2022 EARLY SEASON REPORT

Columbia Shuswap Regional District
Golden and Electoral Area ‘A’
Mosquito Control Program

Submitted by Morrow BioScience Ltd.
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Executive Summary

Morrow BioScience Ltd. (MBL) is entering into the first year of a renewed 5-year contract providing mosquito control services to the Golden and Area 'A' region within the Columbia Shuswap Regional District (CSRD). The goal of the early-season report is to present predictions for the 2022 mosquito season based on current environmental conditions and anticipated climate influences.

Early May snowpack within the Upper Columbia Basin, contributing to the regional Columbia River and Kicking Horse River, is largely predictive of the potential extent of flooding within the Golden and Area 'A' region. The snowpack in the Upper Columbia basin was at 121 percent of normal on 1 May. The current Snow Water Equivalent data at a representative snow survey station are trending higher than the historical maximum value for a high-elevation station within the Upper Columbia basin. Relatively high snowpack and increased potential for precipitation due to prevailing La Nina conditions could mean an above average water year for local rivers. As a result, floodwater mosquito development habitat may also be increased, leading to additional monitoring and treatment requirements. Given the potential for another high-water year, MBL is preparing for increased reconnaissance, monitoring, and treating in areas with historically high concern calls/emails.

Site monitoring began on 13 April, as snowmelt sites started showing signs of early melting. A total of 2.3 ha has been treated as of 10 May. MBL staff will again utilize the real-time data collection portal and provide site-specific data on client-enabled dashboards. The dashboard will allow the CSRD program manager to instantaneously determine the site monitoring and treatment status, including the ability to access historical point-associated data.

Education outreach efforts in 2022 will be provided through various platforms: 1) an information booth at a Golden farmer's market, social media, website, and radio. Additional improvements to the CSRD mosquito control program for 2022 include evaluating the floodwater mosquito habitat at the north and south limits of the purview, additional website blogs, and enhanced site and sub-site profiles. MBL remains committed to providing the CSRD with consistent updates on benchmarks throughout the season. The mid-season report will be delivered to the program manager immediately following the peak in the Columbia River (Donald gauge), with frequent updates provided throughout the season.

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Introduction

This report is provided to the Columbia Shuswap Regional District (CSRD) and will serve as a projection tool for the 2022 mosquito season within Golden and Area 'A'. The report includes a discussion regarding the magnitude of potential flooding within the Golden and Area 'A' region, as it relates to floodwater and snowmelt mosquito larval abundance. Supporting data include current snowpack information within the basins contributing to the regional Columbia River and Kicking Horse River. The weather forecast for the spring and summer are outlined and discussed as they pertain to the potential impact on the regional mosquito production. This report offers a prediction of how the mosquito season may develop based on current weather forecasts and snow levels; it is possible that conditions could change in May. The mid-season report will have more thorough explanations of environmental conditions affecting floodwater mosquito larval levels and an update on all deliverables.

Monitoring Methodology

Floodwater and snowmelt mosquito larvae are the primary targets of the Golden and Area 'A' region mosquito control program. Snowmelt larvae hatch first in the season (i.e., April – mid May). The majority of snowmelt sites within Area 'A' are located on the mountain benches above the Columbia Wetlands. Female snowmelt mosquitoes lay their eggs in puddles or depressions within the landscape that are likely to receive snowmelt in the spring. Certain snowmelt mosquito species begin to hatch at approximately 4°C water temperature and can complete development to adult emergence at 10°C (Clements 1992). Thus, Morrow BioScience Ltd. (MBL) staff monitor these sites frequently beginning in early to mid-April.

Female floodwater mosquitoes (e.g., *Aedes vexans*, *Ae. sticticus*) deposit their eggs on damp substrate primarily along the Columbia River and Kicking Horse River corridors. When the high water caused by the freshet and/or significant localized precipitation inundates these areas, the result is large-scale floodwater mosquito egg hatching. If numerous seasons have passed between high-water years, then high river levels may produce a compound number of floodwater mosquito larvae.

Because the eggs of certain floodwater *Aedes* species have been documented to complete embryogenesis at lower threshold aquatic temperatures between 6°C and 8°C (Trpis et al. 1973), hatching may commence in the early spring within the programs. Time-to-hatch is considerably longer at lower aquatic temperatures, but early identification of hatching events allows for more responsive site monitoring and, thus, higher treatment efficacy rates. MBL staff begin monitoring floodwater mosquito development sites as soon as the Columbia River and Kicking Horse River levels show a steady increase, typically in mid-May.

