REGIONAL DISTRICT OF EAST KOOTENAY
WASA, TA TA CREEK, SKOOKUMCHUCK
MOSQUITO CONTROL PROGRAM
2019 YEAR-END REPORT

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Executive Summary

Morrow BioScience Ltd. (MBL) has now completed the 23rd consecutive year as mosquito control contractor for Wasa/Ta Ta Creek/Skookumchuck within the Regional District of East Kootenay. This season, 2019, concludes the 3rd year of a 5-year contract. Thus, mosquito development site knowledge has been acquired in low and high-water years and through early and late freshet seasons. The primary goal for the mosquito control program is to reduce floodwater mosquito abundance within Wasa/Ta Ta Creek/Skookumchuck. Most control activity takes place along the Kootenay River and at associated seepage sites.

Immediately preceding the mosquito season the snowpack in the East Kootenay Basin, contributing to the Kootenay River, was lower-than-normal. A regional warming trend in early May within the contributing snow basin led to the start of the mosquito season. Secondary warming stints in May triggered the melting of the majority of regional snowpack and led to the peak in the local Kootenay River. The Kootenay River at Fort Steele peaked on 4 June (3.424 m). Considerable precipitation was locally received in July, augmenting river levels beyond the natural trend of the freshet. The lack of compounded egg abundance in mosquito development sites and the lower water levels resulted in a reduced requirement for treatment. No known sites were missed in 2019. Accordingly, no concern calls or emails were received. One human-case of West Nile virus was reported by the CDC from the Okanagan in 2019, but the person was likely infected out-of-province.

Between 5 June and 10 July, a total of 232 hectares were treated by ground. Treatment efficacy was assessed as high. No aerial events were required in 2019 due to considerably low regional Kootenay River levels. A real-time monitoring and treatment data dashboard was provided to the RDEK program manager. The dashboard enabled the manager to view up-to-date treatment information and ensure quality control.

Communications with in-program residents remains a priority for MBL. Education outreach efforts included presenting a season update at the Electoral Area ‘E’ Town Hall meeting in Kimberley on 3 June 2019. One interview was given to Black Press on April 4 forecasting the 2019 mosquito season, which ran in various newspaper outlets throughout the province, including in the Cranbrook Townsman. The relatively minimal press for the mosquito program was likely due to the considerably low adult mosquito nuisance issues. The reach of social media posts continues to increase annually, meaning that more residents around Wasa/Ta Ta Creek/Skookumchuck are aware of mosquito abatement efforts.

Season Highlights

- The average snowpack in the East Kootenay Basin was 77 percent of normal in April, immediately preceding the onset of the mosquito season.
- A region-wide warming event within the East Kootenay Basin prompted considerable low and mid-elevation snow melt conditions in early May
- A late-May warming trend across the province prompted the majority of contributing snowpack to melt.
- The snowpack in the contributing basin was depleted by the end of June.
- The peak Kootenay River level at the Fort Steele gauge occurred on 4 June at 3.424 m.
- The peak was the lowest since 2016.
- No aerial treatments were required in 2019 due to considerably low Kootenay River levels.
- Total Aquabac® ground treatments were 929 kg (232 ha).
- Hotline calls/emails were non-existent, likely due to the low snowpack and lower regional river levels.
- MBL's real-time data management and mapping portal provided RDEK program managers with improved ability to target areas and gave quality control assurance for clients.

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 providers for the Wasa/Ta Ta Creek/Skookumchuck within the Regional District of East Kootenay (RDEK) since 1997. In 2017, MBL started a renewed five (5) year contract; this season – 2019 – is the third of the contract.

The considerable mosquito habitat, program reach, and interannual regional river peak variations makes the Wasa/Ta Ta Creek/Skookumchuck mosquito control program complex. However, throughout the previous 22 seasons, MBL staff has acquired thorough knowledge of the program regarding site locations and effective treatment timing. In addition to the knowledge base, numerous improvements have been made to the program since its inception, including: intensive site survey along the Kootenay River floodplain, identification of new mosquito development sites, trending decrease in complaint calls, the addition of a real-time data collection and review portal, increased public engagement both through social media and through in-person events, and improved environmental awareness through annual carbon offset purchases. MBL's goal is to continue to provide effective mosquito control to the Wasa/Ta Ta Creek/Skookumchuck residents, while remaining socially and environmentally responsible.

Carbon Offsets

The spatial reach of the Wasa/Ta Ta Creek/Skookumchuc mosquito program is such that driving is an inevitable requirement. The accumulated mileage over the course of 2019 was approximately 5,728 km (ground transportation only).

As an estimation, the driving requirements for this program result in the production of approximately 2 tonnes of CO_2 emissions. To offset this addition of CO_2 to the environment, MBL has committed to purchasing carbon offsets. To fulfill this commitment, carbon offsets are purchased through the West Kootenay EcoSociety[1]. When the carbon offsets are purchased, a proof of purchase and certificate from the offset provider will be delivered to the RDEK.

Methodology

The primary targets of the Wasa/Ta Ta Creek/Skookumchuck mosquito control program are floodwater mosquito larvae. Unlike container mosquitoes (e.g. *Culex pipiens*), female floodwater mosquitoes (e.g. *Aedes vexans*, *Ae. sticticus*) deposit their eggs on damp substrate. Within the Wasa/Ta Ta Creek/Skookumchuck area, floodwater mosquito development sites primarily exist along the flooding corridor of the regional Kootenay 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 numerous seasons have passed between high-water years, then high river levels may produce a compounded number of mosquito larvae.

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

MBL field technicians begin monitoring all known mosquito development sites within the Wasa/Ta Ta Creek/Skookumchuck program area prior to rising Kootenay River in the spring. Mosquito development sites are adaptively managed, meaning that the regional river levels and local temperatures largely dictate how frequently sites are visited, 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. Ground treatment of mosquito development site using a backpack blower.

Larval mosquitoes in sufficient number (i.e. >4/dip) are treated by ground applications of a microbial larvicide product called Aquabac® (Image 1). This product has the active ingredient *Bacillus thuringiensis israelensis* (Bti) and is carried in a corncob formulation. The mode of action for Bti is relatively simple and with a rather high degree of species specificity. Receptors within the mid-gut region of the mosquito larvae are specific to the toxin proteins that are produced alongside each bacterial spore. After the mosquito larvae ingest the toxin protein, disruption of the larval mid-gut cells occurs because of cleavage of the protoxins by mid-gut proteases. This event causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert 2000).

