followed by consistently increasing regional Columbia River and Kicking Horse River levels. This year, floodwater mosquito development site monitoring

began early in June. Although most of the floodwater mosquito development sites are not active until the regional Columbia River exceeds 2.5 m, sites were monitored beginning in early-June to evaluate site conditions and catch the leading edge of any potential hatching events that may have occurred with the rising regional river levels. Warm ambient temperatures coincided with increased floodwater mosquito development site monitoring and larval mosquito treatments in June.

Appendix I shows a map of average larval densities found throughout the 2024 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 map (**Appendix I**), data are 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 mosquito 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 also 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. Of note, the areas with highest recorded larval abundance amongst known sites are at the confluence of Kicking Horse River and Columbia River at Golden, between the Columbia River and the Trans-Canada Highway throughout Golden proper, near the Columbia River Wetlands RV Park, the Nicholson area, and the Parson area. No new mosquito development sites were identified throughout the Area ‘A’/Golden program purview in 2024.

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 points, may contain sample points that lie directly on hexbin borders, or contain treatment area associated with a point that is officially housed within a neighbouring hexbin; each of these circumstances may create skewed results.

Low and late Columbia River and Kicking Horse River peak levels resulted in the need for fewer treatments in 2024. A total of approximately 1,651.65ha (7,917 kg) were treated within Area ‘A’/Golden in 2024. For comparison, MBL has treated 1144.13 ha less in 2024 than in 2023 – a higher water year. Aerial sites north of Golden were treated this year to remedy long standing mosquito annoyances around the Wiseman, Forde and Donald communities. No known sites were missed in ground-based or aerial treatment efforts, however, challenges with booking the helicopter meant we were later than ideal on the last aerial treatment. Hot weather shortened the treatment window coupled with a later than ideal treatment meant we missed some key larvae, particularly in the southern portion of the program.

Ground Application Summary

Mosquito development sites within Area 'A'/Golden are visited on a weekly basis unless conditions required more frequent monitoring (i.e., Columbia River levels > 3m, ambient temperatures > 20°C, large precipitation event). Sites are treated when a standard dip (350ml) collects 5 or more late instar (3rd or 4th instar) larvae per dip. All sites are checked within two days of the initial treatment to ensure high treatment efficacy. If necessary, touch-up treatments are conducted.

The first ground treatment occurred on 22 April (**Figure 6**). Treatments conducted in the early portion of the season (April and May) took place at snowmelt sites within local bench communities above the Columbias wetlands surrounding Golden, BC. Treatments conducted on 28 June took place at floodwater-associated sites. Floodwater mosquito development site treatments occurred between 28 June and 14 August (Figure 6).

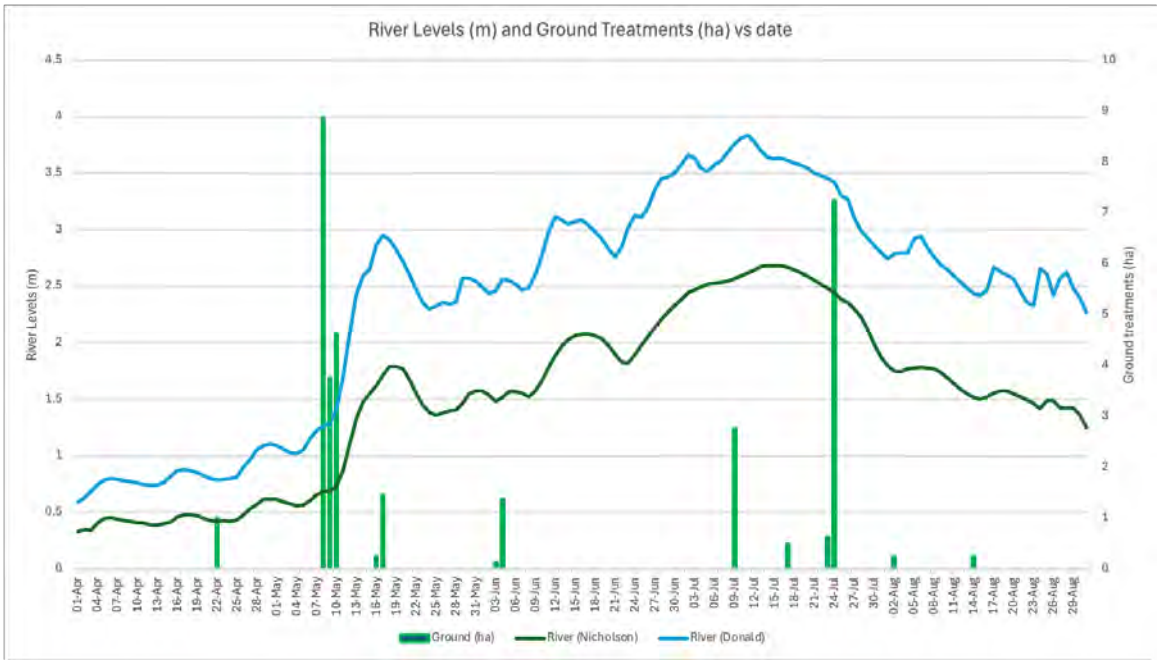


Figure 6 Columbia River levels (m; Donald gauge and Nicholson gauge) with total mosquito development area treated by ground (ha) from 1 April – 31 August 2024. Note ground treatments (ha) are recorded on the alternate y-axis.

