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Water Monitoring for Neonicotinoid Pesticides in the Nicomekl Watershed

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EXECUTIVE SUMMARY

Surface water quality monitoring for neonicotinoid insecticides (neonics) in the Nicomekl River watershed was carried out during the agricultural growing season late May to mid-July, 2020. This sampling was conducted to determine changes in neonic levels measured in 2017 and 2018 throughout the Lower Mainland and the Okanagan by the Ministry of Environment and Climate Change Strategy (ENV) and the Ministry of Agriculture (AGRI).

Neonics are a group of insecticides that are commonly used in agricultural crop production as spray or seed-coating treatments for control of various insect pests. Due to their persistence in the aquatic environment, neonics can be detected in water courses many years after application has occurred.

The objective of this project was to determine if compliance verification and outreach efforts in 2019 conducted by AGRI and ENV have improved the levels of neonics found in the Nicomekl watershed. Six surface water quality monitoring locations within the Nicomekl watershed were sampled on a bi-weekly occurrence for three neonic active ingredients: imidacloprid, clothianidin, and thiamethoxam. These active ingredients are currently approved for agricultural use in Canada and their concentrations were compared to the Health Canada Pest Management Regulatory Agency (PMRA) chronic and acute endpoints.

Key findings of this study included:

- Imidacloprid had the highest maximum concentration at 1.8 times the PMRA acute endpoint, followed by clothianidin (below acute endpoint), and thiamethoxam (below acute endpoint).
- Imidacloprid had the highest mean concentration at 5.1 times the PMRA chronic endpoint (at the Tributary 2 location), followed by clothianidin, and thiamethoxam.
- The highest maximum and mean concentrations of imidacloprid were detected at the Tributary 2 location. The only detection of clothianidin was at the Nicomekl Downstream location, which is the same location where the highest mean and maximum clothianidin was found in 2017.
- The concentration of all neonics decreased at all sites in 2020 compared to both the 2018 and 2017 sampling events, however the upstream tributary sites detected higher concentrations of imidacloprid in 2020 in comparison to sites sampled directly on the Nicomekl River.
- The imidacloprid concentrations measured in the upstream tributaries exceed endpoints where impacts on aquatic life are expected. It is unknown whether the neonics detected in 2020 are due to recent pesticide applications or persistence from previous years' applications.

Recommendations:

- Pesticide inspections should be carried out at sites located upstream from the Tributary 1 and Tributary 2 monitoring locations.
- Focus on sampling in the upstream tributary areas in comparison to the Nicomekl River itself, in order to identify potential point source locations.
- Consider discontinuing monitoring for thiamethoxam.
- Sample following rainfall events if possible.
- Evaluate the effectiveness of Anderson Creek (Tributary 1) and the Nicomekl River Upstream control monitoring locations.

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1. BACKGROUND

Neonicotinoids (neonics) are a group of broad-spectrum insecticides that are commonly used in agricultural practices. They are typically sold as spray formulations that can be applied to both crops and bare soil to control various pests, but they also can come in the form of a seed coating. The active ingredients in this group of insecticides include clothianidin, imidacloprid, thiamethoxam, acetamiprid, nitenpyram, and nithianzine (Sapsford, 2018). Health Canada's Pest Management Regulatory Agency (PMRA) has proposed imidacloprid, clothianidin, and thiamethoxam being phased out of use by 2021 following a two-phase re-evaluation process (Sapsford, 2018; Harker, 2020). The first phase of the re-evaluation was conducted in 2018 and was used to determine neonics' impacts on pollinators (Sapsford, 2018). The first phase outlined new regulations for the use of neonics and has prohibited their use on crops such as berries and cucurbit vegetables (PMRA, 2019).

Neonics have been found to be highly toxic to both aquatic macroinvertebrates and pollinators, and these long-lasting exposure effects can be found due to delayed lethal effects (Sapsford, 2018; Harker, 2020). Due to their persistence in the aquatic environment, neonics can be detected in water courses many years after application has occurred. These insecticides can persist in soil for an extended period, which in turn allows leaching into water courses for years following the primary application (Sapsford, 2018). This makes it difficult to target a specific source location. Toxicity studies on invertebrates have shown the binding of neonics to receptors (the physiological mechanism of toxicity) to be long-lasting, nearly irreversible, and cumulative over multiple exposure events, often prolonging exposure and causing delayed lethal effects (Morrissey et al. 2015; Sanchez-Bayo et al. 2016). For sensitive species (such as Ephemeroptera, Trichoptera, and Coleoptera taxa), short-term lethal effects have been observed at concentrations <1µg/L in water (Morrissey et al. 2015; Raby et al. 2018).

Table 1 summarizes the chronic and acute toxicity endpoints for the neonics examined in this study.

Table 1: PMRA chronic and acute endpoints for the three neonic parameters observed in this study

	Imidacloprid (µg/L)	**Clothianidin (µg/L)**	**Thiamethoxam (µg/L)**
Chronic Endpoint	0.041	0.020	0.026
Acute Endpoint	0.360	1.50	9.0

Testing for neonics in the Nicomekl River in 2020 is a continuation of a project originally led by the Ministry of Environment and Climate Change Strategy (ENV) and the Ministry of Agriculture (AGRI) which occurred throughout the Lower Mainland and the Okanagan in 2017 and 2018. The project was originally generated as part of a pan-Canadian Environmental Monitoring Working Group (EMWG) study to test neonics levels in streams across Canada (Harker, 2020). After the 2017 and 2018 study, inspections were conducted at ten pesticide storage areas within the Nicomekl watershed. These inspections were performed by Integrated Pest Management (IPM) Officers within ENV. It was found that seven out of the ten sites had at least one neonic product stored, and although compliance actions were taken for improper storage, no risk of entry to water systems was observed (Harker, 2020).

The Nicomekl River watershed is the primary focus for the 2020 re-sample study, as exceedances of chronic and acute endpoints were observed in the previous studies for all three tested parameters of neonics (thiamethoxam, clothianidin, and imidacloprid).

The Nicomekl River originates from ground springs in Langley, B.C. near Milner Village (located approximately near 216 Street and 64 Avenue) and flows southwest before draining into Mud Bay. The Nicomekl River has a total length of 34 km and has a drainage area of approximately 149 km^3 (Environment Canada, 2020). The Nicomekl watershed contains some greenhouses and nurseries, as well as agricultural land containing a small amount of vegetables, berries, and corn where neonic products can be applied (Sapsford, 2018). The watershed also contains single and multiple family residential areas, commercial and industrial areas, and the Nicomekl River and its tributaries flow past golf courses, the Langley Regional Airport, schools, and municipal parks.

Re-sampling in 2020 was undertaken to determine whether education and compliance verification efforts towards farms and greenhouse operations made by ENV and AGRI in 2019 have improved the levels of neonics found in the Nicomekl watershed. These education and compliance efforts included: conducting outreach with specific agricultural producers in the area, verifying that product labels were up to date, promoting awareness of application restrictions around water bodies, providing information on drift-management, and ensuring proper storage procedures (Eby 2019).