As the season progresses and more mosquito development sites are flooded, it becomes increasingly difficult to treat sites by ground due to inaccessibility and concurrent site activation. At this point, a helicopter is used to conduct aerial treatments. The aerial campaign uses the same pesticide as ground applications, although with a higher application rate to permeate canopy cover. High water years may require 2-day aerial treatment campaigns, due mostly to the level of flooding involvement associated with the Kootenay River foreshore sites.

Image 2. Standard dip showing 2nd and 3rd instar larvae.

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

Sites are treated when a standard dip (350ml) collects 5 or more late instar (3rd or 4th instar) larvae per dip (Image 2). When flooding commences and ambient temperatures rise, many dips easily exceed this threshold. Larval densities within the range of 200-500 per dip (observed as high as 1,000 per dip) are commonly detected. All sites are checked within one or two days of the initial treatment to ensure high treatment efficacy. If necessary, touch-up treatments are conducted.

Environmental Conditions

The three main environmental conditions that affect regional Kootenay River levels throughout the mosquito season (i.e. April – August) are: 1) ambient temperature in snow basins contributing to the river, 2) local precipitation, and 3) the snowpack in the basin contributing to the Kootenay River. Local ambient temperature is also of interest due primarily to the effect local ambient temperature can have on mosquito egg hatching and development rates. As such, all noted conditions are tracked throughout the season.

Snowpack

Floodwater mosquito abundance within Wasa/Ta Ta Creek/Skookumchuck is primarily governed by regional Kootenay River levels. In turn, the water levels of that system are governed by the freshet released from East Kootenay Basin. When snowpacks exceed 100 percent of normal, higher-than-average Kootenay River levels are expected during the mosquito season.

In April, immediately preceding the 2019 mosquito season, the East Kootenay Basin was 77 percent of normal[2]. The April snowpack hasn't been this low since 2015. Comparable

[2] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/river-forecast/2019_apr1.pdf

to previous seasons, very little late-season snow was received to the basin following the 1 April Snow Survey and Water Supply Bulletin. Given the lower-than-average snowpack in the Kootenay River catchment, the associated 2019 river peak was not expected to be high.

While the weather in 2019 within the influential basin was generally accepted as normal, a warming trend in the southern portion of the province, including the East Kootenay Basin depleted almost all snow below 1600 m by 1 May[3]. A secondary warming trend in early May caused a large amount of snow to melt in basins across the province, resulting in greatly decreased snowpacks by early June. Continued warming trends in early June further depleted snowpacks in the East Kootenay Basin, such that majority of snow stations were depleted of the remaining estimated Snow Water Equivalent (SWE), by mid-June. By the end of June, all snow stations comprising the East Kootenay Basin had been completely depleted of snow[4].

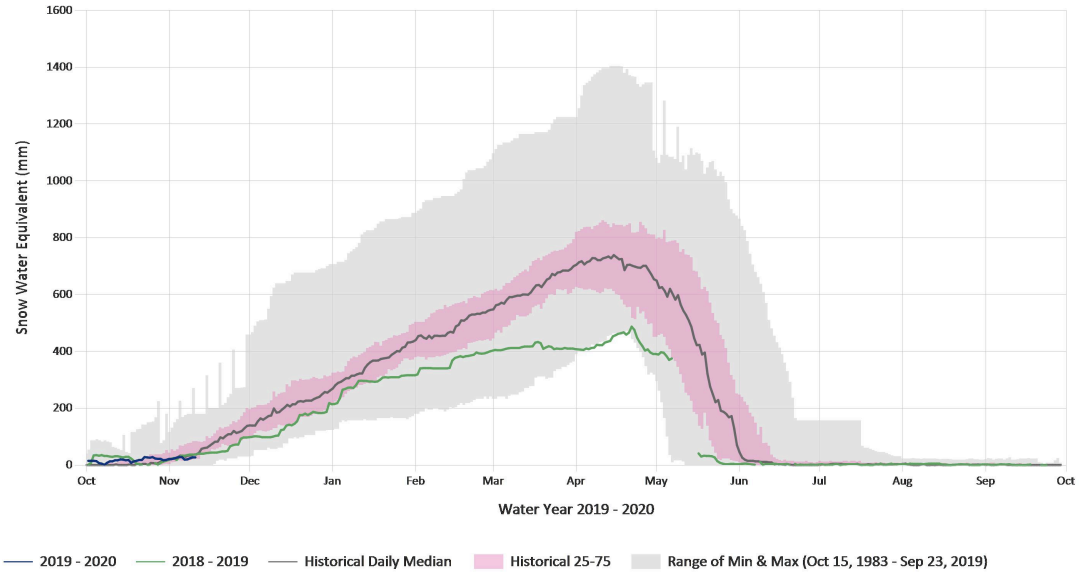

Figure 1. Automated Snow Weather Station data from Morrissey Ridge (ID: 2C09Q). Green line represents data from 2018-2019.

The Automated Snow Weather Station at Morrissey Ridge (ID: 2C09Q) is one of the closest weather stations to Wasa/Ta Ta Creek/Skookumchuck (Figure 1) within the East Kootenay Basin. It serves as representative station regarding the 2019 snowpack melting trend. However, it does not necessarily represent the other stations' relative snowpack. The snowpack noted in Figure 1 is lower than the historical daily mean at numerous points in the season; the snowpack at higher elevation snow weather stations within the East Kootenay Basin approaches the historical daily mean at times.

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

Local Precipitation

Significant temporally and spatially concentrated precipitation accumulation may elevate regional Kootenay River levels. Local precipitation can also temporarily increase seepage site levels, where considerable mosquito development habitat is located. Thus, tracking local precipitation accumulation can aid MBL field staff with determining how long mosquito development sites may require management. The Kootenay River gauge at Fort Steele and the Cranbrook Airport weather station provide weather information allowing for interannual comparison of environmental conditions. The Cranbrook Airport weather station is the closest weather station to the Wasa/Ta Ta Creek/Skookumchuck area. This comparison allows for some level of prediction regarding larval mosquito development rate and treatment timing requirements.

The precipitation received at the Cranbrook Airport (ID:1152105) during the 2019 mosquito season ranged from below average to considerably greater-than-average (Figure 2). Precipitation accumulation in the Wasa/Ta Ta Creek/Skookumchuck region was close to average for April, thus it is likely that precipitation did not augment the Kootenay River or lend greatly to microsite (i.e. hoof print, car tracks, etc.) creation. However, May precipitation was higher than normal and likely augment local Kootenay River levels and associated seepage sites.

