Regional District of East Kootenay, Mosquito Control Program for Wasa, Ta Ta Creek, Skookumchuck, B.C.

2016 Final Report

Submitted to: Jamie Davies, Environmental Services Coordinator
Regional District of East Kootenay
19-24th Ave S
Cranbrook, BC, V1C 3H8
(250) 489-2791

Submitted by: Morgan Sternberg, Data and Research Manager
Morrow BioScience Ltd.
PO Box 1013
Rossland, BC, V0G 1Y0
(250) 231-4455

Table of Contents

LIST OF FIGURES

Cover photo credits: Jeff Jackson, MBL field technician (2014)

Executive Summary

The 2016 season is the 19th season that Morrow BioScience Ltd. (MBL) has conducted floodwater mosquito control operations for Wasa, Ta Ta Creek, Skookumchuck area within the Regional District of East Kootenay (RDEK). Since the commencement of our contract, considerable and continuing efforts have been made to reduce floodwater mosquito annoyance issues. Efforts include the identification of new mosquito development areas specific to low and high regional Kootenay River levels. In 2016 MBL developed and tested a real-time, online data collection and mapping tool with the intent of introducing this new tool to all of MBL's programs in 2017. Overall, MBL has increased ground monitoring activities and decreased reliance upon aerial operations, thus lessening the environmental impact of the program over the past 18 years. Local residents and businesses have been an integral aspect to the success of this program.

The 2016 season began with an average snowpack in basins associated with the regional river. Abnormally high ambient temperatures that occurred in early April led to early Kootenay River peaks (at Fort Steele). The local Kootenay River peaked on 8 June (3.32 m). Consistent precipitation throughout the 2016 season likely did not add to the Kootenay River peak, but did maintain seepage site levels longer than would normally be expected.

Mosquito development sites along the Kootenay River became active in late May in 2016; treatments started on 2 May. Unseasonably high ambient temperatures in April led to a rapid increase in local river levels and provided ideal floodwater mosquito hatching environmental cues shortly thereafter. Consequently, the majority of ground treatments took place between mid-May and mid-June. Because the Kootenay River at Fort Steele had a peak that was relatively low, no aerial treatments were required in 2016. The total ground treatments amounted to about 595 ha (i.e. 3,571 kg). One new site was located in 2016. All new and existing sites were successfully treated in 2016. Ground treatments continued through mid-June because the Kootenay River was relatively low and receded quickly.

A new website (morrowbioscience.com) was launched in 2015, providing a comment platform for interested residents. MBL frequently updates our Facebook and Twitter accounts to reflect up-to-date mosquito and treatment related information for MBL's contract areas. To provide residents with a further avenue of contact, MBL has a toll-free mosquito hotline (1-888-733-2333) that is checked daily during the mosquito season. No complaint calls/emails were received in 2016. Alternately, residents commented about how pleased they were with the control efforts and results by MBL field technicians. MBL remains committed to remaining available to residents for questions or concerns, increasing monitoring efforts, providing increased control efficacy, and investing in public education efforts. In 2017, MBL will also have a booth at a Wasa, Ta Ta Creek, Skookumchuck community event to interface directly with interested residents.

Introduction

Morrow BioScience Ltd. (MBL) became the mosquito control contractor for the Wasa, Ta Ta Creek, Skookumchuck area within the Regional District of East Kootenay (RDEK) in 1998. In that time, MBL field technicians have gained considerable experience regarding the location, extent, and mosquito development timing for each of the mosquito development sites. This report will outline the accomplishments made to date for 2016, discuss regional environmental conditions affecting mosquito populations and monitoring efforts, review the success in fulfilling the proposed deliverables, and present all final data.

It is MBL's goal to reduce floodwater mosquito nuisance within the contract and adjacent areas for each of our control programs. The general reduction in floodwater mosquito annoyance is due, in large part, to the thorough monitoring and timely treatments conducted by MBL field technicians. Throughout this 19 year tenure, field technicians have gained a strong knowledge of each mosquito development site in low and high water years.

Involved citizens within the contract areas further augmented the thorough understanding Wasa, Ta Ta Creek, Skookumchuck sites. Residents have been able to provide historical information about the ecology and geography of the area. Ultimately, this understanding enables field staff to appropriately time applications resulting in the reduced need for aerial treatments. MBL fosters the community involvement aspect to this mosquito-monitoring program and recognizes that it is an essential element to achieving the ultimate goal: reduction of floodwater mosquito annoyance while remaining environmentally conscience.

MBL's corporate philosophy involves conducting effective floodwater mosquito control while achieving a low environmental impact by adhering to Integrated Pest Management principles. To achieve control objectives, MBL employs a consistent and frequent site-monitoring regime. Whenever possible, mosquito development sites are treated by hand or backpack blower, thus reducing the dependency on aerial applications. The success of this program is further supported by the fact that site visits can occur with little notice and as dictated by environmental circumstances because MBL's regional head field technician resides in Cranbrook.

Program Development

At the beginning of MBL's contract in 1998, the entire Wasa, Ta Ta Creek, Skookumchuck area was surveyed. Historically recognized sites were ground-verified. Since that time, all of the historical sites as well as all new sites have been added to a GIS database and subsequently mapped. Electronic data files based on the GPS waypoints have been supplied to the RDEK.

New mosquito development sites are discovered regularly due to the complicated influences of regional Kootenay River freshets coupled with the rapid production of beaver dams. In an effort to continually improve the quality of mosquito control to the Wasa, Ta Ta Creek, Skookumchuck residents, MBL field technicians continually survey areas for water obstruction issues.

In order to provide transparency and quick recall of treatment activities, MBL has developed a real-time online data collection and management solution. This data portal is presented in mapping format. It was successfully tested in 2016 in another contract area. Notes associated with each site will include the river level(s) at which floodwater larval mosquito activity began, the time of the year in which treatment began, access points, residential contact information, as well as data specific to monitoring/treating purposes MBL will be introducing this online data collection and mapping tool to all of our programs in the 2017 season.

Significant Regional Environmental Conditions

Snowpack

Snowpack in basins influential to the Kootenay River near Wasa, Ta Ta Creek, Skookumchuck is an important environmental variable to track, as it can reveal how severe the freshet may be at varying points in the season. Following the real-time snowpack levels will also indicate when the freshet has ended. As the freshet is the primary factor affecting floodwater mosquito development, it is a benefit to the overall success of the program to understand the snowpack and freshet variations throughout the season.

Snow survey stations take continuous snowpack measurements and the results are reported in real-time. Snow basin indices are then calculated from those measurements. In addition to these indices, ‘percent of normal’ calculations are also made. Specifically, when snow pack depths are measured, their heights are then compared to ‘normal’ heights (from comparable dates in previous seasons), revealing what ‘percent of normal’ the current levels are. These indices can aid field technicians in preparing for the freshet.