This project measured the presence and concentrations of the neonic active ingredients imidacloprid, thiamethoxam, and clothianidin in the Nicomekl watershed and was completed from the end of May to late July in 2020. The tributary sample locations were selected in the 2018 study to assess if the pesticide was being transported from upstream into the main reach of the Nicomekl River. The sample locations on the Nicomekl River mainstem were selected to represent upstream and downstream of main productive agricultural land along the Nicomekl River (Sapsford, 2019). These locations can be used to help assess the movement of neonics, as well as potentially identify a point source, as previous studies were unable to locate an exact source.

As detection may be increased after rainfall events due to increased runoff, weather data was collected in order to help gauge its effect on sample detection levels. The inferences that may be drawn are limited due to the short sampling period of the project, but it provides an overview to compare to the previous sampling years.

2. TERMINOLOGY

Neonicotinoids: (Neonics) are a group of broad-spectrum insecticides. They derive their toxicity from agonistically binding to nicotinic acetylcholine receptors (nAChRs) on the post-synaptic nerve membrane and firing uncontrollable nerve impulses in the affected organisms.

Insecticides and active ingredients: are a class of pesticides that are used to control insects. Insecticide formulations are composed of two parts: active ingredient(s) and formulants. The active ingredients in a pesticide are what control the target pest, and a pesticide may contain one or more active ingredients. Formulants may aid in the stabilization, mixing, or application of the pesticide.

Acute and Chronic Toxicity Endpoints: are used to establish toxicity thresholds. Acute studies are shorter in duration and examine acute endpoints such as mortality and behavior. LD50 (lethal dose) is a common acute endpoint, defined as the dose of a compound required to kill half the test organisms. Chronic studies are longer in duration and examine non-lethal endpoints such as reproduction, long-term survival and growth. Chronic studies assess the effects of extremely low concentrations of compounds that may persist in the environment for long periods of time.

3. OBJECTIVE

The objective of this project was to determine if compliance verification and outreach activities in 2019 conducted by AGRI and ENV IPM improved the levels of neonics detected the Nicomekl River watershed.

4. METHODS

All samples were collected by ENV staff in the Monitoring, Assessment and Stewardship group (MAS) in 2020 between May 27 to July 20. Surface water grab samples were collected on a bi-weekly schedule, alternating the day of the week in which the samples were collected for variability during the limited project period. Grab samples were collected in accordance with *Protocol for Surface Water Monitoring for Neonicotinoids* by the EMWG, including the use of gloves and a sampling pole depending on site access and water level (Harker, 2020). The project field sampling period was limited due to COVID-19 restrictions.

Water samples were collected in two laboratory-supplied 250 mL amber glass bottles at each sampling location. No duplicate or replicate samples were collected for this study due to the cost of the analysis. All water samples were submitted to ALS Laboratory in Burnaby and were sent for analysis at the ALS lab in Waterloo. The reported detection limit (RDL) for these samples is 0.0050 µg/L. Field parameters were recorded using a YSI professional plus unit and included values for pH, conductivity, temperature, and dissolved oxygen (DO, in mg/L and %) which was calibrated prior to use.

Site selection for the 2020 resample was determined by the sites that were previously sampled during the 2017 and 2018 studies and shown in the figures below. The only site that differed in the 2020 study was an upstream control location, which was selected due to ease of access and its location away from intensive agriculture. The goal of this upstream control location was to have the lowest threshold detection of any neonics active ingredients to use as a baseline site for all the other sample locations.

Concentrations of neonics collected in 2020 were compared to the PMRA chronic and acute endpoints for imidacloprid, clothianidin, and thiamethoxam (Table 1). The current guideline from the Canadian Council of Ministers of the Environment (CCME) has created an interim working chronic guideline for imidacloprid of 0.23 µg/L (Harker, 2020). There are no established guidelines from CCME for thiamethoxam and clothianidin.

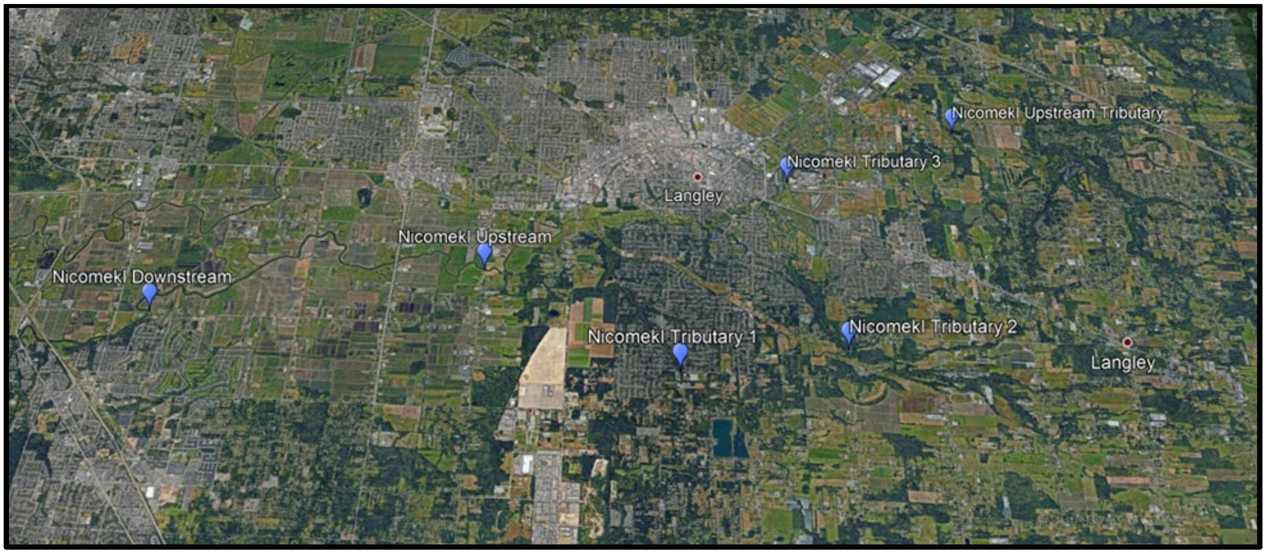

Figure A1: Nicomekl neonics sampling locations in 2020.

Figure A2: Nicomekl River Upstream and Downstream sample locations for neonics in 2020.

5. RESULTS AND DISCUSSION

5.1 Nicomekl Results

The 2020 results can be found in the appendix below. Note that only four samples were collected at the Nicomekl Tributary 1 location instead of five, as Anderson Creek had dried up before the final sampling date. A summary of the results of each individual pesticide is provided below.