Aquabac® (a.i., *Bacillus thuringiensis* var. *israelensis* (BTI)) is the product used for all larval mosquito treatments conducted by MBL. Bti has high target specificity and achieves 95% - 100% efficacy in typical field conditions (Aquabac® Mosquito Biolarvicide - Technical Bulletin). Within Area 'A'/Golden's highly organic floodwater mosquito site conditions, MBL staff note an average field efficacy rate of approximately 85%-90%. The granular formulation was used in 2024. The majority of mosquito development sites within Area 'A'/Golden require 4 kg/ha when treated by ground.

The total area treated by ground in 2024 was approximately 34.82 ha (139.30 Kg Aquabac®; 4 kg/ha) (**Figures 6, 7**). The total area treated by ground in 2024 was 239 ha less than the total area treated by ground in 2023 (**Figure 8**). The decrease in ground-based treatment area in 2024 is due to the low Columbia River and Kicking Horse River peak

levels. Real-time data associated with each treatment are available through MBL’s client-registered, real-time program portal.

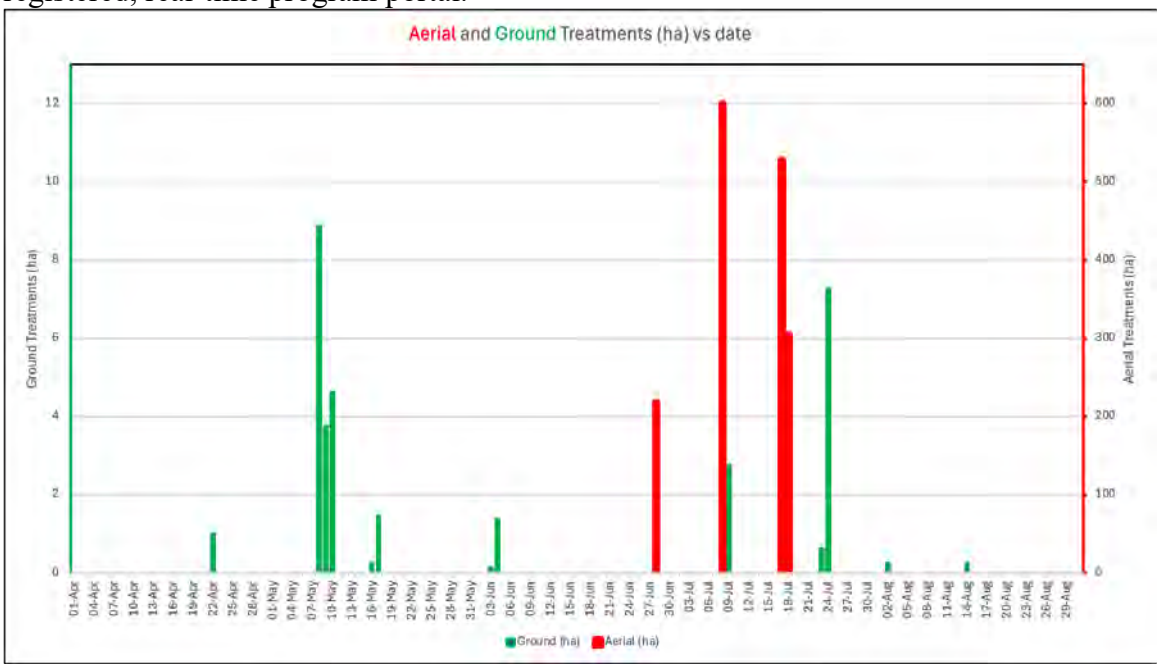


Figure 7 2024 ground-treated and aerially-treated area (ha) by month from April – August. Note that Aerial is on the right axis and Ground is on the left, also note the very different scales.

Relative to the high peak river levels and early arrival of freshet in 2023, floodwater mosquito development habitat was lower and appeared later in 2024. Floodwater and seepage habitat was present from late-June until early-August. (**Figure 8**). The snowpack within influential basins was lower-than-average, melting slowly beginning in early-May. Those conditions across much of the province led to delayed input of freshet to regional river systems by mid-July. Because river levels were sustained for a shorter period in 2024, large scale treatments were not required until late-June.

Ground Application Annual Comparison

A new data parameter that we looked at this season (in summary) was a comparison between the number of treatments, as opposed to the amount treated, between seasons. Several factors can influence this comparison, primarily differences in data logging practices of summer staff. It is interesting to note (fig. 8) that while staff change from year-to-year, the number of treatments remains relatively consistent, save for 2023 (an outlier).

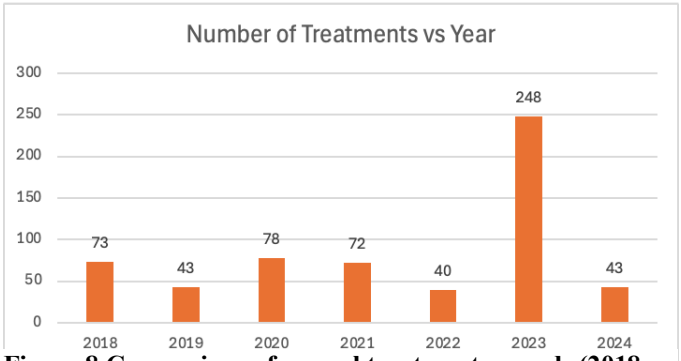


Figure 8 Comparison of annual treatment records (2018-2024).