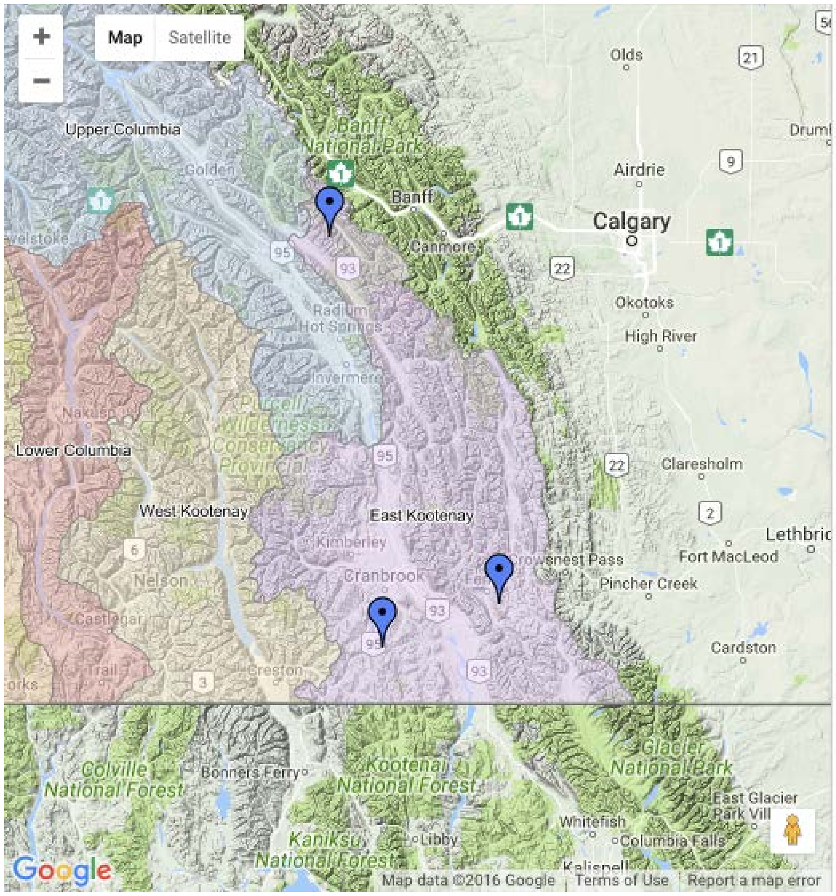

Figure 1. East Kootenay snow survey basin area delineations with pinned snow survey stations. Each regional snow survey affects the Kootenay River at Wasa/Ta Ta Creek/Skookumchuck. (http://bcrfc.env.gov.bc.ca/data/asp/realtime/index.htm).

The main basin that influences the regional Kootenay River freshet is the East Kootenay snow basin (Figure 1). Within the East Kootenay basin, snow pack from the Floe Lake (2C14P), Morrissey Ridge (2C09Q), and Moyie Mountain (2C10P) snow survey stations are most relevant to the Wasa, Ta Ta Creek, Skookumchuck area when attempting to determine freshet concerns (Figure 1; blue pins). Prior to 2014 the River Forecast Centre reported the snowpack in terms of 'percent of normal'. Currently, the Centre reports a comparable value in Snow Water Equivalent (SWE). The SWE is essentially the amount of water that could be found in a designated snowpack if the snowpack were to melt.

Figures 2, 3, and 4 were created by the River Forecast Centre.[1] They depict the SWE throughout the 2016 season for the Floe Lake, Morrissey Ridge, and Moyie Mountain stations, respectively. The green lines represent the real-time data collected for 2016. Evident from each of the figures is the fact that snowpack in East Kootenay basin for 2016 was generally average (Figure 2, 3, 4).

[1] Reference: http://bcrfc.env.gov.bc.ca/data

The time in which all of the snowpack was depleted from each of the snow survey stations was far less than average. The Floe Lake station (Figure 2) is the farthest north and showed that all of the snow within that station was depleted by mid-June. The Morrissey Ridge station (Figure 3) and Moyie Mountain station (Figure 4) showed that the snowpack was depleted by early May and late April, respectively. Each of the East Kootenay basin snow stations experienced a complete snowmelt approximately 6 weeks earlier than in average years.

The early melting of this snowpack coincided with a general warming trend across the southern portion of the province. The result of the early snowpack depletion in the region was a very early freshet in local Kootenay River levels (see Regional River Levels section). It is reasonable to assume that by mid-June, the freshet contribution by the regional snowpack was no longer significant to the Kootenay River levels in the Wasa, Ta Ta Creek, Skookumchuck area. Thus, regional Kootenay River fluctuations within the mosquito season that occurred after mid-June would have been caused by precipitation input only (see 'Precipitation' for more information).

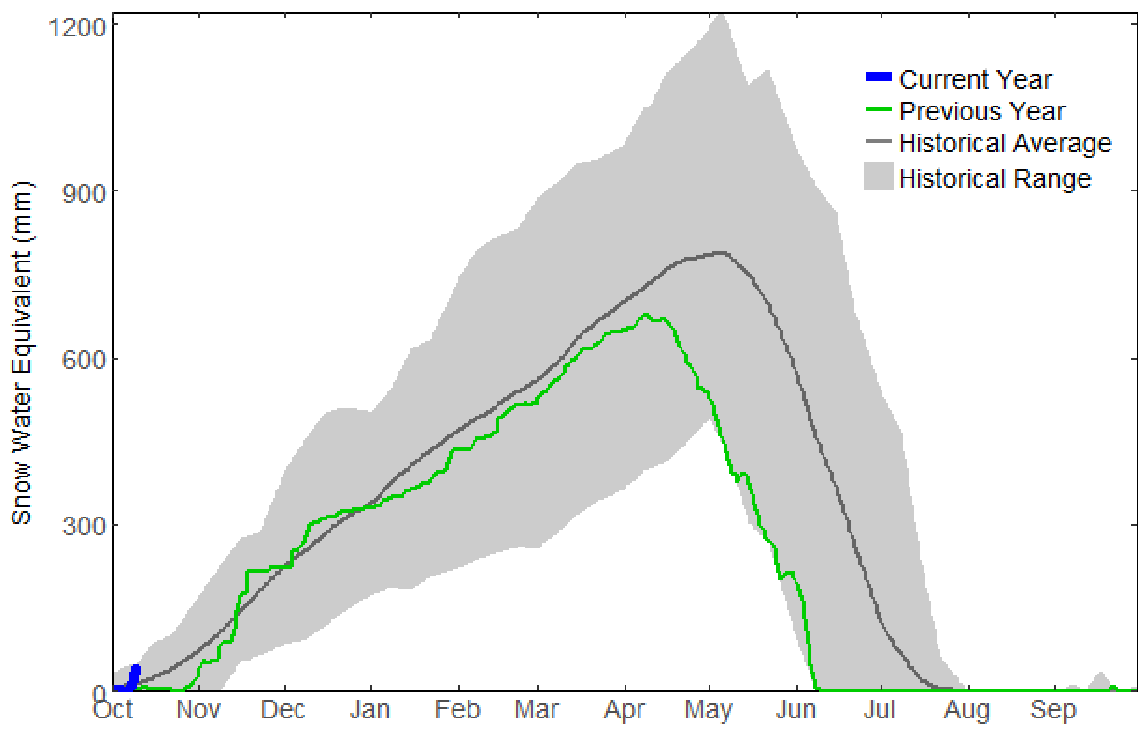

Figure 2. Automated snow pillow data as recorded at the Floe Lake Station (2C14P) in the East Kootenay Snow Survey Basin. The green line represents data for summer, 2016.