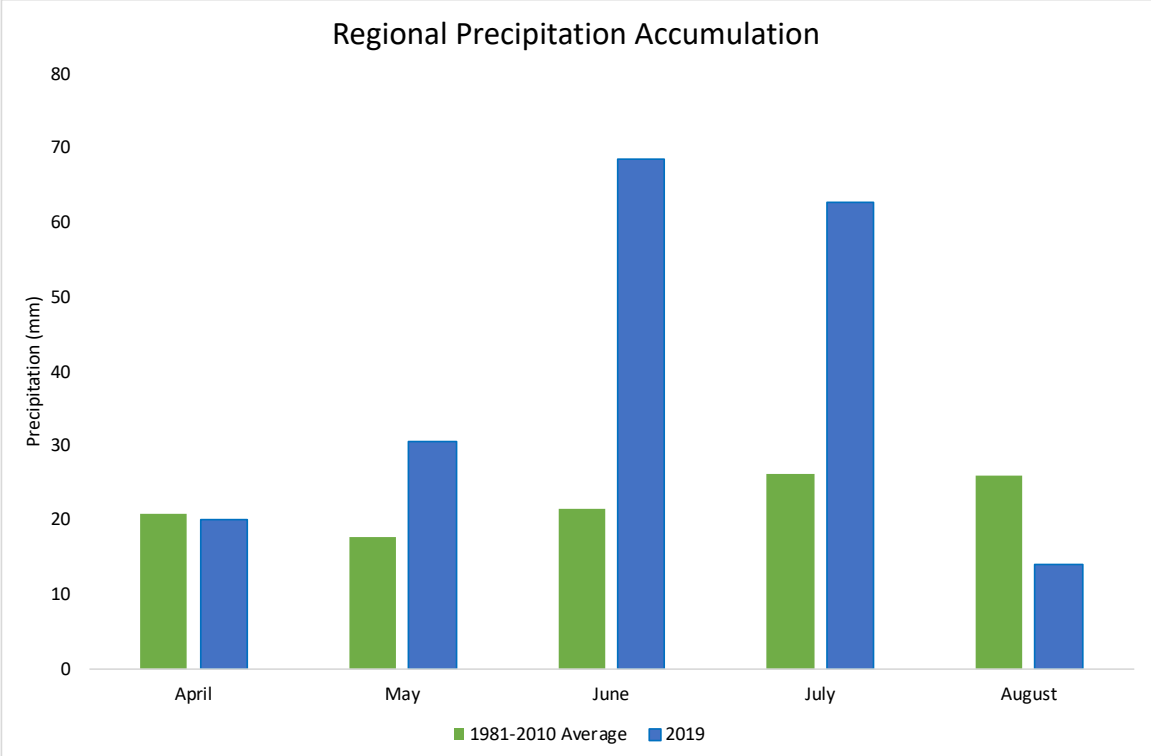

Figure 2. Precipitation values (rainfall and snow accumulation; mm) recorded at the Cranbrook Airport weather gauge (ID: 1152105) for 01 April – 31 August 2019 (blue) and average station precipitation values (1981-2010; green).

June precipitation accumulation (68.7 mm) was more than the combination of April and May values, exceeding the station average (Figure 2). As the peak in the local Kootenay River occurred in June, it is likely that concentrated local precipitation may have accounted

for some of the rise. Additionally, associated seepage sites and micro-sites would have been augmented. Operationally, the relatively high local precipitation input during the height of the freshet season meant that MBL staff had additional sites to manage beyond those directly related to the River.

July precipitation accumulation was also considerably higher-than-average (Figure 2). Kootenay River levels did not recede as quickly as usual due to the precipitation input. Thus, mosquito development habitat was perpetuated beyond normal. Relatively high waters coupled with high ambient temperatures created ideal mosquito hatching cues extending into July (see 'Larval Control' section).

August precipitation accumulation was below average. By this time, floodwater mosquito habitat had been considerably reduced. Thus, the precipitation received in August likely didn't contribute to an extension of the floodwater mosquito season. The small amount of precipitation received in August may have been sufficient to augment container mosquito habitats and trigger hatching events. Thus, adult mosquito presence toward the end of the season was likely due to container mosquito hatches, not floodwater species.

Local Ambient Temperature

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

Trpis and Horsfall (1969) exposed submerged eggs of a common univoltine floodwater mosquito species, *Aedes sticticus*, to various constant air temperatures and recorded hatching success. Results revealed that eggs began to hatch at 8°C, although larval development was slow. Eggs held at 21°C provided the most optimal temperature, of the five temperatures tested, for hatching and larval development (Figure 3). While *Ae. sticticus* is not the sole floodwater species present in Wasa/Ta Ta Creek/Skookumchuck it serves as a representative species for our purposes and provide general developmental benchmarks.