5.1.1 Imidacloprid

The detection of imidacloprid ranged across all six sample locations, but in general was found at higher concentrations in the upstream tributary locations compared to the Nicomekl River mainstem. The highest maximum concentration and mean measured at Tributary 2 site was 0.662 µg/L and a value of

0.212 µg/L respectively (Table 2). This maximum concentration is above the acute endpoint (0.360 µg/L) for imidacloprid, and the mean is found to be above the chronic endpoint (0.041 µg/L). Although one sample was found to be above the acute endpoint, the highest concentrations in the 2020 study (0.662 µg/L) are are much lower than 2018 but only slightly lower than 2017 (0.74 µg/L and 3.40 µg/L, respectively).

There was no significant rainfall recorded within the days prior to sampling or on the sample date. This high detection occurrence in late July was also seen with samples on the Nicomekl River mainstem, with the maximum concentrations measured on July 7. A similar trend was seen during the 2018 sampling, where elevated levels of imidacloprid was found on July 18 in Tributary 1 (0.6 µg/L) and Tributary 2 (3.4 µg/L).

Tributary 1 also had high concentrations of imidacloprid, and all four samples had values above the chronic endpoint. The mean concentration of imidacloprid found at this location was above the chronic endpoint (0.077 µg/L). In comparison, the 2018 study shows two samples had concentrations above the acute endpoint and five samples had concentrations above the chronic endpoint for the same Tributary 1 location.

Although the lowest mean concentration for imidacloprid was found at the Nicomekl Upstream control location, imidacloprid was still detected on two of the sampling days but below the chronic and acute endpoints. The average concentration found for the control location was 0.0095 µg/L. Unfortunately, due to this detection, the control location did not serve its purpose of providing background levels. The levels detected, however, indicated the possible use of neonics further up in the watershed than originally anticipated.

During the 2018 study, there were eight samples that were found to be above the acute endpoint for imidacloprid in the tributary locations. Two additional exceedances of imidacloprid were found above the acute endpoint in 2018 at the upstream and downstream location on the Nicomekl River.

Table 2: Summary of 2020 imidacloprid concentrations measured; bolded figures exceed PMRA chronic or acute endpoint.

Sampling Location	**Sample Size**	**# above detection limit (DLM)**	**Minimum (µg/L)**	**Maximum (µg/L)**	**Mean (µg/L)**
Nicomekl Downstream	5	4	< DLM	0.018	0.013
Nicomekl Upstream	5	4	< DLM	0.017	0.012
Tributary 1	4	4	**0.042**	**0.136**	**0.077**
Tributary 2	5	5	0.019	**0.662**	**0.212**
Tributary 3	5	5	0.013	0.025	0.019
Upstream Control	5	2	< DLM	0.014	0.01

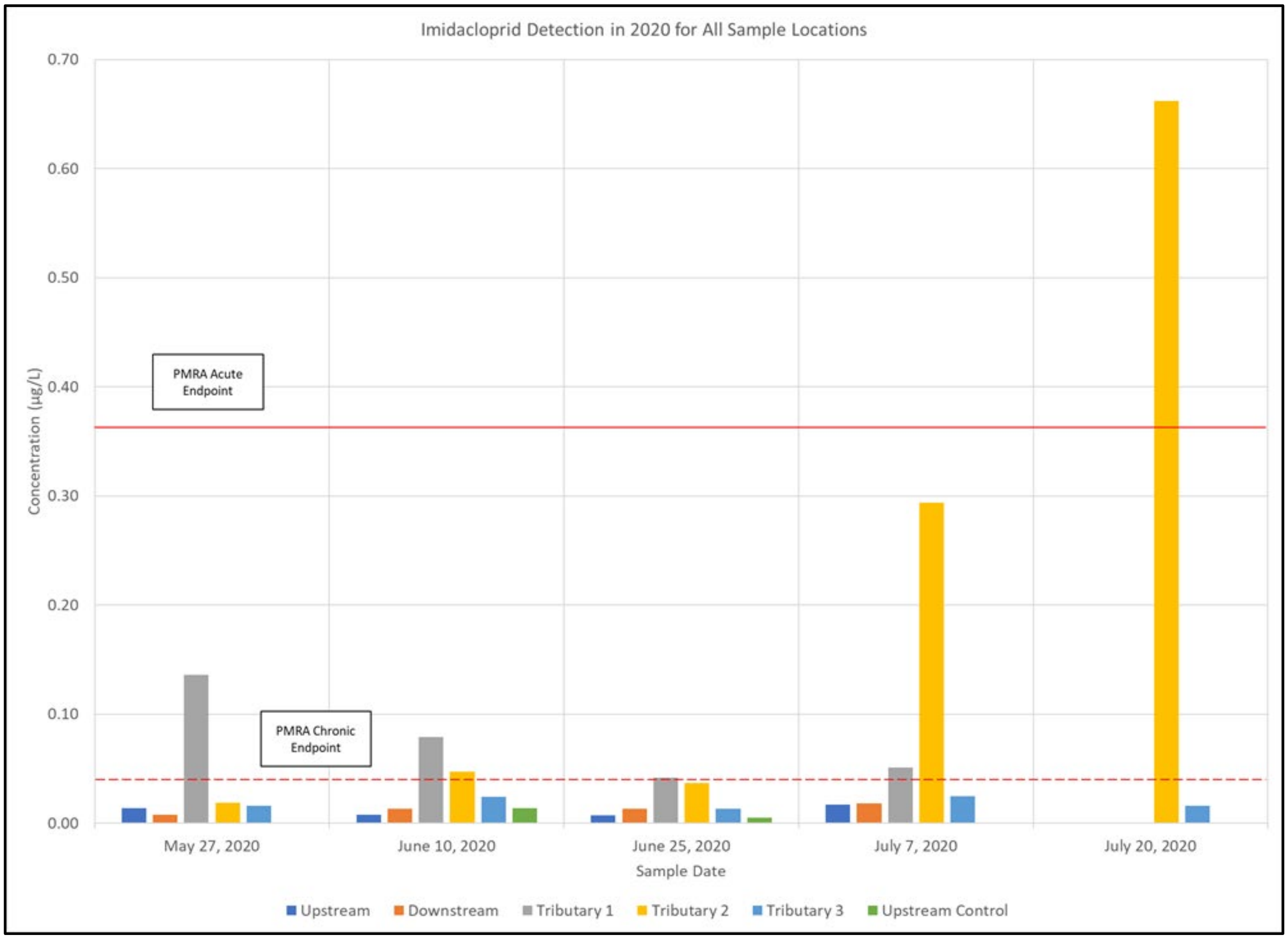

Figure 1: The concentration of imidacloprid detected at all the Nicomekl Watershed sample locations in 2020. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

5.1.2 Clothianidin

Clothianidin was only found above the lab detection limit at the Nicomekl Downstream location during the 2020 study for three out of the five samples (see Table 3). The mean value of 0.013 µg/L at this location did not exceed the chronic or acute endpoints. This detection at the Downstream location may indicate there is an application happening somewhere above this sampling site and entering the stream.