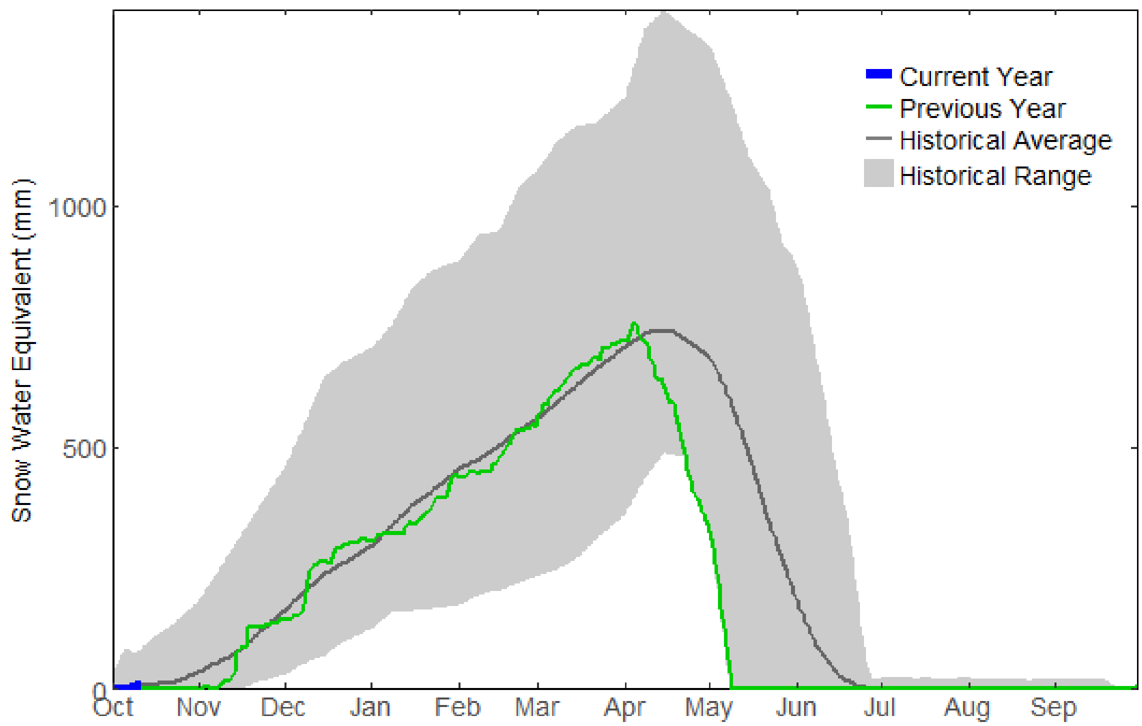

Figure 3. Automated snow pillow data as recorded at the Morrissey Ridge Station (2C09Q) in the East Kootenay Snow Survey Basin. The green line represents data for summer, 2016.

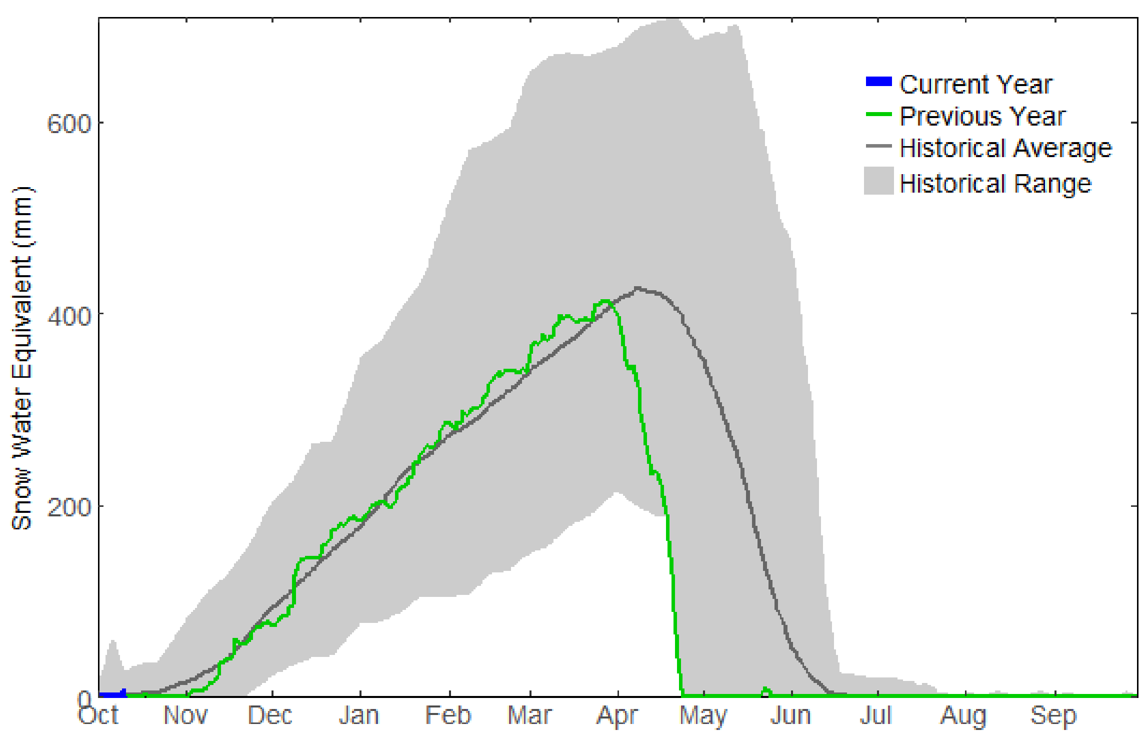

Figure 4. Automated snow pillow data as recorded at the Moyie Mountain Station (2C10P) in the East Kootenay Snow Survey Basin. The green line represents data for summer, 2016.

Ambient Temperature Records

Regional Kootenay River levels can be indirectly affected by ambient temperature spikes occurring in snow basins associated with these river systems in the early part of the mosquito season (i.e., March – June). When ambient temperatures spike, snowmelt comes down through regional rivers, increasing river levels, and creating floodwater mosquito development sites. More specifically, when the Kootenay River (i.e. the 'River') levels increase dramatically in the early Spring, the ground along the River's edges are wetted. The ground immediately adjacent to the River contains floodwater mosquito eggs. These eggs remain dormant until ideal hatching conditions are present, which include water, low dissolved oxygen levels, and sufficiently high ambient temperatures. Typically, these conditions present themselves within the month of May.

Ambient temperatures more strongly influence sites that are shallow, and relatively stagnant, and land-locked. The majority of the mosquito development sites within the Wasa, Ta Ta Creek, Skookumchuck area are shallow and relatively stagnant. Thus, as the ambient temperatures begin to rise, water temperatures more quickly reflect ambient temperatures, as well, creating an ideal environment for mosquito development. Larvae develop slower in cool water and much faster in warm water. In fact, in a laboratory study performed by Mohammad and Chadee (2011), *Aedes* mosquito eggs (i.e., floodwater mosquito eggs) were subjected to 35 °C conditions. Under this temperature, optimal feeding, and optimal spatial distribution conditions it took as little as six days for first instar larvae to emerge as adults.

Weather data described within this report are recorded at the Cranbrook Airport weather station (Climate ID: 1152104). This station records the most relevant weather information for the purposes of this mosquito control program.