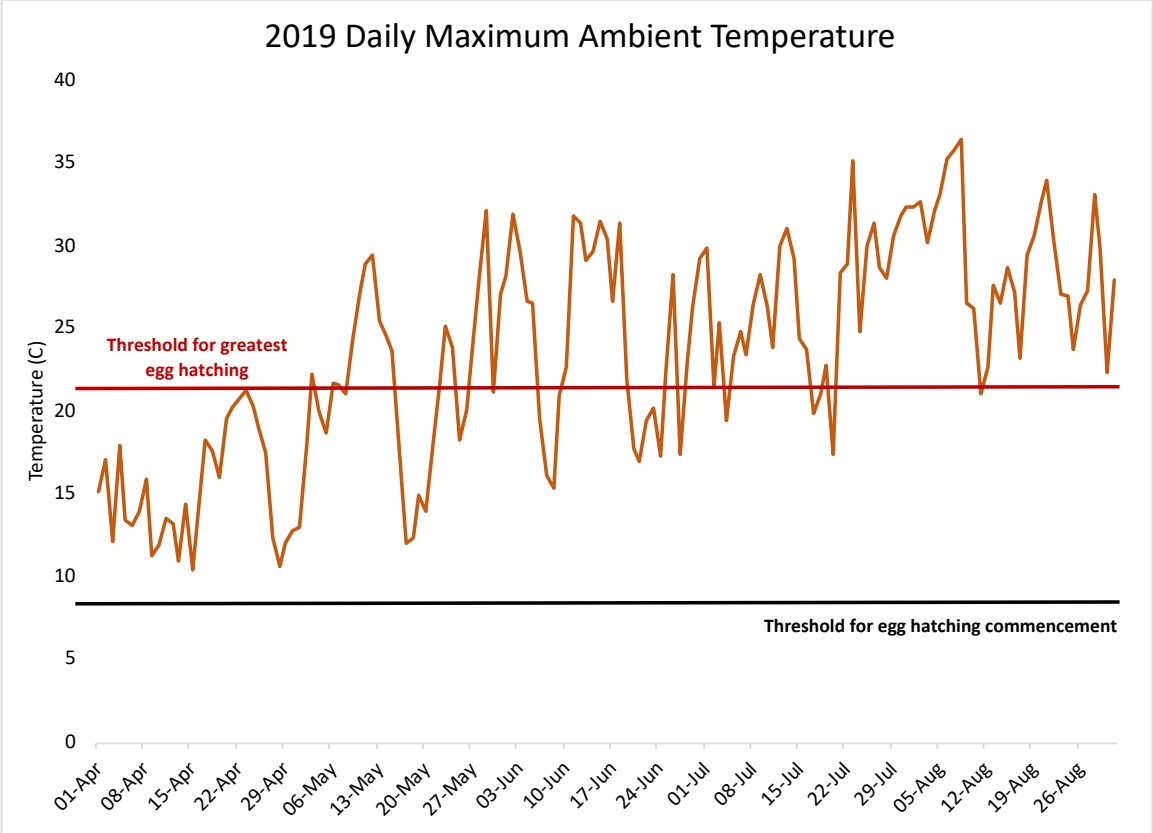

Figure 3. Maximum daily ambient temperatures (C) as recorded at the Kootenay River gauge at Fort Steele (ID: 08NG064) 01 April – 31 August 2019. Lower line illustrates threshold at which *Ae. sticticus* eggs commence hatching; upper red line illustrates threshold at which most *Ae. sticticus* eggs hatch.

The 2019 season began with seasonal ambient temperatures for April. All daily maximum ambient temperatures noted in April were above the threshold for mosquito egg hatching commencement. Given that April temperatures were well above those noted as being sufficient for hatching, floodwater mosquito eggs within Area 'A'/Golden were likely activated within April if exposed to flooding conditions (Figure 3).

It is important to note that while there were likely sufficient hatching cues for mosquito eggs in April, the larval development at those temperatures would have been notably slow (Trpis and Horsfall 1969). Additionally, the average ambient temperature and associated, delayed water temperature, are important to consider as temperatures are correlated with dissolved oxygen levels. As water temperatures rise, dissolved oxygen levels decrease, which ultimately triggers mosquito egg hatching if eggs have been appropriately conditioned by other environmental factors (Horsfall 1956). The displayed daily maximum ambient temperature levels are meant to conservatively depict the earliest point at which mosquito egg hatching may occur (Figure 3). The potential for larval development in the early portion of the season is the primary reason for annual site monitoring commencement during that time.

Local ambient temperatures in May and June were relatively warmer and more consistent with the most favourable larval development conditions (Figure 3). As expected, hatching and larval development rates increased considerably within those months. Appropriately,

larval treatments were concentrated in June when ambient temperatures and the Kootenay River levels were more consistently high (Figure 3).

Ambient temperature does not directly relate to floodwater larval mosquito abundance after the Kootenay River levels measurably and consistently recede, due to lack of water as a cue for hatching. However, ambient temperature does increase development rates for larval and adult mosquitoes (Ciota et al. 2014). Thus, any floodwater mosquitoes that successfully emerged would have had a reduced lifespan with the heightened ambient temperatures into late August (Figure 3).

Localized adult mosquito annoyance due to container mosquito presence may have occurred. Container mosquito habitats near residential homes can be created throughout the summer whenever water is coupled with high ambient temperatures. MBL technicians regularly inform residents that container mosquito species can be reduced around homes by ensuring their environments are either free of water or refreshed frequently.

River Levels

Within the Wasa/Ta Ta Creek/Skookumchuck area the majority of floodwater mosquito development sites are found along the flooding corridor of the Kootenay River. As the presence of water and associated dissolved oxygen levels are hatching cues for floodwater mosquito eggs, tracking the regional river levels provides predictive capabilities with regards to mosquito larval development.

A small pulse of water came through the system in late April. Another pulse of snowmelt came through the Kootenay River mid-May. With ambient temperatures in the contributing East Kootenay Basin increasing in May, the Kootenay River levels (Fort Steele gauge; 08NG065) also increased consistently (Figure 4). Following a provincial warming trend in late-May, the Kootenay River peaked on 4 June (3.424 m).