In 2022, MBL staff started to monitor mosquito development sites on 13 April. As of 10 May, approximately 2.3 ha have been treated (9.3 kg Aquabac®). Early season treatment focal areas have been the Palumbo Swamp, ditches throughout Donald, and the Anderson Road Slough. Other snowmelt mosquito sites are being frequently monitored, although development has been notably slow due to the relatively cooler temperatures.

MBL field technicians have developed an in-depth database of site profiles and consistently added new sites to the monitoring regime throughout MBL's tenure as mosquito control contractors for the Golden and Area 'A' region mosquito control program. Site monitoring is governed largely by ambient temperature data within contributing basins, local precipitation accumulation data, and changes in regional river levels. All snowmelt and floodwater mosquito development sites are monitored on a weekly basis throughout the mosquito season. When both local gauges on the Columbia River (i.e., Nicholson gauge, ID: 08NA002; Donald gauge, ID: 08NB005) show rising River levels along with consistently high ambient temperatures, monitoring efforts may increase to a semi-weekly schedule. Mosquito Hotline calls and emails also inform site monitoring efforts; residential concern calls may alert MBL staff to previously unknown mosquito development sites. In this way, sites are adaptively monitored and adaptively treated. Monitoring and treatment timing adjust to reflect intra-regional habitat variations and accompanying mosquito species variations.

Image 1. Standard dip (350 ml) from a floodwater mosquito development site showing 3rd and 4th instar mosquito larvae.

MBL field technicians treat mosquito larvae in the 3rd and 4th instar stages (Image 1). This treatment technique is designed to target the instar stages with the highest feeding rate, leading to higher treatment efficacy. Additionally, by waiting until mosquito larvae are in the 3rd and early 4th instar stages, early instar larvae are available as food sources in their ecosystem.

Late instar larval mosquitoes in sufficient number (i.e., >4/dip) are treated with applications of Aquabac®, a microbial larvicide product. This product has the active ingredient *Bacillus thuringiensis israelensis* (Bti) and is carried on a corncob formulation. The mode of action for Bti is relatively simple and with a 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 Bti bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs. This event leads to considerable damage to the wall of the gut and quickly results in larval death (Boisvert and Boisvert 2000).

As the season progresses and more mosquito development sites become flooded, it is increasingly difficult to treat sites by ground due to site access challenges and simultaneous larval development at multiple sites. At this point, a helicopter is utilized to conduct aerial campaigns (i.e., program-wide treatments). Aerial applications use the same pesticide as ground applications, although with a higher application rate to permeate canopy cover. Aerial campaigns within the Golden and Area 'A' program typically require one day, depending on the Columbia River levels and environmental conditions. All sites are checked within one or two days of the initial treatment to ensure treatment efficacy. If necessary, touch-up treatments are conducted. MBL will continue to maintain close and clear communication with the CSRD program manager

to ensure all sites are effectively managed and to assess whether program managers have been alerted of possible new mosquito development sites.

Data Management

MBL's real-time data collection portal will be utilized again in 2022. This portal enables MBL staff to electronically update site information regarding the number of mosquito larvae and pupae per dip, adult mosquito presence, treatment amounts, take photos, and maintain site profile details. All data are related to GPS points and made instantaneously available to the CSRD mosquito program manager in a user-friendly format.

The tool has helped MBL staff increase operational efficiencies. The portal also provides an easily accessible reference platform for discussions between MBL staff and the CSRD program managers via a client-authorized dashboard. The dashboard displays sites and all associated data.

Education Outreach

Providing residents with mosquito-related information is a cornerstone of MBL's mosquito control programs. The goals for education outreach are to raise awareness about mosquito habitat reduction around residences (i.e., remove standing water, refresh outside standing water sources frequently, cover water sources, etc.), provide personal protective tips for avoiding nuisance mosquitoes (i.e., long-sleeved and loose clothing, repair screens on homes, recommendations for personal mosquito deterrents, etc.), and also to provide residents with assurance that the CSRD contractors for the Golden and Area 'A' region are committed to mosquito control in their area.