When comparing the previous three mosquito seasons (i.e. 2013-2016), the maximum ambient temperature data in 2016 are generally similar through June (Figure 5). However, in mid-April of 2016 ambient temperatures spiked across the southern portion of the province, far exceeding those of recent regional history (Figure 5). According to the BC River Forecast Centre, daily ambient temperatures ranged between 2-4°C above normal for the month of April. This long stint of unseasonably warm weather brought out the entirety of the snowpack in both the Morrissey Ridge and Moyie Mountain snow stations (Figures 3,4) and led to an exceptionally early freshet with numerous spikes in local Kootenay River levels.

Ambient temperatures receded back to normal levels in May, before spiking in early June (Figure 5). It is likely that the temperature spike experienced in June helped expedite the final melting of high elevation snowpack in the Flow Lake snow station (Figure 2). Additionally, the spike in local ambient temperatures likely led to the seasonal peak in the local Kootenay River levels. The higher-than-normal ambient temperatures in the early portion of the season, coupled with the subsequent freshet, meant that mosquito larvae had optimal environmental cues for early hatching.

According to records from the Cranbrook Airport weather station, the peak of the daily ambient temperature in the area for the main portion of the mosquito season occurred on 7 June (Figure 5; 33.5 °C). High temperatures experienced in early June likely did provide an environment that allowed mosquitoes to mature more quickly than normal if they had not been controlled in previous efforts. After early June, maximum ambient temperatures reduced and remained constant through August (Figure 5). Numerous unsettled pressure systems moved through the southern portion of BC in the summer of 2016, resulting in lower-than-normal ambient temperatures.

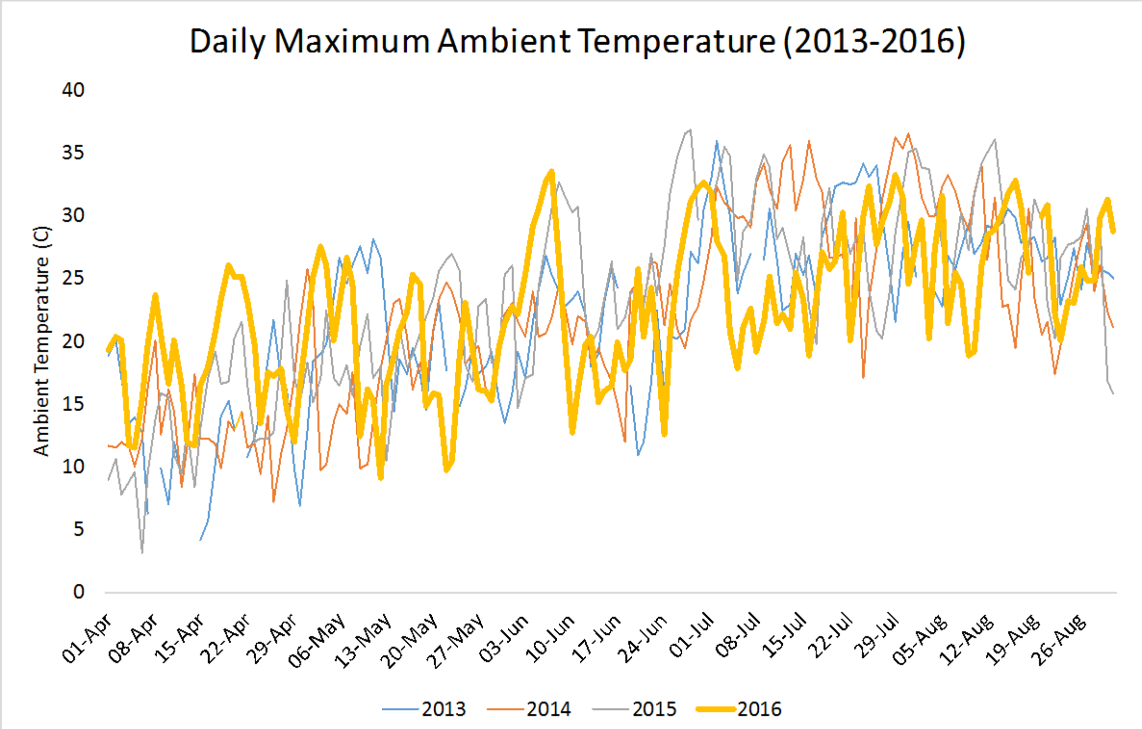

Figure 5. Maximum daily temperature (°C) as recorded at the at the Cranbrook Airport, BC (Climate ID: 1152105) between 1 April – 31 August, 2013-2016. Gaps in the data represent days wherein the monitoring station was not functioning properly.

Precipitation

Precipitation is an important environmental parameter to monitor within a floodwater mosquito control program, along with snowmelt and ambient temperature. While not the major contributor to overall river levels in the local Kootenay River levels, precipitation can impact levels when the ground is saturated in influential basins or when considerable precipitation is received during the peak of the freshet. It can also affect certain sites that are not necessarily associated with the River, but that are fed by snowmelt. If a large amount of precipitation occurs on top of snowmelt, the rain rolls off of the snowmelt and can pool in areas where mosquito development takes place.

During the time of recorded precipitation accumulation in 2016, May received the highest recorded amount of precipitation (as snow or rainfall) for the year (71.8mm; Figure 6). The precipitation received in May, 2016 was higher than that of any month (April – August) in 2015 (Figure 6). Likely, a large portion of the total precipitation received in May of this year was in the form of rain, which added to already high regional river levels. June - August recorded accumulations were average or slightly below average, so it is unlikely that precipitation events contributed measurably to local river levels in those months while the Kootenay River at Fort Steele was peaking.

While precipitation likely did not play a major role in the recorded peak river levels, it is possible that this amount of relatively consistent precipitation accumulation between May and August did provide sufficient water to maintain seepage sites that may have otherwise receded. These seepage sites proved to contribute greatly to larval densities in 2016. Seepage site persistence, combined with warming temperatures provided ideal mosquito larval development conditions in May and June, thus requiring more treatments in that time frame than is usual (see 'Larval Treatment' section).

By mid-June, all of the local snowpack had been depleted from the contributing basins, so any spikes in local river levels can be reasonably attributed to precipitation events. As such, a spike in local Kootenay River levels occurred in early July, which is thought to correlate with a multi-day precipitation event that occurred farther up-stream from Fort Steele in that timeframe. This precipitation helped bolster existing mosquito development sites, but did not result in any additional treatments (see 'Larval Treatment' section).

It is important to discuss the fact that as the floodwater mosquito development sites are receding, container mosquito development sites are likely increasing. Container mosquito species, such as certain *Culex sp.* mosquitoes, can also be a very local nuisance. These species require sites that have stagnant water for breeding and maturation. Specific sites include flat roofs, rain gutters, old tires, tree holes, birdbaths, and rain barrels, to name a few. It is possible that these container mosquitoes continued to be a nuisance through July and into August due to a sufficient amount of water in their favoured environments and relatively high ambient temperatures. While MBL's mandate does not include controlling container mosquitoes, field staff help concerned residents reduce potential container mosquito breeding sites on their property by advising them to remove or replace standing water regularly.