The highest values of clothianidin were found at the Nicomekl Downstream site during the 2018 study, which found a maximum concentration of 0.0312 µg/L and a mean concentration of 0.0136 µg/L. The highest concentrations were found during the period spanning from the start of May to the end of June, which is consistent with the findings in 2020. Clothianidin was also detected at the Tributary 2 location in 2018 at a very low concentration (0.0065 µg/L) however it was not detected at this location in 2020.

Table 3: Summary of 2020 clothianidin concentrations measured.

Sampling Location	Sample Size	# above detection limit (DLM)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)
Nicomekl Downstream	5	3	< DLM	0.018	0.013
Nicomekl Upstream	5	0	< DLM	n/a	n/a
Tributary 1	4	0	< DLM	n/a	n/a
Tributary 2	5	0	< DLM	n/a	n/a
Tributary 3	5	0	< DLM	n/a	n/a
Upstream Control	5	0	< DLM	n/a	n/a

5.1.3 Thiamethoxam

Only one sample measured thiamethoxam above detection limits at the Tributary 2 sample location on July 7th, 2020. The value was recorded to be just above the lab's detection limit (0.005 µg/L) (see Table 4).

Thiamethoxam was found during the 2018 study at multiple locations. It had the largest mean concentration at the Tributary 1 location (n = 1), but it had the largest overall detection at the Tributary 2 location, with thiamethoxam being above detection for all 11 sample dates.

Table 4: Summary of 2020 thiamethoxam concentrations measured.

Sampling Location	Sample Size	# above detection limit (DLM)	Minimum (µg/L)	Maximum (µg/L)	Mean (µg/L)
Nicomekl Downstream	5	0	< DLM	n/a	n/a
Nicomekl Upstream	5	0	< DLM	n/a	n/a
Tributary 1	4	0	< DLM	n/a	n/a
Tributary 2	5	1	< DLM	0.005	n/a
Tributary 3	5	0	< DLM	n/a	n/a
Upstream Control	5	0	< DLM	n/a	n/a

5.2 PMRA Endpoint Exceedances

Of the three neonic active ingredients analysed, only imidacloprid exceeded PMRA endpoints in 24% of overall data. There was a single acute endpoint exceedance for imidacloprid at the Tributary 2 sample location, and six chronic endpoint exceedances for imidacloprid at the Tributary 1 and Tributary 2 sample locations.

The highest concentration of imidacloprid was found during the last sampling date (July 20th) at the Tributary 2 sample location. The detection on this day was found to be above the current acute endpoint.

The Tributary 1 site had the most chronic endpoint exceedances for imidacloprid (100%, n = 4) out of all the locations in the 2020 study. Chronic endpoint exceedances also occurred at the Tributary 2 site for imidacloprid (40%, n = 5) and the location also had a single exceedance of the acute endpoint (20%, n = 5) in 2020. No other parameters or locations exceeded PMRA endpoints in 2020.

5.3 Summary of Findings

- Concentrations of detectable neonics were generally lower than the 2017 and 2018 concentrations measured. The 2020 data showed a significant decline in the detection of thiamethoxam and clothianidin.
- Neonic active ingredients imidacloprid, clothianidin, and thiamethoxam are still being detected in water samples collected on the Nicomekl River and its tributaries. It is unknown where neonics are entering the watercourses due to the upstream control sample showing detectable concentrations of neonics.
- The highest maximum concentrations were found for imidacloprid, followed by clothianidin, and finally thiamethoxam.
- The greatest mean concentrations were the neonics parameter imidacloprid, followed by clothianidin, and finally thiamethoxam. This is consistent with the findings from the 2017 and 2018 study.
- The highest maximum and mean concentration of imidacloprid was found at the Tributary 2 sample location. The highest maximum concentration of clothianidin was measured at the Nicomekl Downstream location, which matches the trend in 2017.
- Although imidacloprid was still detected above both chronic and acute endpoints, the overall values were lower that that recorded in the 2017 and 2018 sampling. This follows the trend of decreased detection that was seen from 2017 to 2018.
- Only a single sample was found to be above the detection limit for the active ingredient thiamethoxam.

6. CONCLUSIONS

The 2020 sampling has shown that neonics are still present in the Nicomekl watershed, but in much lower quantities than in previous years. Compliance verification and outreach activities conducted in 2019 may have contributed to reducing the concentrations of neonic pesticides measured in the Nicomekl watershed. Of the three active ingredients analysed in this study, imidacloprid was the only one found above the PMRA chronic and acute endpoints. These endpoint exceedances were found in the Nicomekl tributary sample locations.

The highest concentrations measured for imidacloprid occurred at the end of May and the end of July. These high concentrations occurred at roughly the same time in the 2018 study. Future sampling efforts should consider sampling earlier in the spring.

The Tributary 2 sample location experienced a significant increase in detection through the month of July resulting in acute endpoint exceedances during both the 2018 and 2020 study. The maximum detected concentration was much more significant in 2018, with exceedances much larger than the acute endpoint. This same trend was observed in 2020 at the same time of year, but not at the same concentration that has been historically measured. At the Tributary 1 location, endpoint exceedances were found in both studies, but again concentrations were much lower in 2020. This trend suggests the need to consider continuing inspections, with a focus on the watershed area surrounding these tributary locations.

It was previously indicated that the impact to aquatic macroinvertebrates communities in the Nicomekl River was likely due to the chemicals' cumulative toxic effect, and that increased levels of imidacloprid was the main contributing factor to this (Harker, 2020). With the overall concentration reduction and fewer endpoint exceedances of all three active ingredients seen in the 2020 data, aquatic macroinvertebrate communities may be less impacted by current toxic exposure in comparison to historical remnants of neonic products, however there may be other contaminants present in the watercourses as this study only focused on neonic pesticides. The study also only focussed on water quality compared to endpoints and did not examine other factors such as benthic invertebrates or aquatic species that may be affected by neonic pesticides.

7. RECOMMENDATIONS

- Compliance verification and outreach activities conducted in 2019 may have contributed to reducing the concentrations of neonic pesticides measured in the Nicomekl watershed in 2020; it is recommended that pesticide inspections of agricultural producers be carried out at sites located upstream from the Tributary 1 and Tributary 2 sample locations (Westcan Greenhouse, Glenwood Valley Farms, etc.), as these sample locations had high levels of imidacloprid detected and previous education efforts were focused elsewhere in the watershed.
- Concentrations continue to be higher in the upstream tributary areas of the Nicomekl watershed in comparison to the Nicomekl River mainstem. Future sampling should continue to focus on the upstream tributary locations and inform future compliance and outreach activities. Sampling multiple locations along the upstream tributaries may also help to determine potential point sources.
- Thiamethoxam was found to be below detection limit for almost all samples during 2020 and may no longer need to be tested for in future studies.
- Future sampling should be designed to determine whether neonic presence is due to ongoing use versus persistence from historical use. For example, sampling should aim to capture rainfall to determine if runoff from agricultural fields is a large source of input to the waterways. It would be beneficial to obtain a pesticide application schedule in order to evaluate the direct effects of the pesticides on the waterways following application.
- Anderson Creek (Tributary 1 sample location) dried up in mid-July, and this location may not be worth sampling in future years.
- An alternate upstream control location should be identified and should be selected further upstream or in a suitable adjacent water body with no agricultural land uses.
- Although no final decision has been made by the PMRA regarding neonics use around water bodies, the use of neonics has been restricted for certain crops (berries, cucurbit vegetables, etc.) for the protection of pollinators (PMRA, 2019). If an updated decision further restricts the

use of neonics (especially around water), sampling in the future can confirm whether these restrictions are effective.