In normal years, MBL provides information through numerous platforms, including social media, in person, and in print. The education outreach campaign in 2022 will include a return to hosting an education booth at a Golden farmer's market event. Additionally, multiple FAQ documents addressing each of the topics typically presented at education booths and new blogs will be posted to the MBL website (**www.morrowbioscience.com**) under the 'Resources' tab. As in previous seasons, the MBL staff would like to provide a radio-based outreach effort through an interview with hosts at 104.3 FM EZRock. The timing of the radio interview would be intended to coincide with the peak of local rivers, likely in early-June. Radio-based outreach efforts will only be conducted given approval by the CSRD program manager.

Season Forecast

Snowpack

Floodwater mosquito habitat upstream of the Golden and Area 'A' region is primarily affected by water fluctuations in the Columbia River. The Kicking Horse River contributes additional water to the Columbia River at Golden, affecting Columbia River levels downstream in the Donald area. Snowmelt mosquito development sites within the area are less impacted by regional water levels and more influenced by local snowmelt.

The snowpack in the Upper Columbia Basin can be a good indicator of how much water will come through the Columbia River and Kicking Horse River systems over the course of the spring and early summer. Image 2 provides a snapshot of the relative snowpack across the province within basins from 1 May Snow Survey and Water Supply Bulletin[1], as released by the Province on 10 May. Regional river level variations are important to track because they inform the timing and extent of annual floodwater mosquito hatching events and subsequent required control efforts.