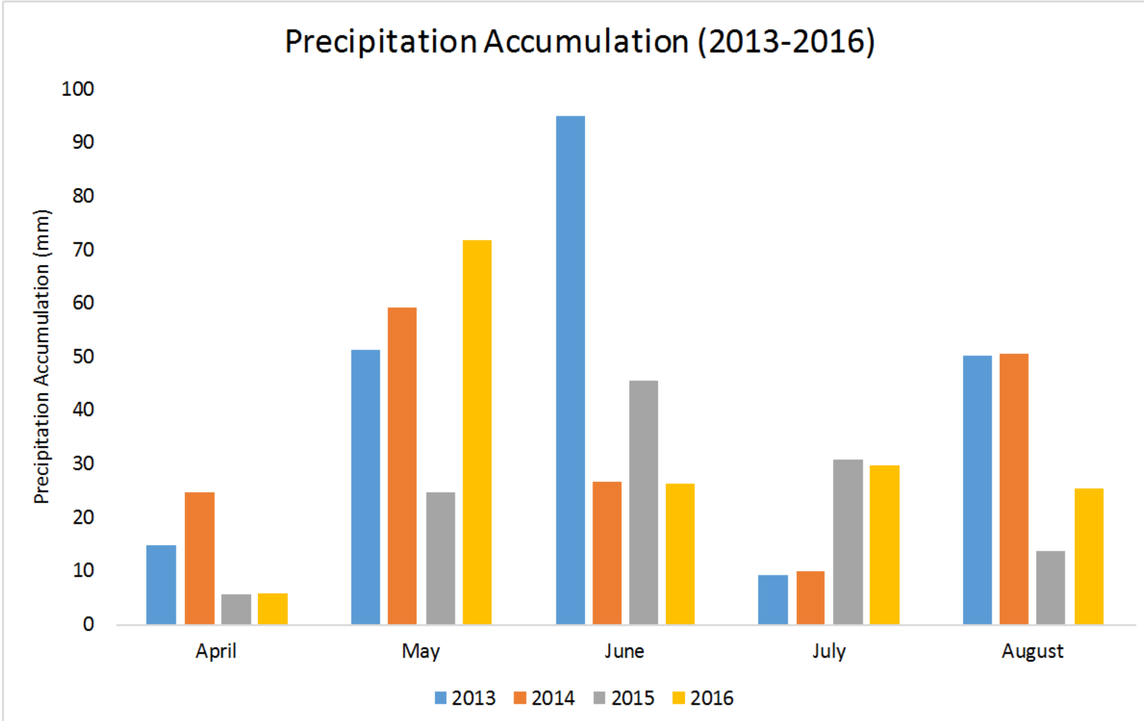

Figure 6. Monthly total precipitation accumulation (mm) as recorded at the at the Cranbrook Airport, BC (Climate ID: 1152105) between 1 April – 31 August, 2013-2016.

Regional Kootenay River Levels

The Kootenay River primarily affects the floodwater mosquito abundance in the area around Wasa, Ta Ta Creek, Skookumchuck. The water levels of this river system are governed by two main influences: 1) local snowmelt and 2) the freshet from the East Kootenay basin (Figure 1). Frequent and large amounts of precipitation can also affect River levels, though typically to a lesser degree than the primary factors listed above.

In early April, there was a region-wide warming trend, causing low and mid-elevation snow pack to come out of local basins associated with the Kootenay River. This large-scale warming trend caused local Kootenay River levels to spike in mid-April and again in early May, prior to receding to more normal levels in mid-May (Figure 7). The early swell in the River system wetted adjacent land, thus wetting mosquito eggs. Early environmental cues were present for successful mosquito larval development, requiring early-season treatments (see 'Larval Treatment' section).

On the heels of the first warming stint for the season was another, exceptional warming period in early June. This second warming stint is believed to have brought out the entirety of the region's high-elevation snow pack, leading to the 2016 season's peak in the local Kootenay River levels in June. The Kootenay River at Fort Steele peaked on 8 June at 3.32 m (Figure 7). This peak then wetted areas directly adjacent to the River, as well as created seepage sites nearby. At this point, mosquito eggs had all of the necessary environmental cues for large-scale hatching. Given the relatively warm ambient temperatures within the region, mosquitoes developed at a rate higher than normal for that time of the year. All of these factors, taken together, necessitated increased treatment efforts.

After 8 and 9 June, River levels experienced a considerable drop (Figure 7). From that point, River levels experienced minor spikes in response to small precipitation events. It is unlikely that the small perturbations due to precipitation occurring after the end of June sufficiently supplemented seepage sites. Thus, no further treatments were necessary after mid-June (see 'Larval Treatment' section).

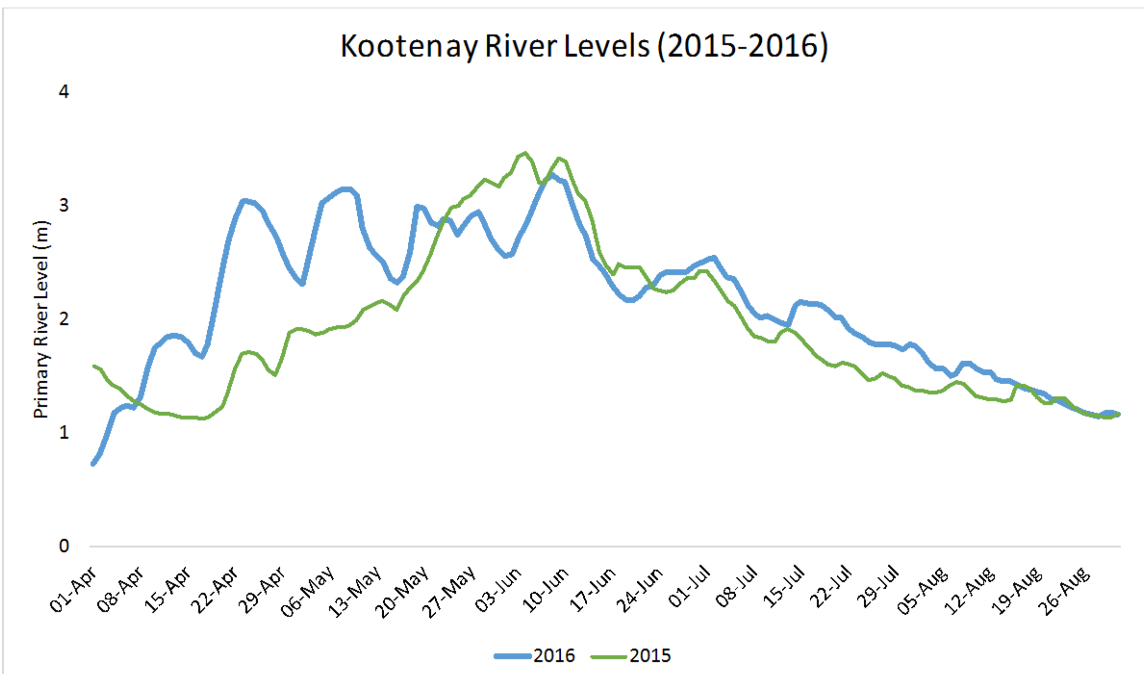

Figure 7. Kootenay River (m), 1 April – 31 August, 2015-2016. Columbia River measurements were taken from the 'Kootenay River at Fort Steele'.