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APPENDIX A: SUMMARY OF NEONICS DETECTIONS AND EXCEEDANCES FOR 2017, 2018, AND 2020

Table B1: List of detection and exceedances for the Nicomekl River in the 2017 study. Exceedances of the PMRA chronic endpoints are bolded, and concentration above the PMRA acute endpoints are bolded and in italics.

Stream	Position	Date	Thiamethoxam	Clothianidin	Imidacloprid
Nicomekl	Upstream	7-Jun-17	< DL	< DL	***0.74***
		19-Jun-17	< DL	< DL	**0.204**
		4-Jul-17	< DL	< DL	0.0361
		17-Jul-17	< DL	< DL	**0.045**
		31-Jul-17	< DL	< DL	0.0339
		14-Aug-17	< DL	< DL	**0.0935**
		28-Aug-17	< DL	< DL	**0.191**
		11-Sep-17	**0.187**	< DL	**0.201**
Nicomekl	Downstream	7-Jun-17	< DL	**0.0220**	**0.0440**
		19-Jun-17	< DL	**0.1630**	**0.2130**
		4-Jul-17	< DL	0.0112	**0.0545**
		17-Jul-17	< DL	< DL	0.0250
		31-Jul-17	< DL	0.0056	0.0348
		14-Aug-17	< DL	< DL	0.0253
		28-Aug-17	< DL	< DL	**0.1500**
		11-Sep-17	0.0097	< DL	**0.0837**

Table B2: List of detections and exceedances for the 2018 Nicomekl River and Tributary sampling. Exceedances of the PMRA chronic endpoints are bolded, and concentration above the PMRA acute endpoints are bolded and in italics.

Stream	Position	Date	Thiamethoxam	Clothianidin	Imidacloprid
Nicomekl	Upstream	8-May-18	0.0049	< DL	***0.5740***
		23-May-18	0.0052	< DL	**0.2480**
		6-Jun-18	0.0064	< DL	**0.0688**
		20-Jun-18	< DL	< DL	0.0302
		5-Jul-18	< DL	< DL	0.0209
		18-Jul-18	< DL	< DL	0.0183
		1-Aug-18	< DL	< DL	0.0191
		15-Aug-18	< DL	< DL	0.0144
		12-Sep-18	< DL	< DL	0.0214
		25-Sep-18	< DL	< DL	**0.0805**
Nicomekl	Downstream	8-May-18	< DL	0.0054	**0.2830**
		23-May-18	< DL	0.0117	***0.3950***
		6-Jun-18	< DL	0.0062	**0.1540**
		20-Jun-18	< DL	**0.0312**	0.0329
		5-Jul-18	< DL	< DL	0.0214
		18-Jul-18	< DL	< DL	0.0225
		1-Aug-18	< DL	< DL	0.0103
		15-Aug-18	< DL	< DL	0.0086
		12-Sep-18	< DL	< DL	**0.0635**
		25-Sep-18	< DL	< DL	**0.0427**
Nicomekl	Tributary 1	8-May-18	< DL	< DL	***0.9040***
		23-May-18	< DL	< DL	**0.2710**
		6-Jun-18	< DL	< DL	0.0191
		20-Jun-18	< DL	< DL	0.0094
		5-Jul-18	< DL	< DL	**0.1310**
		18-Jul-18	**0.1460**	< DL	***0.6050***
		1-Aug-18	< DL	< DL	**0.0535**
		15-Aug-18	< DL	< DL	**0.0483**
		26-Sep-18	< DL	< DL	**0.0735**
Nicomekl	Tributary 2	8-May-18	0.0080	< DL	0.0229
		23-May-18	**0.0295**	< DL	**0.0590**
		6-Jun-18	**0.0276**	< DL	**0.2170**
		20-Jun-18	0.0212	< DL	**0.0948**
		5-Jul-18	**0.0328**	< DL	***1.6100***
		18-Jul-18	**0.0323**	< DL	***3.4000***
		1-Aug-18	**0.0346**	0.0058	**0.2390**
		15-Aug-18	**0.0310**	0.0072	**0.1590**
		28-Aug-18	**0.0275**	0.0074	***0.5350***
		12-Sep-18	0.0235	0.0056	**0.1120**
		26-Sep-18	0.0052	< DL	**0.2890**
Nicomekl	Tributary 3	8-May-18	**0.0268**	< DL	***1.7600***
		23-May-18	0.0206	< DL	***0.8850***
		6-Jun-18	0.0210	< DL	**0.2040**
		20-Jun-18	0.0069	< DL	**0.1050**
		5-Jul-18	0.0049	< DL	**0.0716**
		18-Jul-18	0.0097	< DL	**0.0825**
		1-Aug-18	0.0161	< DL	**0.0625**
		15-Aug-18	0.0081	< DL	**0.0575**
		28-Aug-18	< DL	< DL	0.0344
		12-Sep-18	0.0149	0.0050	**0.0885**
		26-Sep-18	0.0046	< DL	**0.1140**

Table B3: List of detections and exceedances for the 2020 Nicomekl River and Tributary sampling. Exceedances of the PMRA chronic endpoints are bolded, and concentration above the PMRA acute endpoints are bolded and in italics.