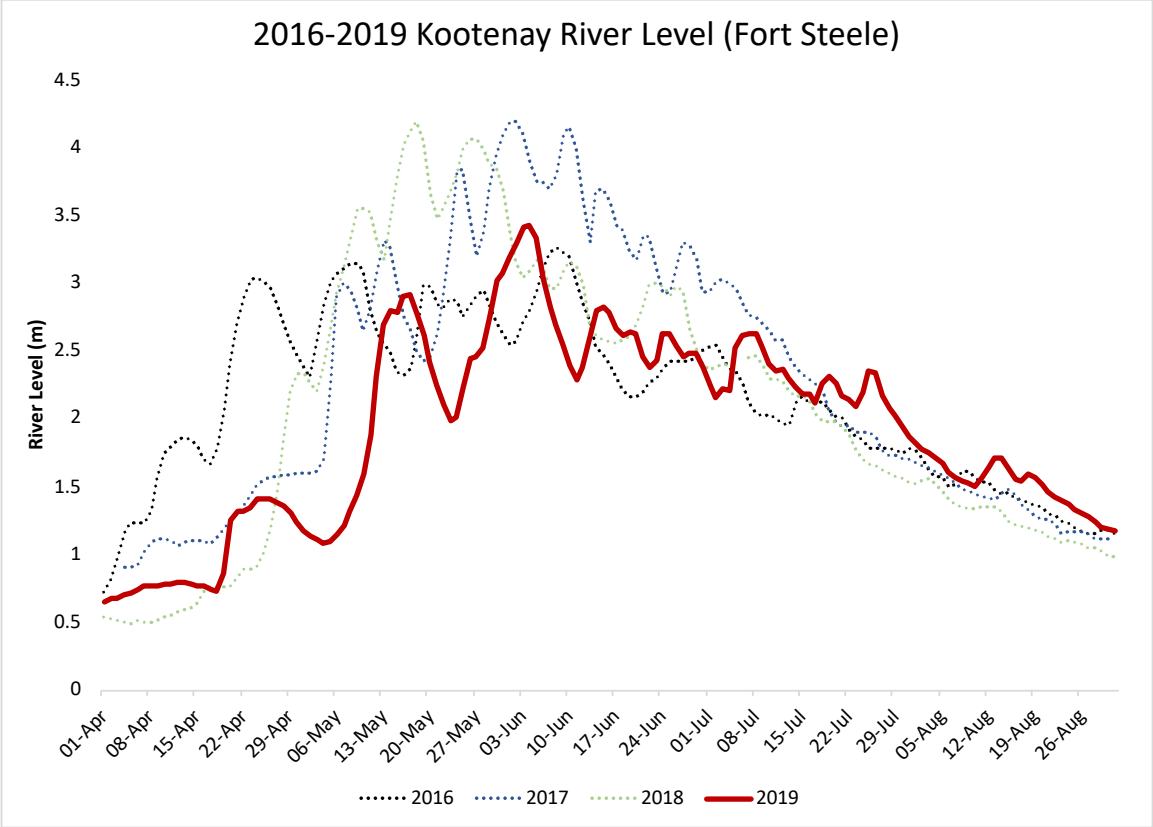

Figure 4. 2019 Kootenay River levels (m) as recorded at the Fort Steele gauge (08NG065; red) with 2016-2018 Kootenay River levels (01 April – 31 August).

Regional river peaks relative to recent seasons is a predictive variable that may help explain an associated year's larval abundance. If the current year's regional river levels far exceed that of preceding seasons, mosquito eggs laid between the high-water mark of both years could have remained dormant until current-year flood waters trigger their hatching. Figure 4 shows the Kootenay River's levels since 2016. Because the peak of the local Kootenay River was 0.77 m lower than the 2018 and 2017 peaks, it is unlikely that the 2019 peak level triggered many dormant eggs to hatch (Figure 4). As such, a lower-than-normal larval abundance was noted in 2019.

Between 24 May and 4 June, the Kootenay River rose at high daily rates, totaling approximately 1.41 m gain in that timeframe. When river levels rise at high rates in the early portion of the season, the typically cool highly oxygenated water moving through the system makes it more challenging for mosquito eggs to hatch. However, because the Kootenay River rose during a period of high ambient temperatures, mosquito eggs were able to hatch.

By late June 2019, the East Kootenay Basin contributing to the Kootenay River was largely depleted of snow[5]. This depletion corresponds with a marked decline in regional Kootenay River levels by early July (Figure 4). However, considerable local precipitation occurred

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

in July, augmenting regional river levels and associated seepage sites beyond the normal decline trend caused by lack of snowmelt. River levels decreased into August due to a lack of snowmelt and lower local precipitation accumulation. Thus, by mid-August many of the mosquito development sites were greatly reduced or dry.

Larval Control

Monitoring within Wasa/Ta Ta Creek/Skookumchuck began on 7 May, immediately preceding the prominent seasonal rise in the Kootenay River (Fort Steele gauge). Appendix I shows a map of average larval densities found throughout the 2019 season. Larval abundance is assessed in the field using a system of ranges (0, 1-4, 5-49, 50+) for early and late instar mosquito larvae. In order to transfer these data to a map (Appendix I), data are ultimately summarized and assigned to a hexbin representing an area of 21.65 ha.

Only wet sites were included in the analysis. An intensity value representing the relative number and life stage of the larvae are assigned to each single sample. For each sample, late instar larvae ranges are weighted more heavily than early instar larvae ranges to indicate targeted life stage and treatment urgency. In this way, each sample is assigned an intensity value from 0 to 1. All sample intensity values are then averaged by hexbin. Thus, each hexbin is 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 areas were immediately south of Skookumchuck, along Moon Rd., and near Wasa Lake (Appendix I).

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 neighbourng hexbin; each of these circumstances may create skewed results.

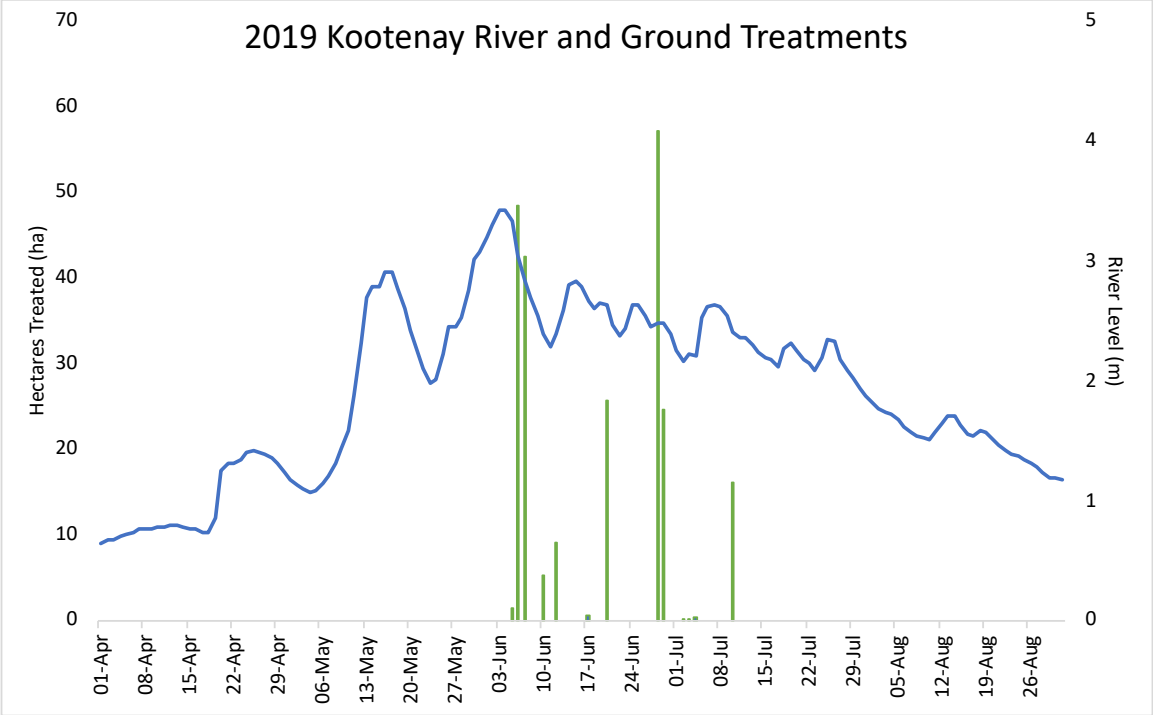

Figure 5. Kootenay River levels (m; Fort Steele gauge) with total mosquito development area treated by ground (ha) from April 1 – August 31, 2019. Note River levels (m) are recorded on the alternate y-axis.