[1] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_may1.pdf

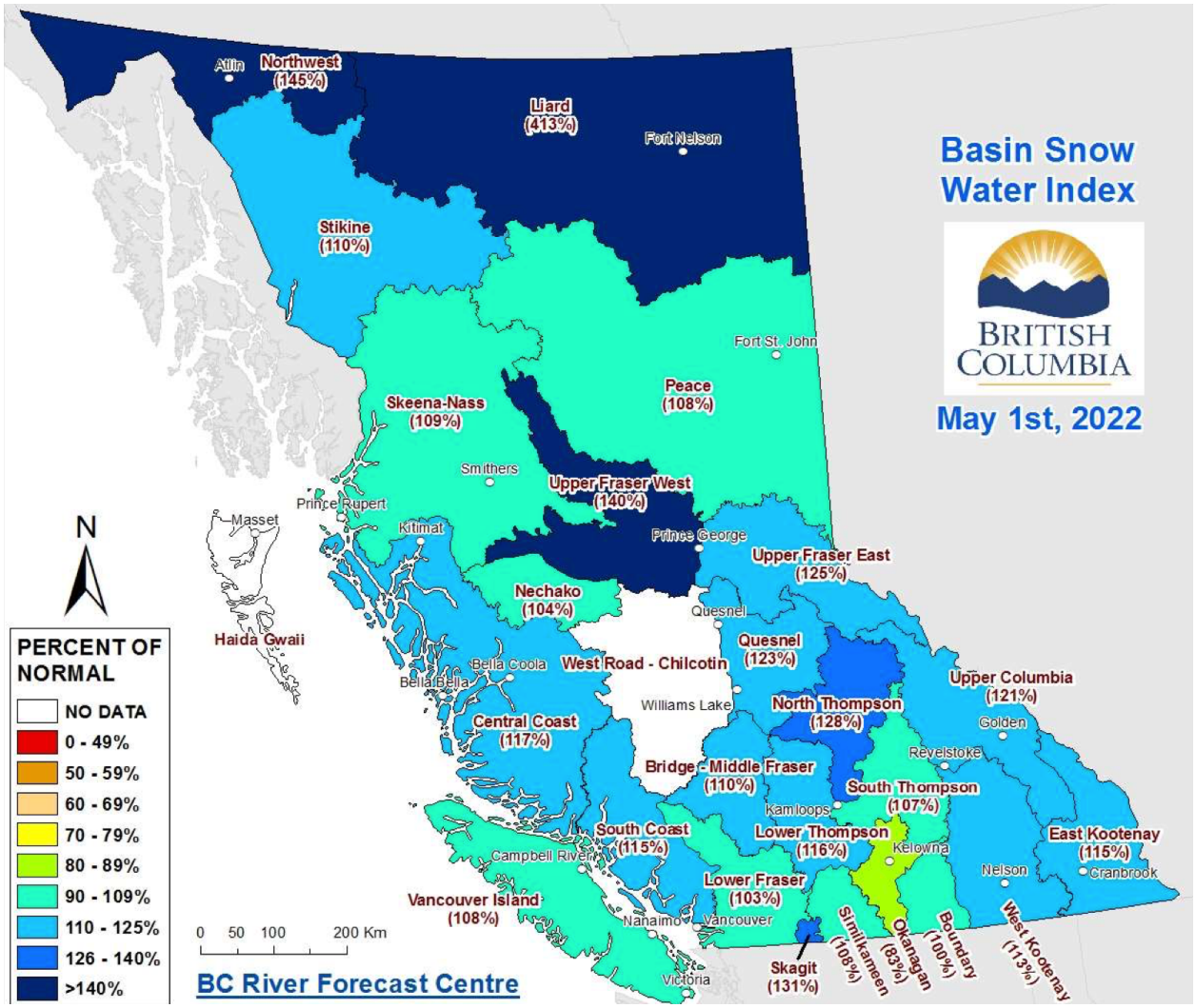

Image 2. British Columbia River Forecast Centre's snow basin water index (1 May 2022).

The snowpack in the Upper Columbia Basin was 121 percent of normal on 1 May (Image 2). The current snowpack was augmented in April following cooler-than-average temperatures and various low-pressure systems in the region. Image 2 shows the snowpack in the Upper Columbia Basin in relation to other BC basins. Notably, most basins around the Upper Columbia Basin have greater than normal snowpack. To further illustrate the basin's high snowpack, Figure 1 shows the Snow Water Equivalent (SWE; mm) for a representative snow survey station, the Wildcat Creek station (ID: 2A32P)[2]. Data were acquired on 10 May. Thus, they provide a more up-to-date gauge of regional snowpack as it relates to the previous season and the historical averages. Note that the current snowpack at the Wildcat Creek station is greater than the maximum levels recorded at that station. Given these data, it is likely that river levels associated with the Upper Columbia Basin, including the Columbia River and Kicking Horse River, will be relatively high in 2022.

[2] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/snow-survey-data

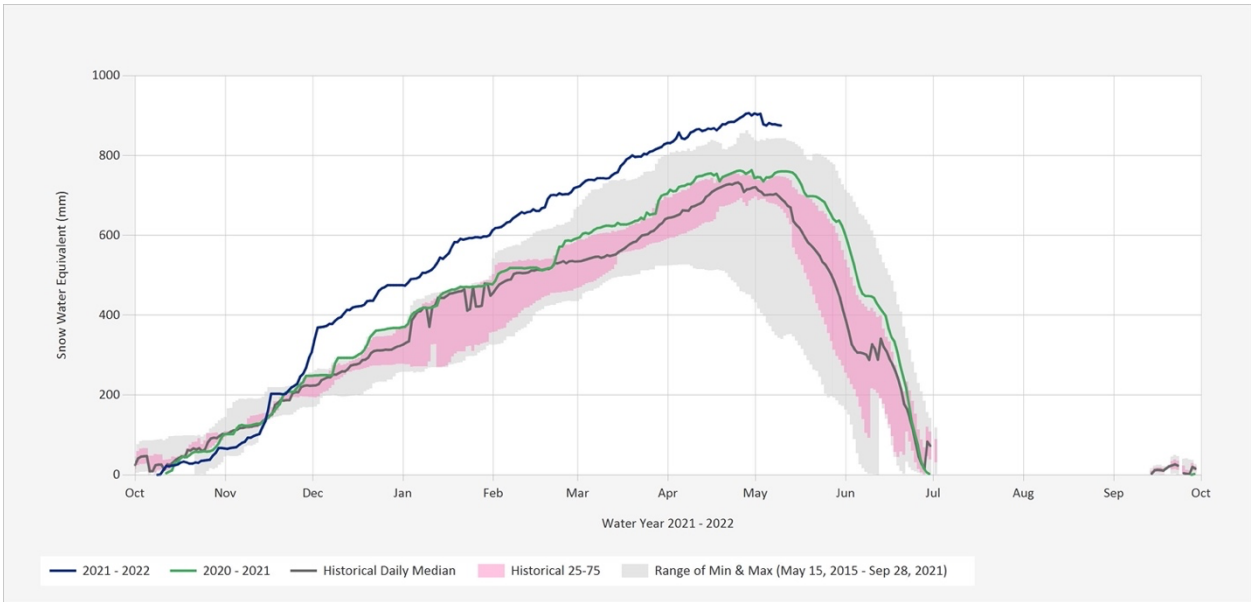

Figure 1. Snow Water Equivalent (SWE; mm) for the Wildcat Creek station (ID: 2A32P) in the Upper Columbia Basin. Accessed on 10 May 2022.