Monitoring Methodology

Aedes vexans and *A. sticticus* mosquitoes are the most common floodwater nuisance mosquitoes within the Wasa, Ta Ta Creek, Skookumchuck area. As opposed to other mosquitoes (i.e., some *Culex*, *Culisetta, Anopholes spp.*), floodwater mosquitoes lay their eggs on damp substrate in areas with a high flooding potential; they are often called 'floodwater' mosquitoes for this very reason. If the water flooding the eggs is sufficiently warm, contains a low enough dissolved oxygen (DO) content, and is organically rich (which contributes to a decreased DO content), hatching will commence (Gjullin et al. 1950).

The mosquito control program for Wasa, Ta Ta Creek, Skookumchuck involves monitoring historically recognized and recently identified mosquito development sites within regional Kootenay River floodplain areas to target floodwater mosquito hatching. Kootenay River fluctuations along with frequent occurrence of beaver dams result in considerably large mosquito development sites. At the peak of the season, high water levels occur in the Kootenay River, which means that the potential for seepage site development is also high. The low-lying farms and benches throughout the floodplain are at a greater risk for the development of seepage from the River. When new sites are found they are entered into a GIS database and added to the monitoring schedule.

In 2016, there were 29 sites monitored within Wasa, Ta Ta Creek, Skookumchuck area. The number of sites decreased from 2015 due to lower regional river levels. Boundaries for mosquito development sites depend on either property ownership, the timing in which the area becomes active, or obvious habitat delineations. Sometimes habitat delineations become difficult to determination due to localized flooding caused by beaver dams.MBL field technicians recommend some beaver dam removal to the RDEK when property owners provide permission.

The regional snowpack came out of the basins approximately 6 weeks earlier than normal. This caused the local Kootenay River to peak considerably earlier than normal. Given the early freshet, all of the known sites from 2015 were visited twice a week beginning in early April. Monitoring began on 1 April and few 1^{st} instar larvae appeared in mid-April. By early May, the ambient temperatures were warm enough for the larval development rate to increase, necessitating treatments through mid-June. All sites were successfully treated and regular site visits continued after June on a weekly basis through August. Through the height of the season, certain sites are monitored more frequently than others due to their propensity to either produce mosquitoes quickly (e.g. sites that are shallow will typically produce mosquito larvae earlier) or because field staff need to monitor on a shorter schedule as they become familiar with the site mosquito productivity potential.

During each visit, larval counts are made and the larval composition is distinguished between early instar (1^{st} and 2^{nd}) and late instar (3^{rd} and 4^{th}). Also at each visit, notes are made regarding pupal and adult mosquito counts, which aid in determining whether or not a treatment has been missed at a particular site. MBL treatment protocol dictates that field technicians target the late 3^{rd} instar and early 4^{th} instar stages in order to leave more biomass in the water for predators who depend on larvae as a food source.

Larval Treatment

Larvicide Information

Mosquitoes in the larval phase are treated with Aquabac®. Aquabac® is considered a microbial larvicide, meaning that the active ingredient is a bacterium. In this case, the bacterium, *Bacillus thuringiensis* var. *israelensis* (Bti), is soil-borne. 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 as a result of cleavage of the protoxins by mid-gut proteases. An osmotic imbalance across the mid-gut epithelial cell membranes occurs due to this binding, which causes considerable damage to the wall of the gut and quickly leads to larval death (Boisvert and Boisvert, 2000).

Due to the specificity of the mosquito larval midgut receptors to the Bti endotoxins, Bti is a relatively safe treatment option when considering non-target effects potential. Besides mosquitoes, Bti also has an effect on black fly larvae. A commonly voiced concern is whether or not Bti has effects on salmonids. There is a large body of evidence that suggests Bti does not directly affect salmonids. Numerous studies have demonstrated the general safety of exposing fish to Bti (Brown et al. 1998, Brown et al. 2002, Brown et al. 2004). Therefore, amounts of Bti applied in field treatments are highly unlikely to cause direct hazard to juvenile salmonids.

Ground (Hand/Blower) Treatment Summary

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

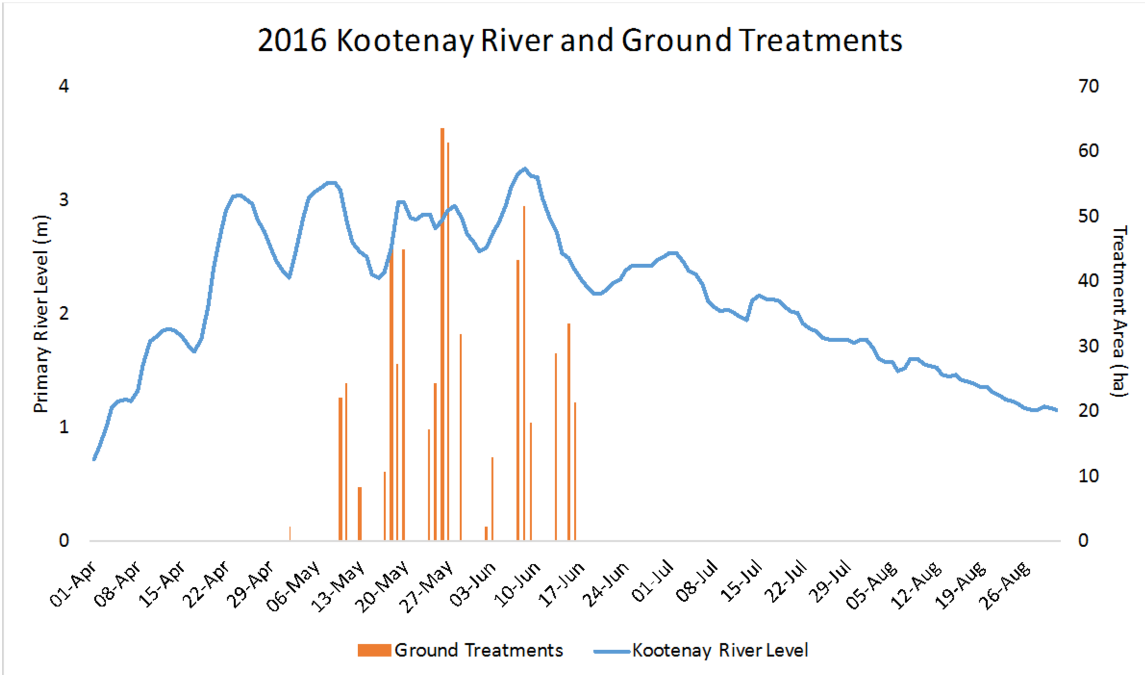

Figure 8. Ground (hand/blower) treatments (ha) with respect to the daily peak of the Kootenay River at Fort Steele (08NG065) for the 2016 season.

In 2016, MBL field technicians applied approximately 3,571 kg by ground (i.e. hand/blower), at a rate of 6 kg/ha in the Wasa, Ta Ta Creek, Skookumchuck area. Thus, approximately 595 ha, in total, was treated by ground (Figure 8; Appendix I). Early and relatively low peaks coupled with sustained River levels through early June created seepage sites which were accessible by ground throughout the entirety of the 2016 season.

Ground treatments started on 2 May (Figure 8) as a result of the early freshet. In early May, rising Kootenay River levels coincided with local ambient temperatures being sufficiently high to cue mosquito hatching events in most sites at once. The early peak, sustained high river levels, and relatively high ambient temperatures early in the season are all considered anomalous conditions. However, as there has been a shift within the previous few years toward earlier snowmelt periods, MBL field technicians were prepared for early monitoring and treatments.