Stream	Position	Date	Thiamethoxam	Clothianidin	Imidacloprid
Nicomekl	Upstream	27-May-20	<0.0050	<0.0050	0.014
		10-Jun-20	<0.0050	<0.0050	0.008
		25-Jun-20	<0.0050	<0.0050	0.007
		07-Jul-20	<0.0050	<0.0050	0.017
		20-Jul-20	<0.0050	<0.0050	<0.010
Nicomekl	Downstream	27-May-20	<0.0050	0.015	0.008
		10-Jun-20	<0.0050	0.018	0.013
		25-Jun-20	<0.0050	<0.0050	0.013
		07-Jul-20	<0.0050	0.006	0.018
		20-Jul-20	<0.0050	<0.0050	<0.010
Nicomekl	Tributary 1	27-May-20	<0.0050	<0.0050	**0.136**
		10-Jun-20	<0.0050	<0.0050	**0.079**
		25-Jun-20	<0.0050	<0.0050	**0.042**
		07-Jul-20	<0.0050	<0.0050	**0.051**
		20-Jul-20	n/a	n/a	n/a
Nicomekl	Tributary 2	27-May-20	<0.0050	<0.0050	0.019
		10-Jun-20	<0.0050	<0.0050	**0.047**
		25-Jun-20	<0.0050	<0.0050	0.037
		07-Jul-20	0.005	<0.0050	**0.294**
		20-Jul-20	<0.0050	<0.0050	***0.662***
Nicomekl	Tributary 3	27-May-20	<0.0050	<0.0050	0.016
		10-Jun-20	<0.0060 (DLM)	<0.0050	0.024
		25-Jun-20	<0.0050	<0.0050	0.013
		07-Jul-20	<0.0050	<0.0050	0.025
		20-Jul-20	<0.0050	<0.0050	0.016
Nicomekl	Upstream Control	27-May-20	<0.0050	<0.0050	<0.0050
		10-Jun-20	<0.0050	<0.0050	0.014
		25-Jun-20	<0.0050	<0.0050	0.005
		07-Jul-20	<0.0050	<0.0050	<0.0051 (DLM)
		20-Jul-20	<0.0050	<0.0050	<0.010 (DLM)

APPENDIX B: NEONICS IN THE NICOMEKL WATERSHED OVER TIME

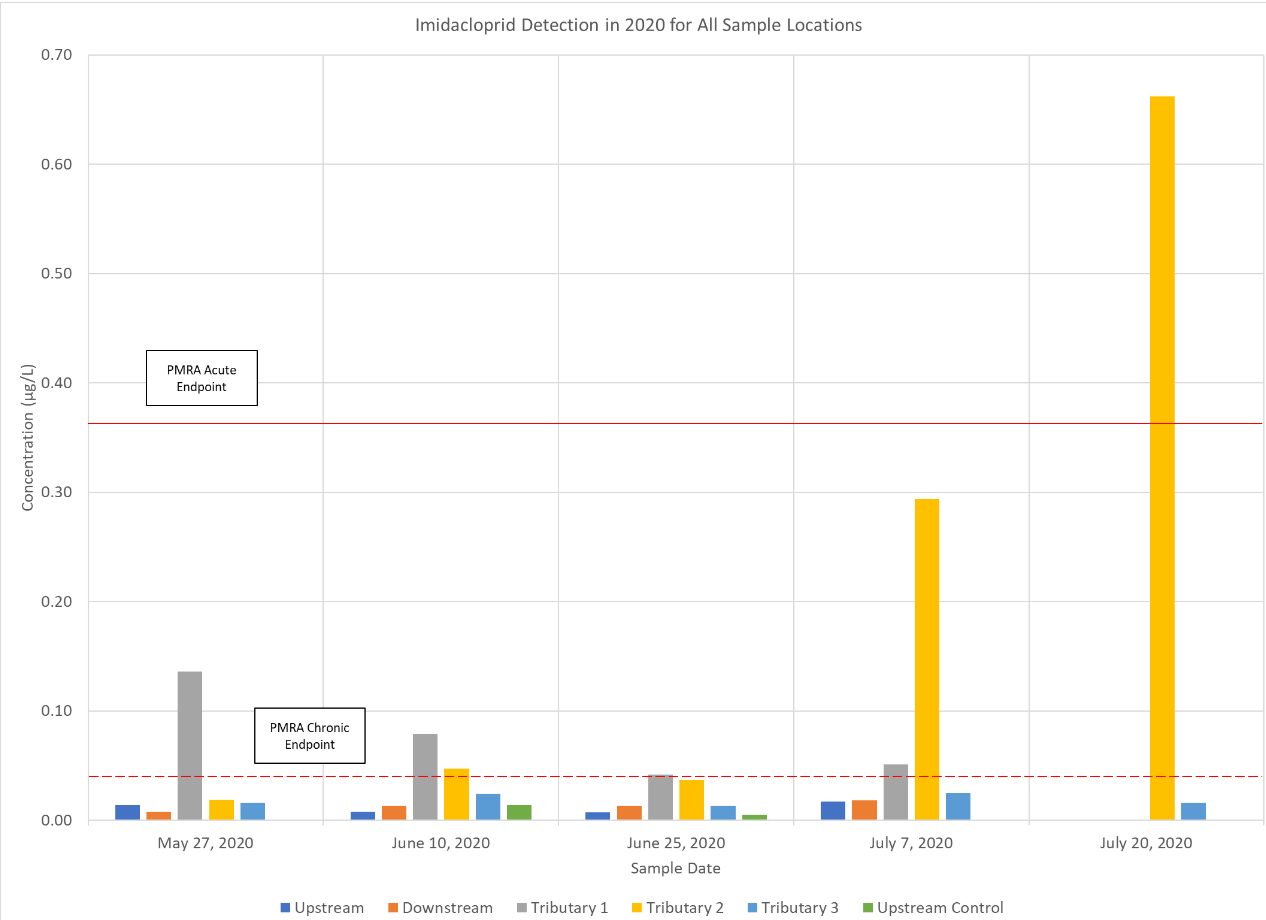

Figure C1: The concentration of imidacloprid detected at all Nicomekl Watershed sample locations in 2020. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