Aerial Application Summary

Floodwater mosquito development sites are treated by air when multiple large-scale sites become active at once and/or when site-access by ground is unsafe. Three (3) aerial campaigns were required within Area ‘A’/Golden in 2024. Treatments took place on 28 June

and 17, 18 July (**Figure 9**). For comparison, two (2) aerial campaigns were conducted in 2023. The difference in required aerial treatment events signifies the longer period of floodwater mosquito site activity within the region in 2024 due to the slow melt of contributing high elevation snowpack. Aerial treatments were conducted using granular Aquabac®. To compensate for increased canopy cover, aerial treatments were applied at an average rate of 7 kg/ha. A total of 1,651 ha were treated by air, equating to a total of approximately 7,917 kg of Aquabac® used. **Figure 9** shows the aerial treatment events (green) with Columbia River (Donald gauge) levels. **Appendix II** includes all treatments within each hexbin (i.e., polygons).

Aerial treatment events typically take place immediately after the Columbia River at Donald has peaked because the Bti is able to reach mosquito larvae before they disperse with rising water. As it is difficult to determine exactly when the peak will occur, aerial treatments often bookend a peak. Additionally, when the Columbia River is sustained at high water levels, more floodwater mosquito eggs may have time and abundant environmental cues to hatch. Aerial treatments were conducted around the initial (i.e., 23 June) and primary Columbia River peaks (**Figure 9**). MBL staff were able to accompany the helicopter pilot again in 2024, which aids in identification and treatment of inconspicuous mosquito development areas. All treatments successfully controlled targeted floodwater mosquito larvae.

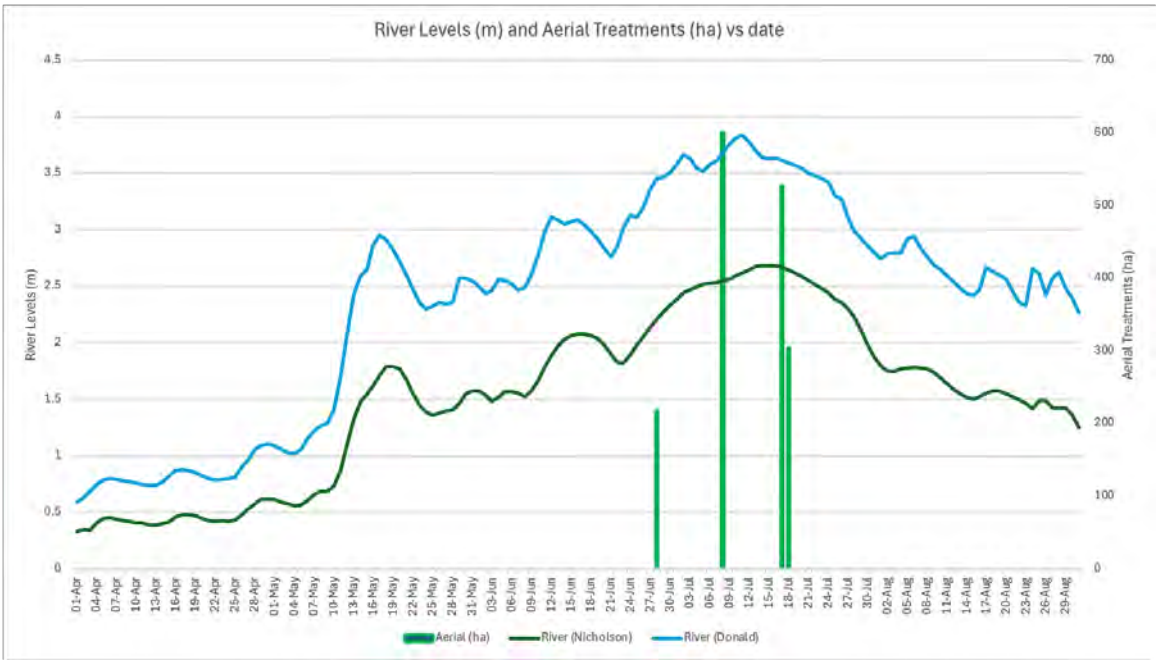


Figure 9 Columbia River levels (m; Donald and Nicholson gauges) with total mosquito development area treated aerially (ha) from 1 April – 31 August 2024. Note aerial treatments (ha) are recorded on the alternate y-axis.