According to the River Forecast Centre, approximately 95% of the snowpack has typically accumulated by early April[1]. As such, the 1 April survey is considered largely indicative of the flooding forecast for the season. It should be noted that late season snow accumulation at high elevation stations has occurred in the past, although the current weather forecasts do not indicate significant changes to the snowpack data noted in Table 1 and Figure 1.

Weather

In addition to snowpack, Columbia River and Kicking Horse River levels can also be affected by regional precipitation, as well as how quickly snowmelt occurs in contributing basins (i.e., regional ambient temperature). El Niño Southern Oscillation (ENSO) conditions greatly influence weather patterns and anticipating its phase (i.e., neutral, El Niño, La Niña) can help predict the amount of precipitation a region may accumulate and general ambient temperature trends.

According to the 1 May Snow Survey and Water Supply Bulletin[3], there is a 59% likelihood of maintaining La Niña conditions through August. The weather pattern ramifications for BC in a La

[3] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2022_may1.pdf

Niña climate include cooler temperatures and wetter weather. The River Forecast Centre specifically notes flooding correlations with recent La Niña years[2]. Interestingly, the Temperature and Precipitation Probabilistic Forecasts for Canada[4] for May – July show that ambient temperatures within basins contributing to the regional Columbia River and Kicking Horse River will be normal. The Temperature and Precipitation Forecasts model also predicts a 40-60% likelihood that precipitation received to Golden and Area 'A' region will be below normal. Long-range forecast discrepancies may exist due to the moderate chance of continued La Niña weather pattern influence into the summer.

Short-range weather predictions include cooler-than-average temperatures within the program purview. Ambient temperatures in April and early May were cooler than normal. Cooler temperatures led to a slowed freshet during that period. However, if concentrated warm weather occurs in 2022 as it did in 2021 during June and cause a concentrated snowmelt, flood conditions are likely. Precipitation received on top of the freshet may also cause localized flooding. These conditions may activate additional floodwater mosquito habitat beyond that identified in 2021. MBL staff are monitoring snowpack levels, weather forecasts, and river levels daily to be prepared for large-scale treatments earlier than normal.

Program Improvements Incorporated in 2022

Providing floodwater mosquito management services for the CSRD throughout high and low-water years, brief and sustained flood levels, and early and late regional river peaks has led to opportunities to fine-tune the program. Internal reviews and partner feedback has been integral in developing the list of improvements to the mosquito management program for 2022. Improvements include:

- Improved site information providing staff with in-depth details on each site and sub-sites. Site profiles were enhanced at the end of the 2021 season in anticipation of new staff members for the 2022 season.
- Expanded blog entries within MBL's website (www.morrowbioscience.com) addressing topics related to mosquito biology, mosquito-borne diseases, novel research, and personal protective tips.
- Evaluation of mosquito abundance in the northernmost and southernmost reaches of the program purview.
- Participation in a radio interview with a local station to disseminate mosquito-related information to residents of Golden and Area 'A' (CSRD approval pending)

[4] https://weather.gc.ca/saisons/prob_e.html

Reporting Schedule

As in previous years, the technical reports will be provided to the CSRD program manager at three points in the season: early, mid, and season-end. The mid-season report will summarize field activities, relevant weather data, and expectations for the remainder of the season; it will be provided to the CSRD immediately following the peak in the Columbia River (Donald gauge). The final report will summarize data collected throughout the season and address all program deliverables. In the interim, activity updates will be supplied to the CSRD program manager via phone or email. Supplementary reports can be provided, upon request, and instantaneous data is made available via MBL's real-time client-enabled dashboard.

Contacts

MBL recognizes the importance of being available to residents within each of our program areas, as well as keeping them informed of relevant mosquito abatement activities and information. In an effort to continue to provide these connection opportunities, MBL regional managers check their email and phone messages on a daily basis. Managers directly reply to email and phone inquiries within 24 hours. All emails and calls forwarded by CSRD staff will also be responded to within 24 hours of receipt. Additionally, residents may find helpful information on our Facebook page (Morrow BioScience Ltd.), our Twitter feed (@MorrowMosquito), as well as blogs and resources on our MBL website (www.morrowbioscience.com).

As a reminder, the following staff may be contacted directly with any questions that may arise:

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