The first ground treatment occurred on 5 June (Figure 5). Sites remained dry or considerably reduced until late in the mosquito season. Relative to the high-water year of 2018, mosquito habitat was significantly decreased in 2019 due to low Kootenay River levels. The Kootenay River peaked during a period of high ambient temperatures which created ideal mosquito hatching environments. River levels started to recede in late June, although not as quickly as normal due to large precipitation events that occurred in July. By mid-August mosquito development areas were reduced or dry. Ground treatments largely tapered-off towards mid-July. Although river levels remained high, treatments had successfully targeted the sole seasonal mosquito development events for univoltine floodwater mosquito species. The final ground treatment took place on 10 July (Figure 5).

Table 1. 2019 treated area (ha) by method (i.e. ground vs. aerial) and month from April - August.

	April	May	June	July	August
Ground (ha)	0	0	215.2	17.1	0
Aerial (ha)	0	0	0	0	0
TOTAL	0	0	215.2	17.1	0

Appendix II is a map depicting where and how frequently treatments took place in 2019. In certain cases, hexbins denoted as 'Non-Detected' or 'Low' do have treatments associated with them. In these cases, treatments may have been triggered by the larval activity of a representative site. Typically, sites that are difficult to access may be associated with representative sites. Historically, when representative sites become active

the other sites in the area have proven to also be active. Thus, sites with a previous designation of 'Non-Detected' or 'Low' may require a later treatment due to representative sites' activity level without the need to sample.

Ground treatments were applied at a rate of 4 kg/ha. A total of 232 ha was treated by ground, equating to a total of approximately 929 kg of Aquabac® used (Figure 5; Table 1). Typically, sites only require one treatment per season unless additional mosquito larvae are pushed into the site due to the movement of water. If additional treatments at a site are required they occur at increased water levels, hence the treatment overlap is minimal.

Image 3. Kootenay River levels near Wasa on 3 June 2019

No aerial treatments were required in 2019 (Table 1). Even on 3 June, a day before the regional peak of the Kootenay River, levels were not approaching the high water mark (Image 3). Efficacy assessments revealed >90 percent control. Real-time data associated with each treatment was available through MBL's client-registered, real-time program portal. No sites were missed in 2019. Appendix III shows more specific information about site, treatment timing, and extent of treatment.

Public Relations

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

Phone Calls and Emails

Wasa/Ta Ta Creek/Skookumchuck residents have multiple venues to lodge calls or emails with MBL. MBL has a company-maintained hotline (877-986-3363) and email form, outlined prominently on the contact tab of the MBL website (Image 4). Additionally, residents may interact with MBL staff through social media platforms.

Image 4. MBL website contact form

No calls or emails were received in 2019. The lack of calls and emails in 2019 may be due to relatively low Kootenay River levels and/or MBL's adaptive management methodology for mosquito development sites. Through adaptive site management methods, expanding in-house site knowledge, and continued public engagement, MBL endeavours to maintain a low number of Hotline concern calls/emails.

Direct Communications

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 technicians are often asked questions by landowners or residents. These encounters provide an excellent opportunity for public relations. The fact that technicians are visibly monitoring and treating assures residents that attention is being given to mosquito abatement efforts. Additionally, an important outcome of these interactions can be the identification of new sites and larval mosquito activity by involved residents.

Image 5. MBL outreach pamphlet example

MBL pamphlets and contact information is disseminated when field technicians have direct communication with the public (Image 5). MBL's pamphlet includes information regarding the product used in larval mosquito control, personal protective tips, and floodwater mosquito biology. Contact information for MBL

includes the website address, an email, phone number, and social media sites (Twitter, Facebook).

Social Media

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

Facebook (facebook.com/morrowmosquito) remains the primary avenue for MBL to disseminate mosquito-related information. The total number of followers on the MBL Facebook page is currently 305. This number has increased by 25 since October 2018. Regular updates on mosquito abundance began on 3 April following a CBC story regarding the potential for electronic music to deter mosquitoes. In addition to related scientific studies, post topics also included mosquito management efforts, outreach efforts conducted by MBL staff members.

MBL Website

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

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

Public Engagement Opportunities

As part of MBL's commitment to public education surrounding mosquito control, MBL staff participated in an Area 'E' Town Hall meeting on 3 June in Kimberley, BC. The presentation included information on floodwater mosquito biology, mosquito development sites, personal protective measures, and highlighted the progress-to-date within the program. The meeting was well-attended and generated a number of questions from attendants. Future additions to the presentation will include information on mosquito-borne diseases within the region and in nearby regions.

One interview was requested of MBL staff by Black Press in 2019. MBL's head biologist gave the interview on 4 April, with specific attention paid to the forecast for mosquito annoyance in 2019. While this request and interview were not specific to the Wasa/Ta Ta Creek/Skookumchuck, the article was published in various news outlets throughout British

Columbia. The Cranbrook Townsman published the article online on 4 April[6]. The relatively low number of interview requests was likely due to the low water year and related low adult mosquito annoyance.

West Nile virus Summary

Although floodwater mosquito species in Canada are not generally considered WNv vectors, it is important to remain current in regional mosquito-related diseases. 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 September. As of 28 September, there was one confirmed human case of WNv reported in BC[7]. It's suspected that the person in the Okanagan was infected outside the province. It should be noted that Health Canada includes any WNv human cases that are deemed probable or confirmed. Cases may include WNv neurological syndrome, WNv non-neurological syndrome, and WNv unclassified/unspecified.

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

As Washington State and Idaho State share a border with British Columbia, it is important to follow WNv activity in those areas, as well. As of 5 November, there were five (5) human cases of WNv in Washington State. Four of the cases were acquired in-state within counties in the middle of the state[8]. Additionally, 27 mosquito pools and 2 horse/other mammals tested positive for WNv. No birds tested positive for WNv in 2019.