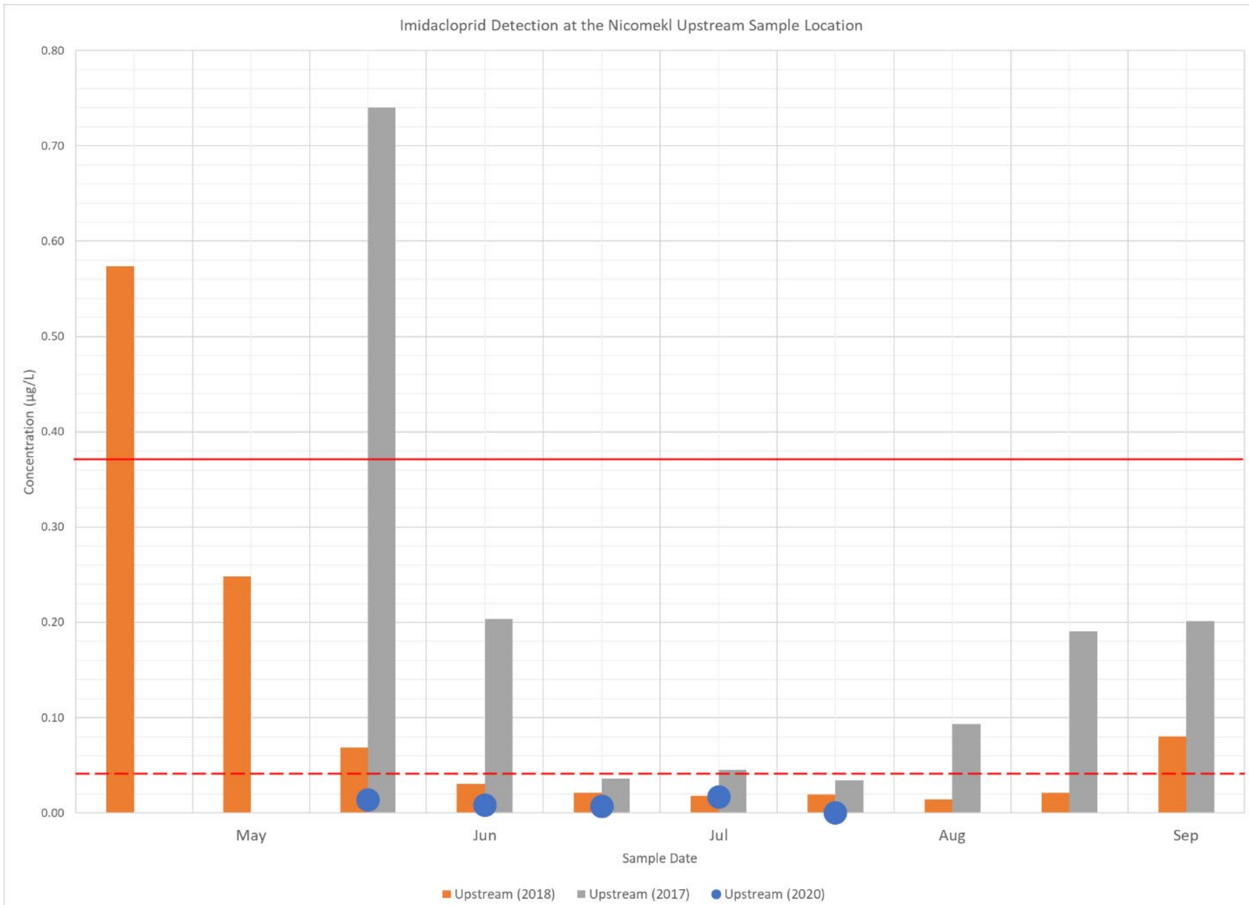

Figure C2: The concentration of imidacloprid detected at the Nicomekl Upstream location during the 2017, 2018, and 2020 sampling years. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

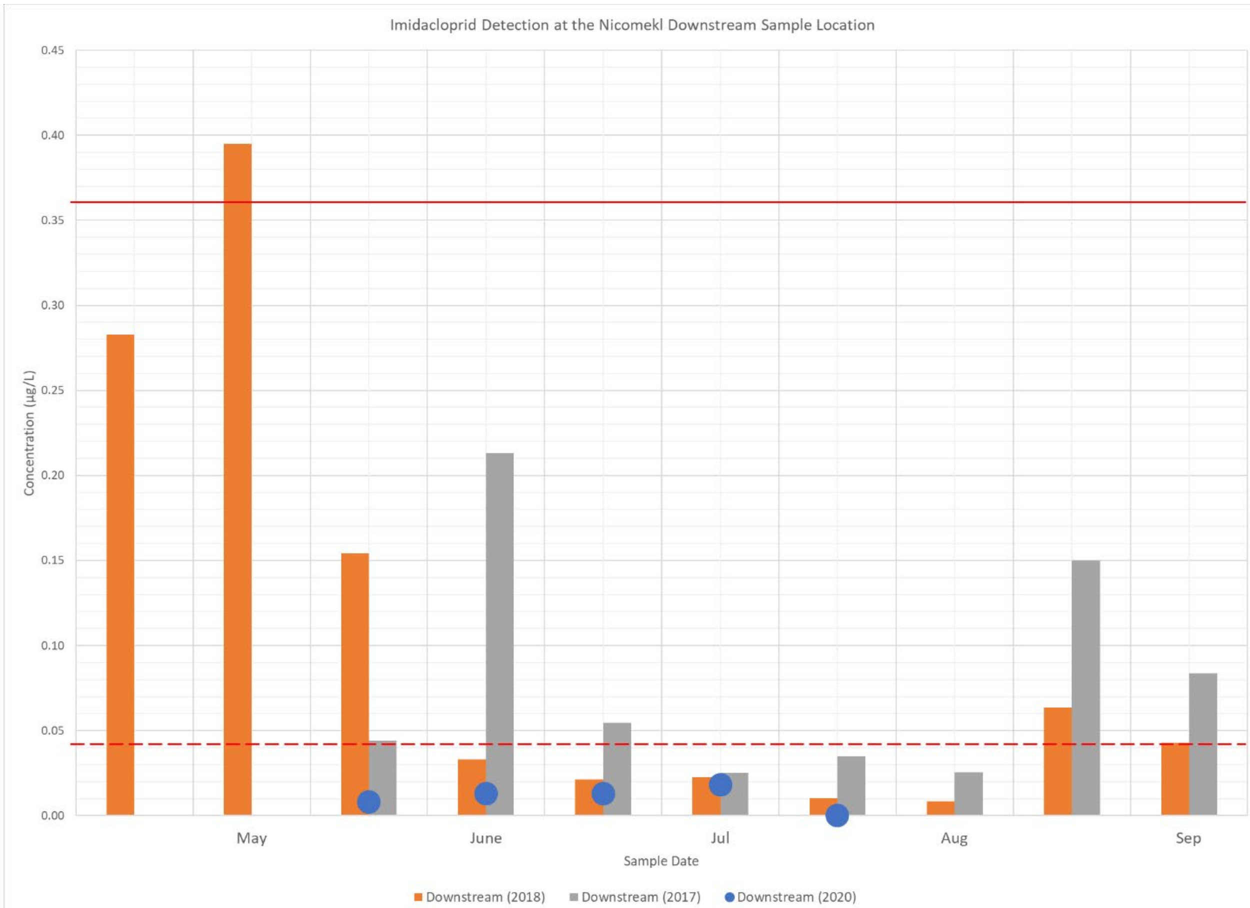

Figure C3: The concentration of imidacloprid detected at the Nicomekl Downstream location during the 2017, 2018, and 2020 sampling years. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