In late May, larval development occurred at an exceptional pace, such that large-scale ground treatments were necessary (Figure 8). The majority of ground treatments in the Wasa, Ta Ta Creek, Skookumchuck area occurred between 10 May and 15 June (Figure 8). After mid-June, ground treatments began to taper off as local Kootenay River levels declined.

The final ground treatment was 16 June, approximately a week after the Kootenay River at Fort Steele peaked (Figure 8). Although treatments concluded in mid-June, MBL field technicians continued monitor sites through the end of August to ensure that further localized precipitation accumulation didn't trigger additional mosquito hatches.

Aerial Treatments

Aerial treatments were not necessary in 2016 because the local Kootenay River did not reach a threshold level which historically triggers significantly more seepage sites to develop.

Public Relations

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

MBL contact information is disseminated when field technicians have direct communication with the public. Contact information for MBL includes an email, phone number, and social media sites (Twitter, Facebook). Another resource for public queries is the new MBL website (morrowbioscience.com). By providing the public with these resources and avenues of communication, it enables community members to follow-up with questions.

The MBL biologist and owner made a presentation to local residents on 4 October at the Wasa Town Hall meeting. The presentation consisted of informing residents about mosquito control efforts conducted by MBL and also included recommendations for mosquito development site reduction measures. The meeting was well attended and garnered community engagement.

No phone calls to the Mosquito Hotline were received in 2016. No emails were received via the MBL website or to the local field technician. Alternately, most residents voiced that they were pleased with the level of mosquito control achieved by MBL in 2016, much of which was made possible due to community involvement in identifying mosquito development sites.

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

Social Media

This year, 2016, is the 5th consecutive year in which MBL had a social media presence. There are five main goals for MBL's social media presence: 1) provide timely and up-to-date information regarding conditions pertinent to mosquito production, 2) relay MBL's current efforts to control mosquitoes, 3) inform the public about MBL's efforts at social sustainability, 4) provide the community with opportunities to get involved with related public events, and 5) offer a platform for mosquito-related discussion amongst involved citizens and the MBL team.

Facebook (facebook.com/morrowbioscience) remains the primary avenue for MBL to disseminate mosquito-related information. Regular updates on mosquito abundance began in April as unseasonably warm weather settled in across southern British Columbia. In addition to field updates, updates were also posted regarding volunteer and outreach efforts conducted by MBL staff members. Scientifically-relevant levels were also posted on MBL's Facebook account, with specific attention paid to concerns surrounding the mosquito-borne Zika virus. Whenever possible, photos of staff in the field were also posted.

The total number of followers on the MBL Facebook page is currently 123. This number has increased by over 40 since the end of MBL's first season on Facebook (2012). Another way to gauge how many people are looking at or responding to MBL's posts is by considering MBL's post "reach". Specifically, each time a follower interacts with the MBL page a subset of their "friends" is exposed to the information that the original follower commented on or "liked". In this way the maximum reach was 333 on July 8 and included a re-post of an article specifying the best ways in which to keep mosquitoes from biting. While this reach is considerable, it pales in comparison to high water years in which the reach exceeded 500. It is likely that MBL's Facebook account receives traffic volume in direct relationship to regional river levels.

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

To date, the maximum number of followers on Twitter is 133. This is an increase of 45 followers from 2014. Part of the reason for the increase in followers through this method is the link between the Twitter account and the Facebook account. Each time a "tweet" was sent out via Twitter, it was also posted to the Facebook page. This way the Twitter feeds reached as many people per day as did the Facebook posts Twitter and Facebook accounts are also linked to the new Morrow BioScience website, enabling visitors to easily connect with each account. Notable Twitter followers include local municipalities and media.

Tweets typically consisted of the following:

- Relevant mosquito-related scientific articles from trusted sources
- Notification of significant increases in river levels
- Updates on adult mosquito levels
- Notification of planned aerial applications
- Photos of field staff and wildlife in the course of operations
- Reminders and notification of public events such as river clean-up days
- Links to WNv activity updates relevant to southern British Columbia

MBL Website

The MBL website (**www.morrowbioscience.com**) was launched on March 26, 2015. This site was developed in an effort 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 particular importance is the 'Contact' tab which allows a person to directly send a message to MBL. Additionally, there are links to MBL's Facebook account and Twitter feed, so interested individuals may have real-time updates on MBL's activities. Improvements to the site in 2016 included adding the local contact information for field technicians and their assigned projects.

In the future, there will also be a science-focused section that will have links to relevant peer-reviewed literature, important websites, and information about Aquabac®, the Bti product used by MBL. News stories relevant to MBL's contract areas and focus will also be posted in the near future. Feedback specific to MBL's website is welcome.

West Nile Virus Surveillance

Along with its partners, the Government of Canada conducts on-going surveillance of West Nile virus (WNv) cases in humans between mid-April and the end of October. As of 17 September, no human clinical cases of WNv in British Columbia were reported to Health Canada. A total of 59 cases were reported across Canada; all cases were in either Quebec, Ontario, Alberta, and Manitoba. 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[2].

According to the Government of Canada, a total of 2.39 percent of all tested mosquito pools have tested positive for WNv (as of 17 September 2016). All mosquito pools were from either Quebec, Ontario, Saskatchewan, or Manitoba. To date, a total of 62 dead birds have been tested for WNv, of which 17 were reported as positive for the virus. Two of these positive bird identifications were from British Columbia (i.e. Cranbrook). both bird specimens were from Ontario. Ten horses from British Columbia also tested positive.

The British Columbia Center for Disease Control conducted enhanced West Nile virus surveillance between 2004 and 2014; the BCCDC no longer produces enhanced surveillance reports.

As Washington and Idaho State share a border with British Columbia, it is important to follow WNv activity in those states, as well. To date, there are 9 human cases of WNv in Washington State; all cases originated in the south-central portion of the state. Additionally, 95 mosquitoes pools, 27 horses/other mammals, and 2 birds tested positive for the virus[3]. The Washington State counties that share a border Canada are Whatcom, Okanogan, Ferry, Stevens, and Pend Oreille. Within those counties, no positive human cases have been reported, although Okanogan County reported 4 positive horse/other mammal cases of WNv, Stevens County reported 6 positive horse/other mammal cases, and Pend Oreille reported 2 positive horse/other mammal cases[4].

To date, there are 8 human cases of WNv in southern Idaho[5]. Additionally, 9 horses and 9 mosquito pools tested positive within the state. The county that borders Canada is Boundary county, within which 4 horses tested positive for WNv.

In general, WNv reports were lower in 2016 than in previous years. This is likely due to the relatively few number of degree days, which correlates with a greater dispersal rate of WNv. MBL is continually updated on WNv activity within BC and its US-bordering counties in order to anticipate public questions and allow for timely responsiveness to additional control efforts, if necessary.

---

[2] http://www.healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/surveillance-eng.php

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

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

[5] http://healthandwelfare.idaho.gov/Portals/0/Health/Epi/WNV/2016WNV%20case%20counts%209%2022%202016.pdf

Future Work

Future work in Wasa, Ta Ta Creek, Skookumchuck area should focus on continuing to search for potential mosquito development sites, expanding the community involvement and education portion to our program, and continuing to monitor for adult mosquitoes. Community involvement and education events could occur at the beginning of the mosquito season and during the season. At least one community event in the Wasa, Ta Ta Creek, Skookumchuck area should be conducted in 2017 and an information booth should be set up. This outreach effort would serve as a platform to inform residents about mosquito control and to field questions/concerns as they pertain to control efforts.