As of 5 November, there were 11 reported human WNv-symptomatic cases identified in Idaho. Additionally, three (3) horses/other mammals and 11 mosquitoes tested positive for WNv. No bird specimens tested positive for the virus. All cases were identified within counties in the southern and southwestern portion of Idaho[9].

[6] https://www.cranbrooktownsman.com/news/b-c-s-mosquito-guy-says-dry-spring-could-mean-fewer-pesky-biters/
[7] https://www.canada.ca/en/public-health/services/diseases/west-nile-virus/surveillance-west-nile-virus/west-nile-virus-weekly-surveillance-monitoring.html
[8] http://www.doh.wa.gov/DataandStatisticalReports/DiseasesandChronicConditions/WestNileVirus
[9] http://healthandwelfare.idaho.gov/Portals/0/Health/Epi/WNV/2019%20WNV%20case%20counts_1092019.pdf

Program Reminders

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

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

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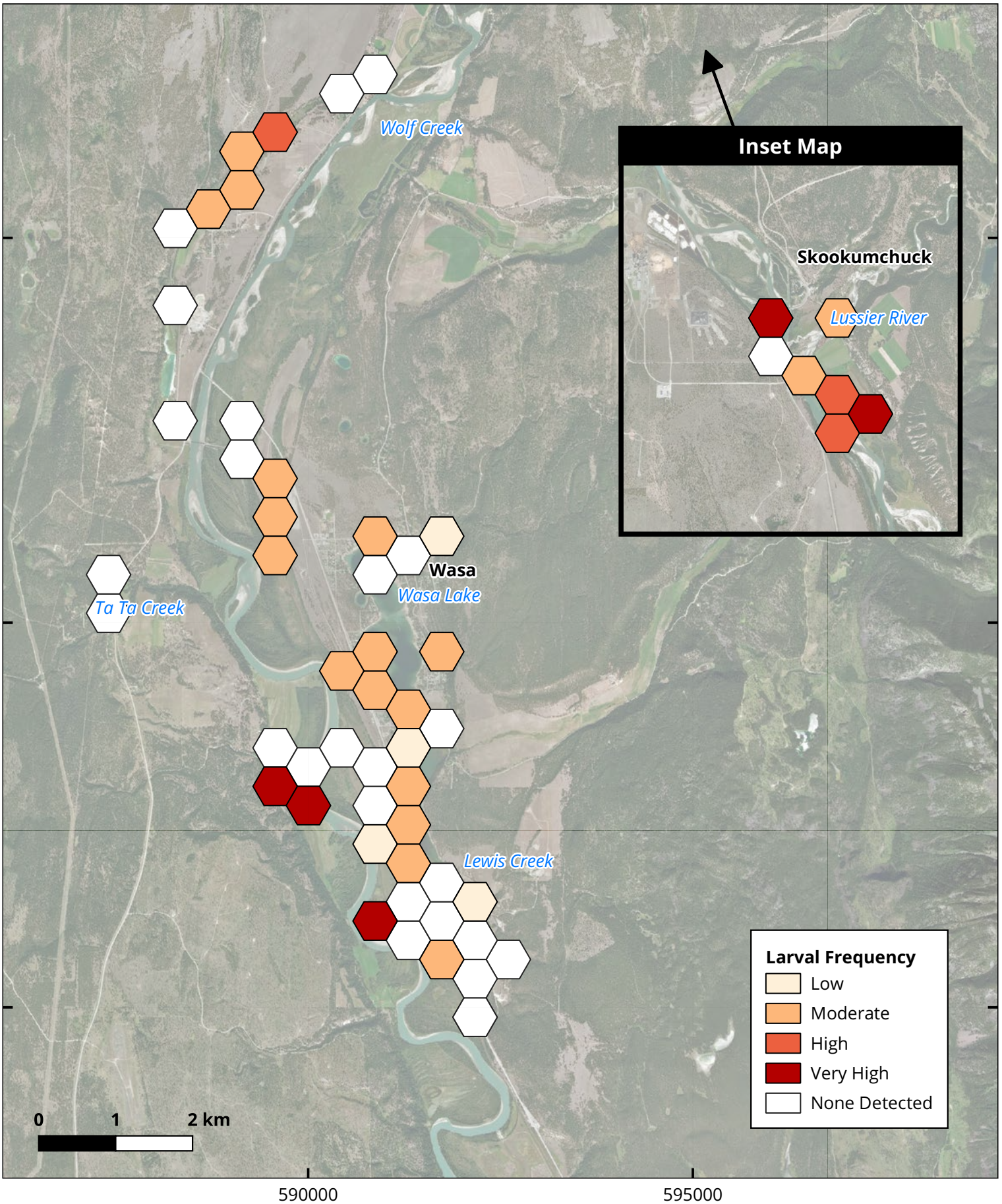
2019 Mosquito Larval Densities at Sample Locations