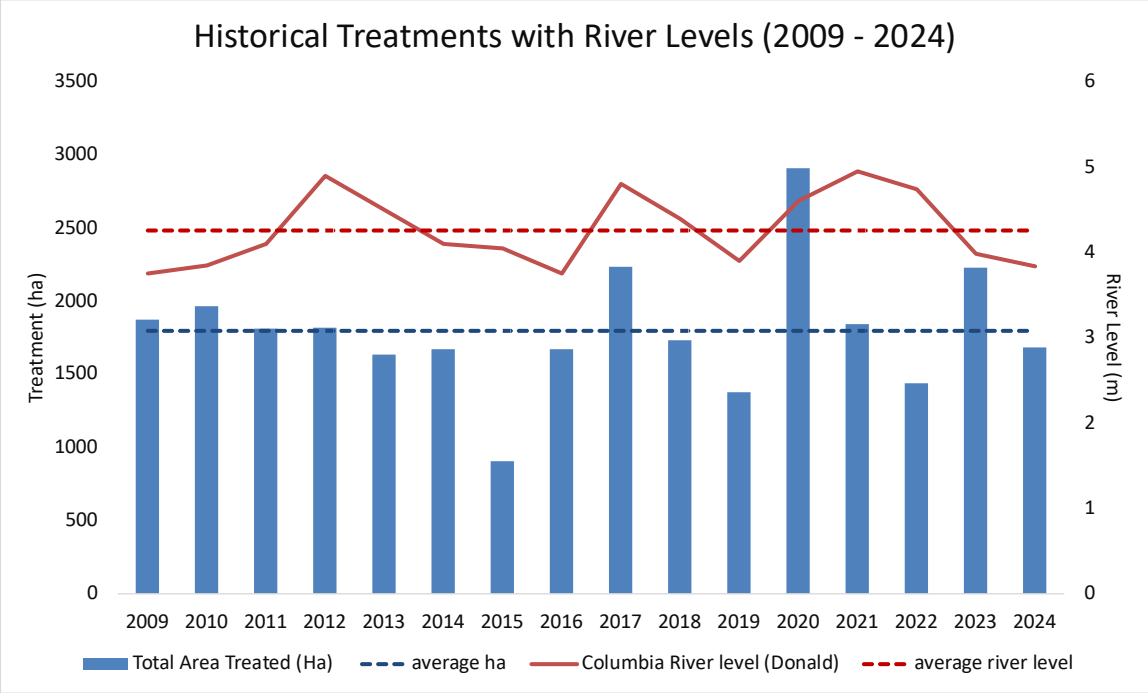


Figure 10 Historic Treatment levels relative to peak river levels (Donald). Note that larval treatment amounts were at or near normal for the river levels (compared to 2011, 2013, 2014, 2018, etc.)

Community Feedback (Studies)

Several studies have been referenced in a series of community feedback email threads (included in "References"). These studies, many based on some excellent work conducted in a salt marsh and associated wetlands in the Carmague region in France, show that mosquito control has negative indirect effects on upper trophic levels in regions with control. While this is true for healthy non-ephemeral wetlands, much of what is presented in these studies does not relate particularly well to ephemeral wetlands, in particular the floodwater ecosystems that are targeted for this program's target species (*A. vexans and A. sticticus*, primarily).

These are all good papers and help to highlight why we do not treat permanent (ephemeral) ponds. These studies do not, however, accurately reflect the floodwater ecosystems that MBL targets for these two species. The Carmague studies are good, but specific to tidal salt marsh and associated permanent wetlands, areas that require many treatments a year to control mosquitoes.

These papers, taken in context, suggest that relatively infrequent control of ephemeral wetlands has limited-to-no measured effect on non-target organisms (Poulin 2012 supports this specifically in the discussion – pgs. 30 and 31). The relevant papers support the hypothesis that regular and frequent treatments affect trophic levels (direct and indirect). The program in Golden and surroundings typically does not encompass more than three treatments per season, and generally these are only in newly flooded areas. Ideally, each

area is only treated once as the water levels rise (in practice, with the aerial application available, this is difficult to ensure, and treatment overlaps occur)[5].

Once the floodwater program is effectively done, the wetlands will almost certainly be producing other mosquito species, in areas where the water has remained post-freshet. Those mosquitoes will support upper trophic levels for the duration of the season (making this program unique - all other programs have relatively dry basins post-freshet). These mosquitoes are not noticed because they do not tend to travel nearly as far as our target mosquitoes, nor do they hatch anywhere close to *vexans/sticticus*.

There is no question that reducing any mosquitoes removes a food source from the ecosystem, and there is an impact. Of all the treatment options available, judicious use of Bti is without question the least impactful with respect to direct and indirect effects on the trophic levels, particularly in ephemeral wetlands.

Several comments discussed bats/birds and their capacity to control mosquitoes; in MBL's experience, there is nothing natural that can manage the floodwater mosquitoes on the scale that would positively impact the program and reduce overall annoyance. If floodwater mosquitoes presented a good base for those predator populations, then the predators would move in and take advantage. We do, however, support adding bat boxes and bird houses. MBL has implemented these strategies in several of our programs, primarily because bats and birds need help, but without the illusion that their presence will control the mosquitoes an appreciable amount.

Discussion

Although water levels (Figure 9, red line) in the Columbia were within 10% of the 15-year average this year, the water came at a time when temperatures were very high. This dramatically accelerates the larval development speed, with ground, water, and ambient temperatures all near their seasonal peaks. Drawing on comparisons with treated area in other years with similar water levels, it appears that field crews were within range, assuming treated area in our records reflects wetted area available for treatment.

Our ideal timing with the helicopter treatments in mid-July (July 17 and 18) would have been 2 days sooner, however we were unable to book the helicopter (the pilots were able to make scheduling changes allowing to treat when we did). This, combined with the elevated temperatures (Figure 3, pg. 12) resulted in the emergence of a significant wave of mosquitoes. These mosquitoes would have started dispersal around July 24, which mirrors some of the comments we received late in the season.