Mosquito development sites can vary from year-to-year, largely depending on regional snowpack, the Kootenay River levels, ambient temperatures, and precipitation accumulation in contributing basins. Due to the changing environmental variables, MBL greatly values the local citizens' abilities to report potentially new mosquito development sites. Citizen awareness adds invaluable knowledge to the MBL field technician's abilities at being able to predict where new, potential sites may arise based on finding low-lying areas. Thus, it is imperative that citizens have the ability to directly contact field technicians to make them aware of potential sites.

To further improve community communication and involvement, along with program transparency and real-time accountability, MBL will be officially launching our real-time online data collection and management portal in 2017. This will improve management capabilities and allow for real-time data summaries for contract area politicians and staff members. This tool will enable MBL field technicians to quickly answer resident questions specific to certain mosquito development sites, on location.

MBL is dedicated to providing each of our programs with the best floodwater mosquito control possible. Within that commitment is the focus on consistent communication and to continually pursuing areas in which to improve.

References

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.

Brown MD, Thomas D, Mason P, Greenwood JG, Kay BH. 1998. Acute toxicity of selected pesticides to the Pacific blue-eye, *Pseudomugil signifier* (Pisces). *J Am Mosq Control Assoc* 14:463-466.

Brown MD, Carter J, Thomas D, Purdie DM, Kay BH. 2002. Pulse-exposure effects of selected insecticides to juvenile Australian crimson-spotted rainbowfish (Melanotaenia duboulayi). *J Econ Entomol* 95:294-298.

Brown MD, Watson TM, Carter J, Purdie DM, Kay BH. 2004. Toxicity of VectoLex (*Bacillus sphaericus*) products to selected Australian mosquito and non-target species. *J Econ Entomol* 97:51-58.

GJullin CM, Yates WW, Stage HH. 1950. Studies on *Aedes vexans* (Meig.) and *Aedes sticticus* (Meig.), Flood-water Mosquitoes, in the Lower Columbia River Valley. Annals Entomological Society of America 43: 262-275.

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.

Appendix I – 2016 Larvicide Treatment Records

DATE	SITE CODE	AMOUNT APPLIED (KG)	METHOD	RATE (KG/HA)	AREA (HA)
02-May	18	13.65	Blower	6.00	2.28
10-May	50	72.60	Blower	6.00	12.13
10-May	48	54.60	Blower	6.00	9.10
10-May	18	4.55	Blower	6.00	0.76
11-May	50	145.60	Blower	6.00	24.23
13-May	28	36.40	Blower	6.00	6.07
13-May	26	13.65	Blower	6.00	2.28
17-May	8	59.15	Blower	6.00	9.86
17-May	10	4.55	Blower	6.00	0.76
18-May	1	163.80	Blower	6.00	27.26
18-May	3	109.20	Blower	6.00	18.20
19-May	1	91.00	Blower	6.00	15.17
19-May	5	72.60	Blower	6.00	12.13
20-May	2	127.40	Blower	6.00	21.23
20-May	14	109.20	Blower	6.00	18.20
20-May	57	9.10	Blower	6.00	1.52
20-May	26	9.10	Blower	6.00	1.52
20-May	8	9.10	Blower	6.00	1.52
20-May	10	4.55	Blower	6.00	0.76
24-May	42	45.50	Blower	6.00	7.58
24-May	2	36.40	Blower	6.00	6.07
24-May	14	9.10	Blower	6.00	1.32
24-May	14	9.10	Blower	6.00	1.32
24-May	3	4.60	Blower	6.00	0.76
25-May	50	136.50	Blower	6.00	22.75
25-May	48	9.10	Blower	6.00	1.52
26-May	29	36.40	Blower	6.00	6.07
26-May	28	345.80	Blower	6.00	57.63
27-May	10	91.00	Blower	6.00	15.17
27-May	2	72.60	Blower	6.00	12.13
27-May	8	72.60	Blower	6.00	12.13
27-May	16	54.60	Blower	6.00	9.10
27-May	5	27.30	Blower	6.00	4.56

27-May	3	18.20	Blower	6.00	3.03
27-May	57	9.10	Blower	6.00	1.52
27-May	4	4.60	Blower	6.00	0.76
27-May	20	4.55	Blower	6.00	0.76
27-May	26	4.55	Blower	6.00	0.76
27-May	22	4.55	Blower	6.00	0.76
27-May	15	4.55	Blower	6.00	0.76
29-May	50	100.10	Blower	6.00	16.68
29-May	42	54.60	Blower	6.00	9.10
29-May	43	36.40	Blower	6.00	6.07
02-Jun	26	9.10	Blower	6.00	1.52
02-Jun	57	4.55	Blower	6.00	0.76
03-Jun	3	45.50	Blower	6.00	7.58
03-Jun	10	27.30	Blower	6.00	4.56
03-Jun	27	4.55	Blower	6.00	0.76
07-Jun	28	145.60	Blower	6.00	24.26
07-Jun	5	36.40	Blower	6.00	6.07
07-Jun	27	27.30	Blower	6.00	4.55
07-Jun	14	18.20	Blower	6.00	3.03
07-Jun	10	18.20	Blower	6.00	3.03
07-Jun	7	9.10	Blower	6.00	1.52
07-Jun	10	4.60	Blower	6.00	0.76
08-Jun	42	163.80	Blower	6.00	27.30
08-Jun	28	109.20	Blower	6.00	18.20
08-Jun	15	27.30	Blower	6.00	4.56
08-Jun	16	9.10	Blower	6.00	1.52
09-Jun	43	45.50	Blower	6.00	7.58
09-Jun	44	27.30	Blower	6.00	4.56
09-Jun	27	27.30	Blower	6.00	4.56
09-Jun	45	9.10	Blower	6.00	1.52
13-Jun	28	54.60	Blower	6.00	9.10
13-Jun	29	54.60	Blower	6.00	9.10
13-Jun	24	27.30	Blower	6.00	4.56
13-Jun	22	18.20	Blower	6.00	3.03
13-Jun	48	9.10	Blower	6.00	1.52
13-Jun	50	9.10	Blower	6.00	1.52
15-Jun	42	91.00	Blower	6.00	15.17
15-Jun	10	54.60	Blower	6.00	9.10
15-Jun	1	18.20	Blower	6.00	3.03

15-Jun	5	18.20	Blower	6.00	3.03
15-Jun	10	18.20	Blower	6.00	3.03
16-Jun	4	45.50	Blower	6.00	7.58
16-Jun	8	27.30	Blower	6.00	4.56
16-Jun	10	27.30	Blower	6.00	4.56
16-Jun	3	27.30	Blower	6.00	4.56

Project Contacts at Morrow BioScience Ltd.

Dirk Lewis
Owner/Biologist
dirk@morrowbioscience.com
604.317.1413

Morgan Sternberg
Data and Research Coordinator
morgan@morrowbioscience.com
250.231.4455

Kendra Lewis
Regional Field Operations Manager
kendra@morrowbioscience.com
250.421.1294