Appendix I

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

Scale = 1 : 65,000 CRS = NAD83 UTM Zone 11N

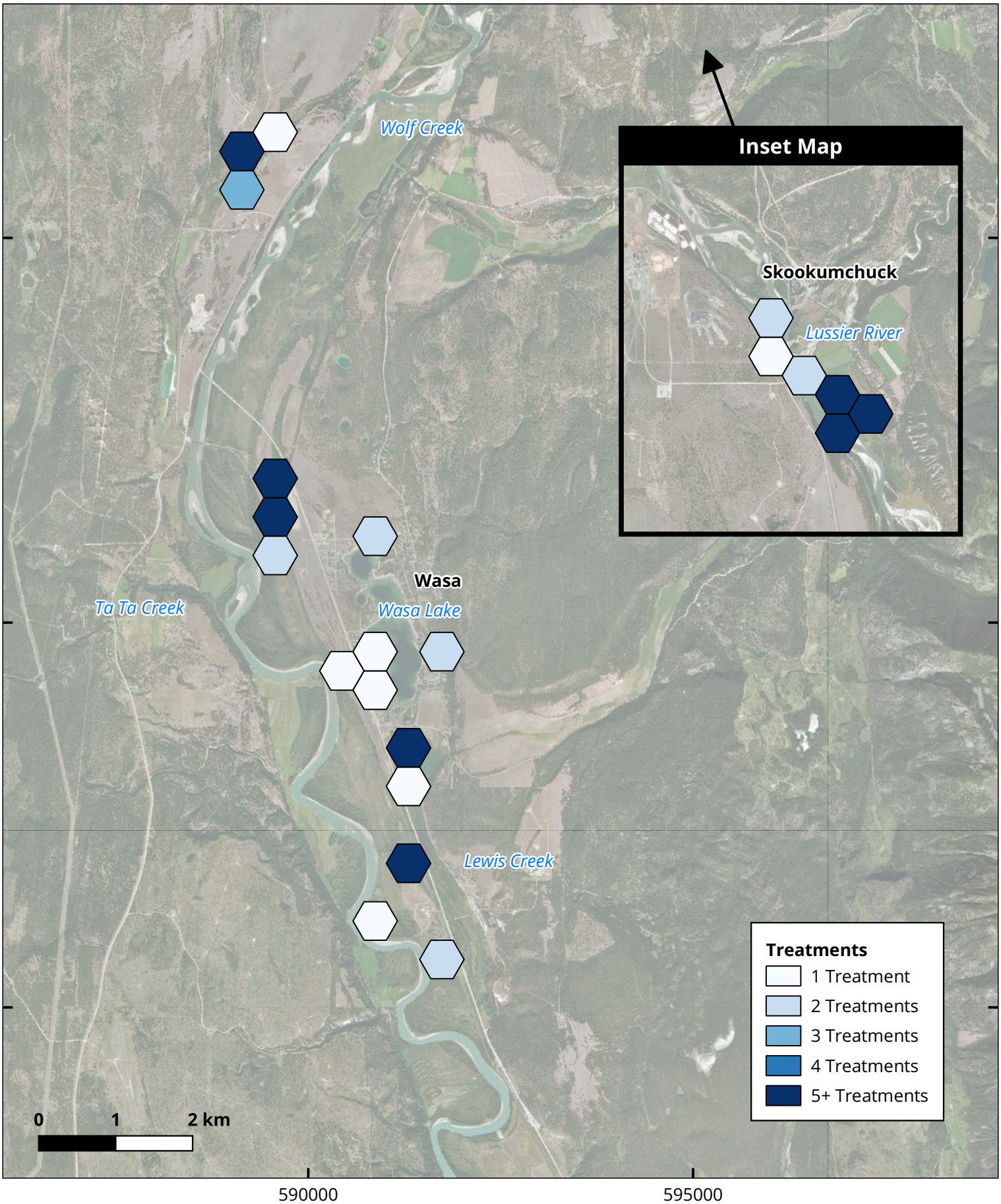


2019 Mosquito Larvicide Treatment Locations

Appendix II

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

Scale = 1 : 65,000 CRS = NAD83 UTM Zone 11N



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

A. Ground Treatments

Site ID	Date	Amount (Kg)	Area (Ha)
21cf3c30-010c-4391-8f3c-1eab69f2961e	2019-06-05	6.0	1.50
6a34301a-17dd-49a9-81bd-7b96fda5cb1c	2019-06-06	18.2	4.55
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	1.0	0.25
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
6a34301a-17dd-49a9-81bd-7b96fda5cb1c	2019-06-06	18.2	4.55
6a34301a-17dd-49a9-81bd-7b96fda5cb1c	2019-06-06	18.2	4.55
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-06	6.0	1.50
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d43c48b4-3d77-4a5b-8ad2-b3b6a71aeb0b	2019-06-07	6.2	1.55
4282d0f8-edfc-4d1c-ac0d-b307d673f780	2019-06-07	18.2	4.55
2107cce1-2b83-4c90-864d-6a7d63eea9aa	2019-06-07	18.2	4.55
2107cce1-2b83-4c90-864d-6a7d63eea9aa	2019-06-07	18.2	4.55
2107cce1-2b83-4c90-864d-6a7d63eea9aa	2019-06-07	18.2	4.55
2107cce1-2b83-4c90-864d-6a7d63eea9aa	2019-06-07	18.2	4.55
4282d0f8-edfc-4d1c-ac0d-b307d673f780	2019-06-07	18.2	4.55
4282d0f8-edfc-4d1c-ac0d-b307d673f780	2019-06-07	18.2	4.55
4e9f9a45-64f6-404e-8287-1d280ab9839d	2019-06-07	12.2	3.05
4e9f9a45-64f6-404e-8287-1d280ab9839d	2019-06-07	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.0	0.75
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.0	0.75

2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.2	0.80
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.0	0.75
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.0	0.75
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.2	0.80
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-10	3.0	0.75
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-12	12.0	3.00
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-12	12.2	3.05
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-12	6.0	1.50
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-12	5.2	1.30
4b72bf93-9e05-453c-bcd9-db53a1bf6002	2019-06-12	1.0	0.25
c4d904ed-8b72-42fa-a2a1-9b1051356ee6	2019-06-17	3.0	0.75
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	12.0	3.00
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-20	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.2	1.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	18.2	4.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	18.2	4.55
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2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.2	1.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.2	1.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.2	1.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.0	1.50
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996e6e2b-1379-4e08-a85a-e0740f23dbf4	2019-06-28	6.0	1.50
996e6e2b-1379-4e08-a85a-e0740f23dbf4	2019-06-28	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-06-28	6.2	1.55
d43c48b4-3d77-4a5b-8ad2-b3b6a71aeb0b	2019-06-28	2.0	0.50
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3fd20330-ef84-4b84-acda-7a748aef1070	2019-06-29	12.0	3.00
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f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	18.2	4.55
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.0	1.50
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.0	1.50
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f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.0	1.50
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.0	1.50
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.2	1.55

f962762a-5460-4bbd-a98c-2b54e74edd57	2019-06-29	6.0	1.50
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984318d4-a97e-4726-918a-3625a8253439	2019-06-29	2.0	0.50
c4d904ed-8b72-42fa-a2a1-9b1051356ee6	2019-07-02	1.0	0.25
06503c9b-b9a5-4174-a58f-18e9bd296c5f	2019-07-03	1.0	0.25
f962762a-5460-4bbd-a98c-2b54e74edd57	2019-07-04	2.0	0.50
1fbf7baf-1b70-4930-8d35-ad814a5ed18f	2019-07-10	6.0	1.50
549546d9-3ed4-4322-a252-af59d81ff78e	2019-07-10	8.0	2.00
549546d9-3ed4-4322-a252-af59d81ff78e	2019-07-10	6.0	1.50
3fd20330-ef84-4b84-acda-7a748aef1070	2019-07-10	2.0	0.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.2	1.55
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.0	1.50
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2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.0	1.50
2366ed08-1130-4eae-89d1-93ef419a5be7	2019-07-10	6.0	1.50