This year saw an August rainfall significantly above normal (Figure 2, pg. 10). Note that the red lines represent total monthly precipitation (mm) and the green lines represent average monthly precipitation (mm). More than double the average rainfall accumulated in and around Golden in August of this year. While this was good news for those affected by fire, it presented more opportunities for local mosquito annoyance. In addition, the wetter

[5] MBL anticipates the use of RPAS in the program will improve the accuracy of treatments significantly.

weather provided favourable conditions for survivorship of the floodwater mosquitoes that dispersed in late July.

MBL did not receive any community complaints through its usual means (the toll-free hotline), but we did receive two via email, both through the CSRD. For comparison, MBL received 15 calls to the hotline specific to this program in 2017, five in 2020 and one in 2022. It benefits the program when residents can speak with us directly. We are able to discuss activities to date, expectations for the remainder of the season, and ways that residents can manage and/or find relief from mosquito infestations.

RPAS (Drone) Update

Unfortunately, the news on RPAS (drone) treatments is not the positive news we would like to deliver. Internally, we have worked throughout the year to prepare for deploying drones for treatment work in 2025; we have nearly completed SFOC (Special Flight Operation Certificate) for flying drones over 25kg, we are insured, and our main drone pilot (Dirk Lewis) has his advanced pilot certificate for complex drone operations. With MBL's transition to Valent products (we previously used and distributed Aquabac) we have several products available for use with drones, as RPAS is a permitted use on all their labels.

That said, the Province reprioritized some of their work and, despite a strong start early in 2024, shelved further work on the certification category for pesticide applications utilizing drones. To date, the only provinces that have categories for pesticide applications with drones are New Brunswick and Quebec. This work was further stalled by the Provincial election, with no direction during the interregnum. MBL is informed that it is likely a year out on the certification category being finalized (pers. comm. with Jon Mullan, Integrated Pest Management Unit Head). This would suggest that the earliest expected treatments would be for the 2026 mosquito season.

Given the financial and environmental savings this technology presents, we will continue to work with the Province to help develop this certification category.

Public Relations

Maintaining positive public relations continues to be a high priority for MBL. Public relations occur on several levels: in-person communication with members of the public, the mosquito hotline, presentations to stake holders, email correspondence, and social media presence. MBL continues to look for new areas to expand this aspect of our program.

Phone Calls and Emails

Area 'A'/Golden residents have multiple venues to communicate with MBL. MBL's Mosquito Hotline (877-986-3363) and email form are outlined prominently on the contact tab of the MBL website (www.morrowbioscience.com). The CSRD has also established a mosquito control website, FAQ links, and report links[6]. We note that there is no contact information for directly reaching contractors in the programs. We recommend amending the website to include current contact information, specifically, having a local phone

[6] https://csrd.bc.ca/187/Mosquito-Control

number that can be forwarded to our hotline. Currently, emails and calls received to the CSRD program manager are documented and forwarded to MBL staff for follow-up.

MBL received only one phone call to the hotline this year; on May 18 a resident was enquiring about expectations for the mosquito season. On August 6 MBL received an email via CSRD staff that indicated the mosquito populations were significantly bad, particularly in the south of the program around Nicholson. It was not possible to determine the timing of the influx of mosquitoes, however, inferring from the timing of the message and the mid-July peak in river levels, it seems likely that the mosquitoes came from the areas missed in the final of three aerials this season (July 17/18 aerial to cover the July 11 peak in river levels).

A second email came in from a resident in the Blaeberry area (Aug. 21) requesting information on the program. It is unclear if this was in response to high mosquito levels. Efforts were made to coordinate with the resident, resulting in a visit by field staff in September confirming the site information in our database.

It typically takes 2-3 weeks for mosquitoes to emerge and disperse following hatching events associated with peak river levels. When rivers rise slowly, as occurred beginning in 2024, mosquitoes may emerge and disperse weeks after peak levels. The potential timeline for mosquito emergence and dispersal in 2024 likely ranged from late-June through late-August.

MBL remains committed to continuing reconnaissance efforts to identify floodwater mosquito development sites, adaptive site management, and expanding in-house knowledge of sites. Expanding public engagement reach may also result in the identification of new sites and reduction of mosquito larvae in the region. Through these efforts, MBL aims to further reduce adult mosquito nuisance within the Area ‘A’/Golden mosquito control purview.

Direct Communications

Direct communication between MBL staff and the public can occur in many situations. 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 residents. These encounters provide an excellent opportunity for public relations. An important outcome of these interactions can be the identification of new sites.

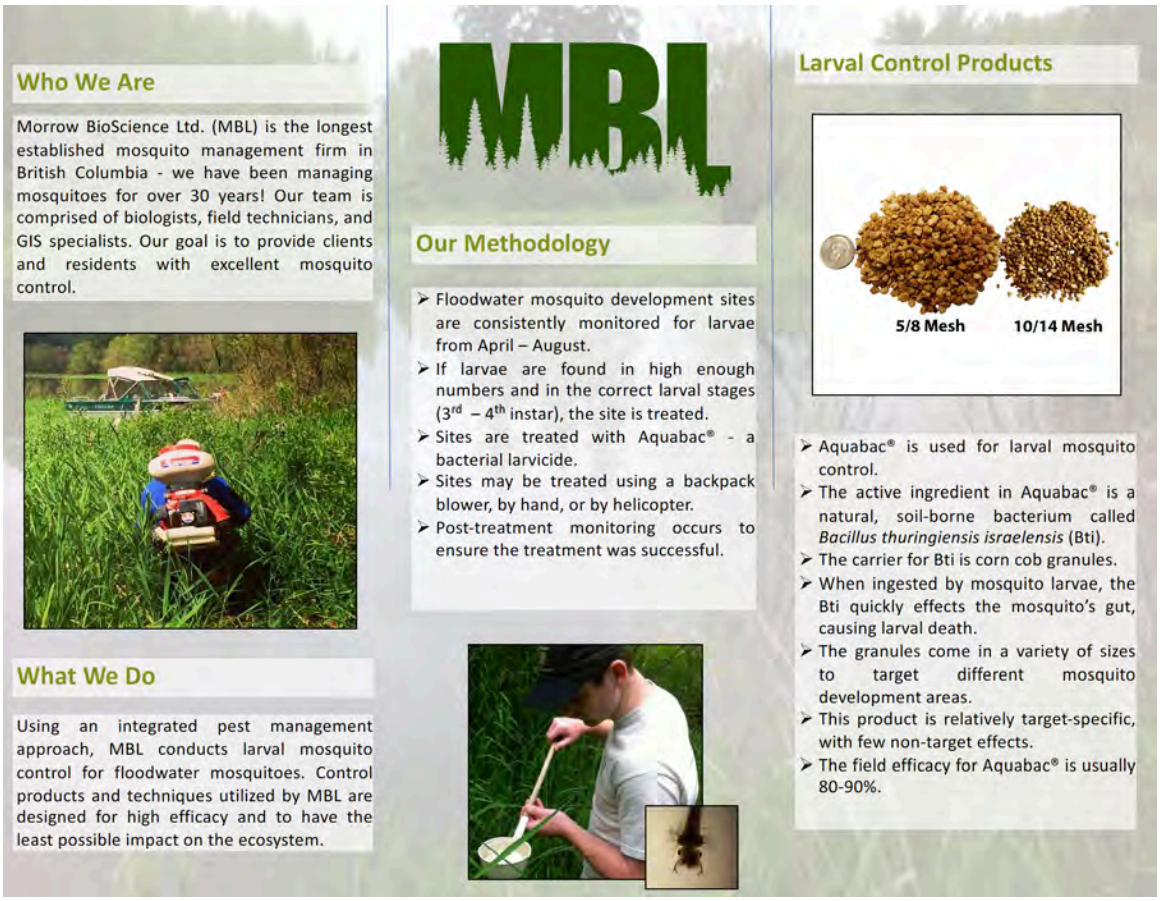


Image 2. MBL education outreach pamphlet.

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 (Facebook, Instagram). Additionally, MBL staff may provide residents with an outreach pamphlet (Image 2). The pamphlet includes information about the larval control product used, mosquito biology, and personal protective tips.

Social Media

MBL maintains a presence on social media with a Facebook account (facebook.com/morrowbioscience), and Instagram account (morrowbioscience), which are regularly updated. There are five 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 regarding environmental 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 remains the primary avenue for MBL to disseminate mosquito-related information on social media. Regular updates on mosquito abundance began in early April. All posts related to the Area ‘A’/Golden mosquito program included the hashtag: #CSRDmosquito.

Image 3. Facebook post of Area 'A' mosquito development site reconnaissance (2 June 2022)

MBL Website

The MBL website (**www.morrowbioscience.com**) was launched in 2015 and redesigned in 2021 (Image 4). This site was developed to allow clients and the public to have access to information about MBL’s background, activities, outreach, and company. To further support residents in contract areas, the homepage includes visible tabs for resources and the contact information. The ‘Contact ’tab allows users to directly send a message to MBL. Additionally, there are links to MBL’s Facebook account so residents have access to real-time updates on MBL’s activities.

Image 4. Morrow BioScience Ltd. homepage (www.morrowbioscience.com)

The website specifically highlights two sets of FAQs focused on (1) mosquito biology and disease transmission, and (2) the active ingredient used in control efforts (*Bacillus thuringiensis* var. *israelensis*). MBL has added blogs discussing relevant education outreach topics. Information dedicated specifically to mosquitoes and COVID-19 (published in May 2020) remains available on the website.

Communication with program residents remains a priority for MBL. On 2 September, 2024, Christopher Cheung with The Tyee, an independent daily news website based in Vancouver, BC, published an in-depth article on mosquito abatement, past and present. The article included excerpts from an interview with MBL's owner and lead biologist, Dirk Lewis. While not specific to this program, the interview provided advice specific to personal protective measures and mosquito habitat reduction tips.

Although this interview was requested by a publication based on the coast, the subject matter included tips for residents to reduce mosquito habitat around homes and how to increase personal protective measures. These recommendations are applicable to all program residents. If opportunities arise, MBL staff ensure that the CSRD mosquito program manager is consulted prior to agreeing to an interview. Every effort will be made to accommodate interviews which assist in raising awareness about mosquito control efforts and personal protective measures.

West Nile Virus Summary

Even though floodwater mosquito species in Canada are not the main West Nile virus (WNv) vectors, it is important to remain current in regional mosquito-related diseases. Along with its partners, Health Canada compiles on-going provincially reported surveillance data of WNv cases in humans, animals, and mosquito pools between 1 January and 29 September.

As of 26 October, two human cases of West Nile Virus (WNv) were reported in the province of British Columbia.[7] Canada's National Microbiology Lab (NML) is currently working alongside provincial and territorial health authorities to conduct weekly mosquito

[7] Seasonal update - Mosquito-borne disease surveillance - Vector-borne disease surveillance in Canada — Canada.ca

surveillance and monitoring to regularly assess the risk of mosquito-borne diseases in Canada[8].

Of note, mosquito pool surveillance data are not reported to Health Canada from British Columbia, and it is possible that other information is not reported by the BCCDC to Health Canada.

As Washington State and Idaho State share a border with British Columbia, it is important to follow WNv activity in those areas, as well. According to the Center for Disease Control, as of 8 October, one human case of WNv was reported in Washington State. No mammals or birds tested positive for WNv. Idaho identified six (6) human WNv cases[9]. All cases were identified within counties in the southern and southwestern portion of Idaho.

Zika Virus Summary

No information regarding Canadian Zika cases has been reported by the Public Health Agency of Canada since 2017 and Heath Canada will no longer be updating case counts[10]. HealthLinkBC reports that no Zika cases have originated in Canada due to presumed lack of vector mosquito species[11]. There have been human Zika cases reported in Canada prior to 2024, however those were determined to have been acquired while traveling.[12]

According to Peach (2018), the primary Zika mosquito vectors (i.e., *Aedes aegypti*, *Ae. albopictus*) are not found in British Columbia. *Ae. albopictus* has been found on east coast but tested negative for Zika. There is currently a low risk for Zika virus to circulate within British Columbia.

[8] Fight the bite: Mosquito borne diseases are on the rise in Canada (science.gc.ca)
[9] Current Year Data (2024) | West Nile Virus | CDC
[10] https://www.canada.ca/en/public-health/services/diseases/zika-virus/health-professionals.html#_Surveillance_in_Canada
[11] https://www.healthlinkbc.ca/health-feature/zika-virus
[12] Zika Virus Facts & Resources | HealthLink BC

2025 Program Recommendations

- Re-advertise the mosquito hotline and look at other ways for community input/contact during the mosquito season.

- Prepare the region for the likelihood of RPAS treatments, with a townhall style meeting to discuss the program and showcase the technology.

- Amend the CRSD website to include means for contacting MBL directly (recommended a local number forwarded to the MBL hotline).

- Work with the Provincial Parks to explore treatment of mosquito development habitat located within Burges James Gadsden Provincial Park.

- Notify the Ministry of Environment of the CSRD intent to treat mosquitoes in 2025 under the CSRD Pest Management Plan. Notification should take place 2 months before the start of the season.

- It is important to attach copies of all the mosquito development site maps with the Notice of Intent to Treat (NIT).

References

Breeland SG and Pickard E (1967) Field observations on twenty-eight broods of floodwater mosquitoes resulting from controlled flooding of a natural habitat in the Tennessee Valley. *Mosq News* 27: 343-358.

Boisvert M, Boisvert J. (2000). Effects of *Bacillus thuringiensis* var. *israelensis* on target and non-target organisms: A review of laboratory and field experiments. *Biocontrol Sci Tech* 10:517-561.

Bruhl, C.A, Despres, L., et al (2020). Environmental and Socioeconomic Effects of Mosquito Control in Europe Using the Biocide *Bacillus thuringiensis* subsp. *Israelnsis* (Bti). *Science of the Total Environment* 724 137800.

Ciota, A.T., A.C. Matacchiero, A.M. Kilpatrick, L.D. Kramer. (2014). The Effect of Temperature on Life History Traits of *Culex* Mosquitoes. *J Med Entomol*. 51(**1**): 55-62.

Hershey, A.E, Lima, A.R et al (1998). Effects of *Bacillus Thuringiensis Israelensis (BTI)* and Methoprene on NonTarget Macroinvertebrates in Minnesota Wetlands. *Ecological Applications* 8(1), 1998, pp. 41-60.

Jakob, C., Poulin, B (2016), Indirect Effects of Mosquito Control Using *Bti* on Dragonflies and Damselflies (Odonata) in the Camargue. *Insect Conversation and Diversity* (2016) 9, 161-169.

McCarty, J.P, Winkler, D.W (1999). Foraging Ecology and Diest Selectivity of Tree Swallows Feeding Nestlings. *The Condor* 101: 246-254.

Mohammad, A. and Chadee, DD. (2011). Effects of Different Temperature Regimes on the Development of *Aedes aegypti* (L.) (Diptera: Culicidae) Mosquitoes. *Acta Tropica* 119: 38-43.

Peach, D. (2018). An Updated List of the Mosquitoes of British Columbia with Distribution Notes. J. *Entomol. Soc. Brit. Columbia* 115: 126-129.

Peach, D.A.H., Almond, M., and Pol, J.C. (2019). Modeling Distributions of Aedes japonicus japonicus and Aedes togoi (Diptera: Culicidae) in the United States, Canada, and northern Latin America. *J Vect Ecol* (44(1): 119-129.

Poulin, B. (2012). Indirect Effects of Bioinsecticides on the Nontarget Fauna: The Camargue Experiment Calls for Future Research. *Acta Oecologica* 44 28-32.

Poulin, B., Lefebvre, G., et al (2022). Long-term Persistence and Recycling of *Bacillus thuringiensis israelensis* Spores in Wetlands Sprayed for Mosquito Control. *Ecotoxicology and Environmental Safety* 243 114004.

Poulin, B., Lefebvre, G., Paz, L. (2010). Red Flag for Green Spray: Adverse Trophic Effects of *Bti* on Breeding Birds. *Journal of Applied Ecology* 47, 884-889.

Read, N.R. and Moon, R.D. (1996). Simulation of Development and Survival of *Aedes vexans* (Diptera: Culicidae) Larvae and Pupae. *Environ. Entomol.* 25(5): 1113-1121.

Trpis, M. and Horsfall, W.R. (1969). Development of *Aedes sticticus* (Meigen)) in Relation to Temperature, Diet, Density, Depth. *Annals Zoologici Fennici*, 6(2): 156-160.

Project Contacts at Morrow BioScience Ltd.

Dirk Lewis
Owner/Biologist
dirk@morrowbioscience.com
604.317.1413

Barry McLane
GIS Manager
barry@morrowbioscience.com
250.231.6934

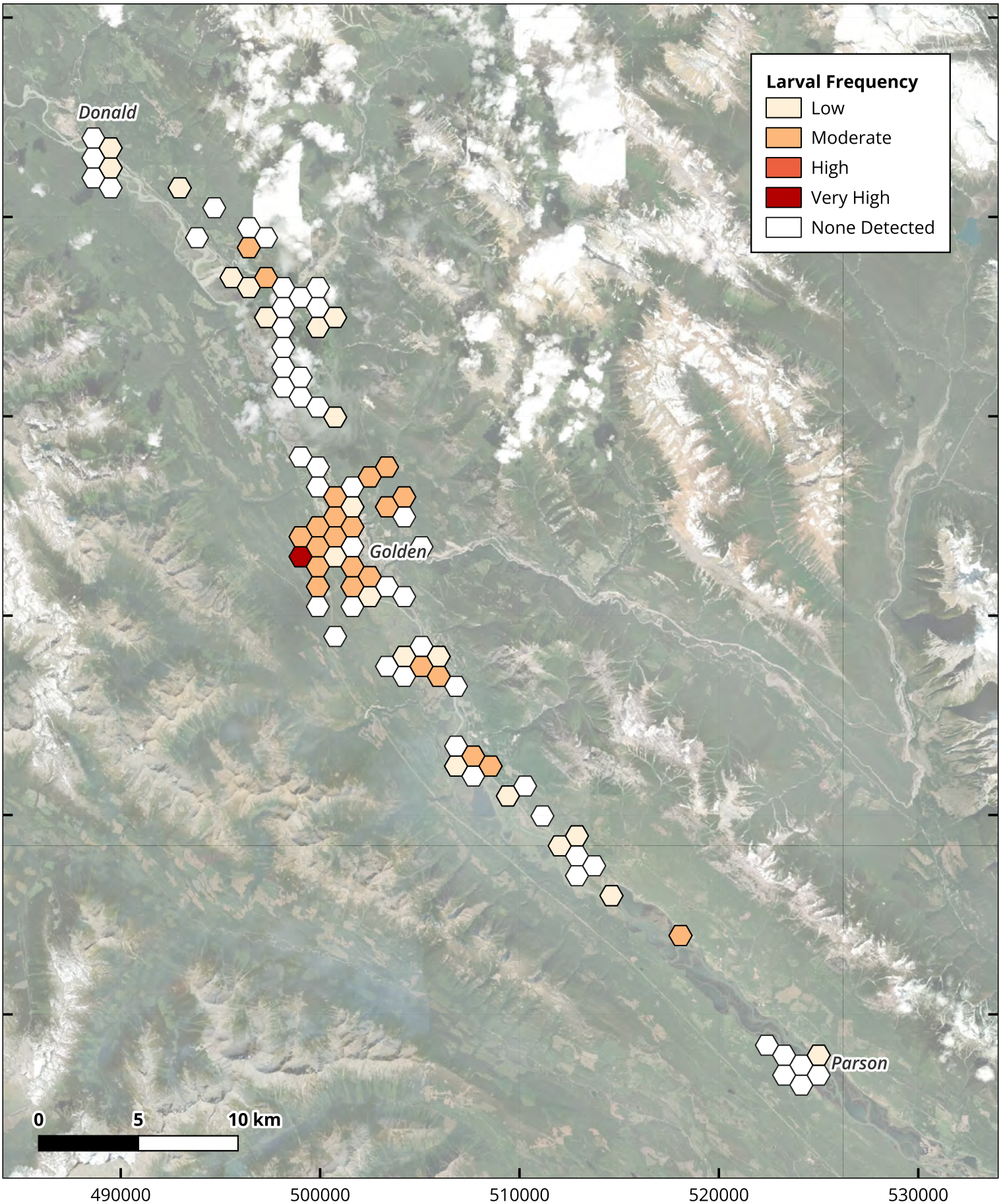
Laurie Davis
Administrative Assistant
laurie@morrowbioscience.com
250.231.7353

2024 Mosquito Larval Frequency at Sample Locations

Appendix I-A

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



2024 Mosquito Larvicide Treatments

Appendix II

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