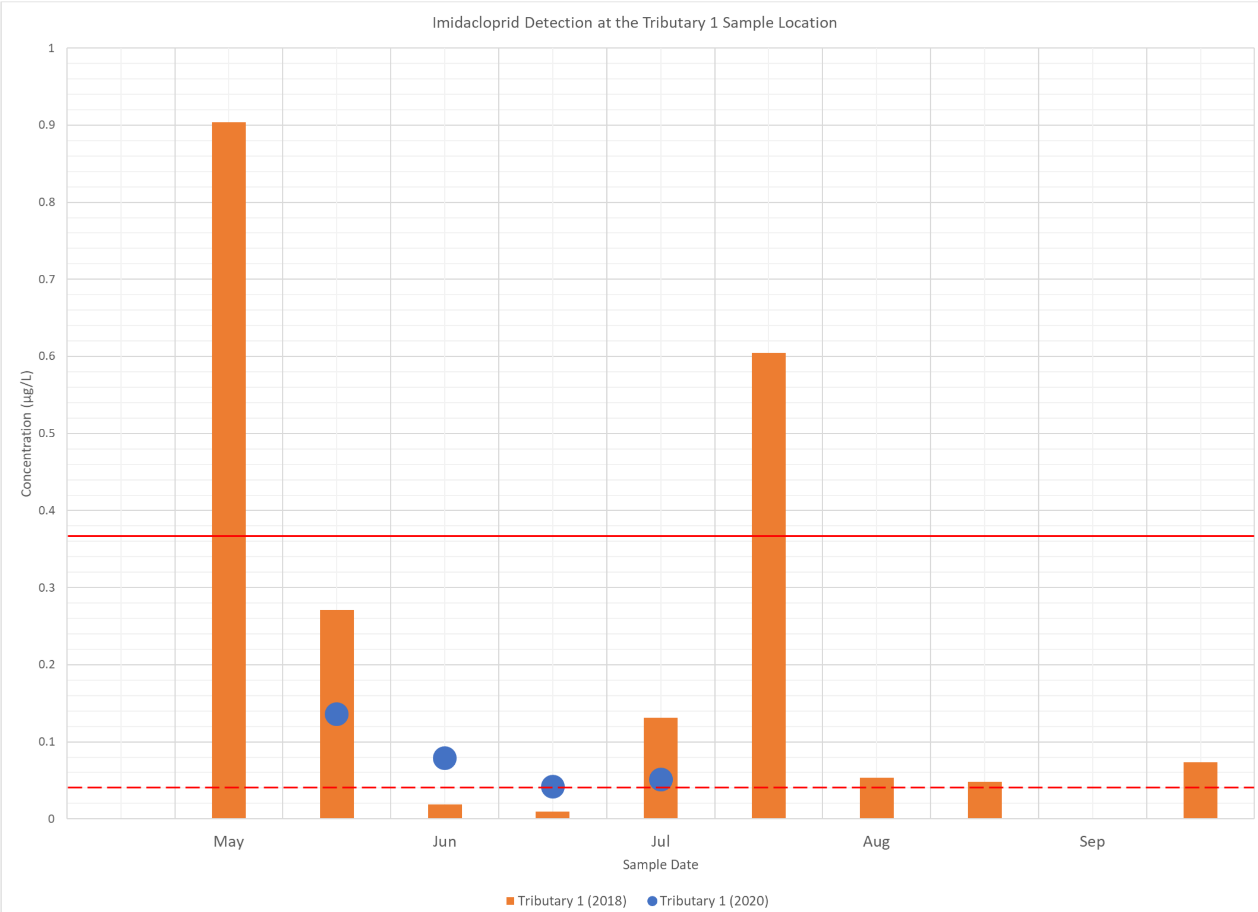

Figure C4: The concentration of imidacloprid detected at the Tributary 1 location during the 2018 and 2020 sampling years. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

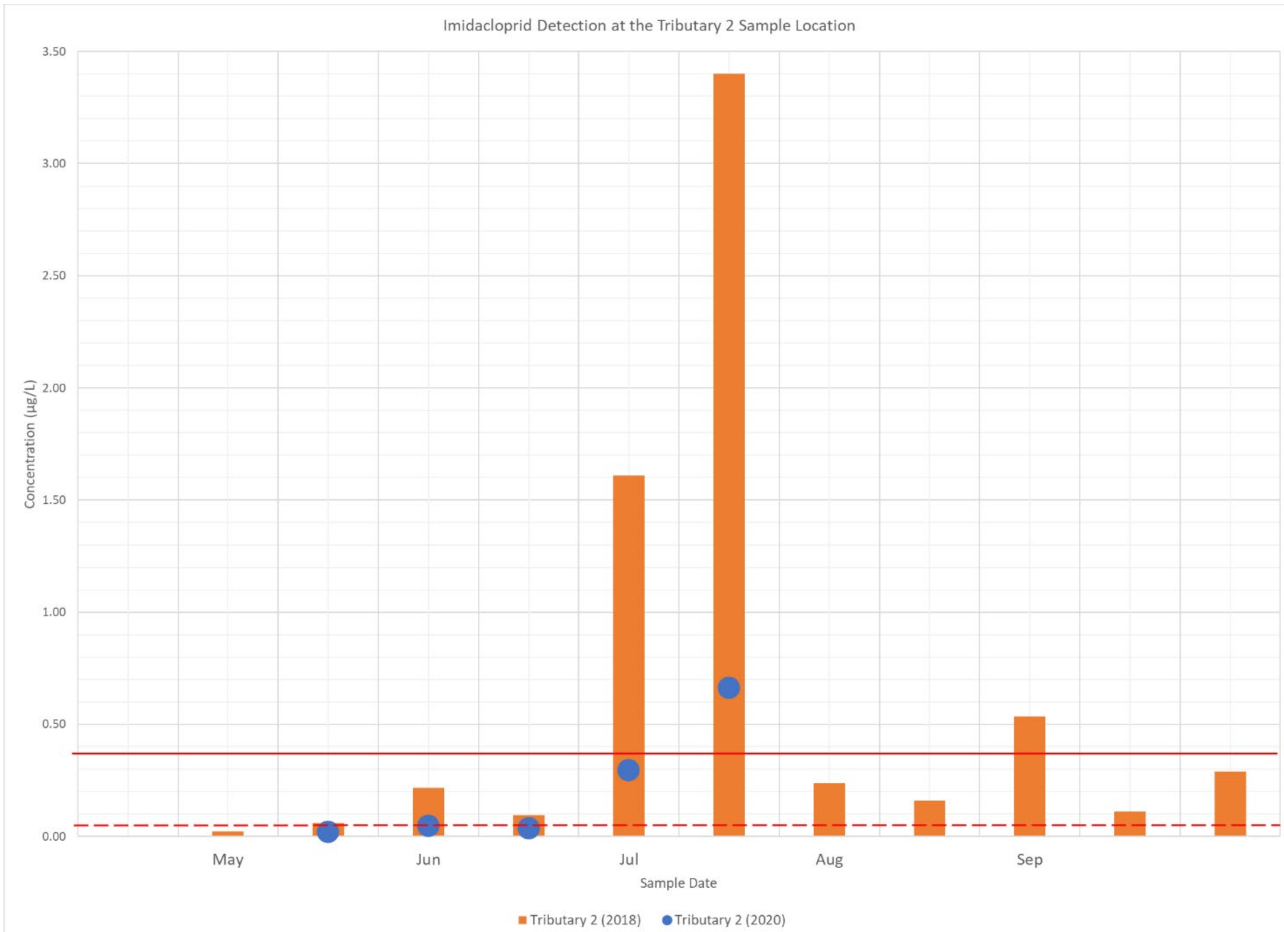

Figure C5: The concentration of imidacloprid detected at the Tributary 2 location during the 2018 and 2020 sampling years. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

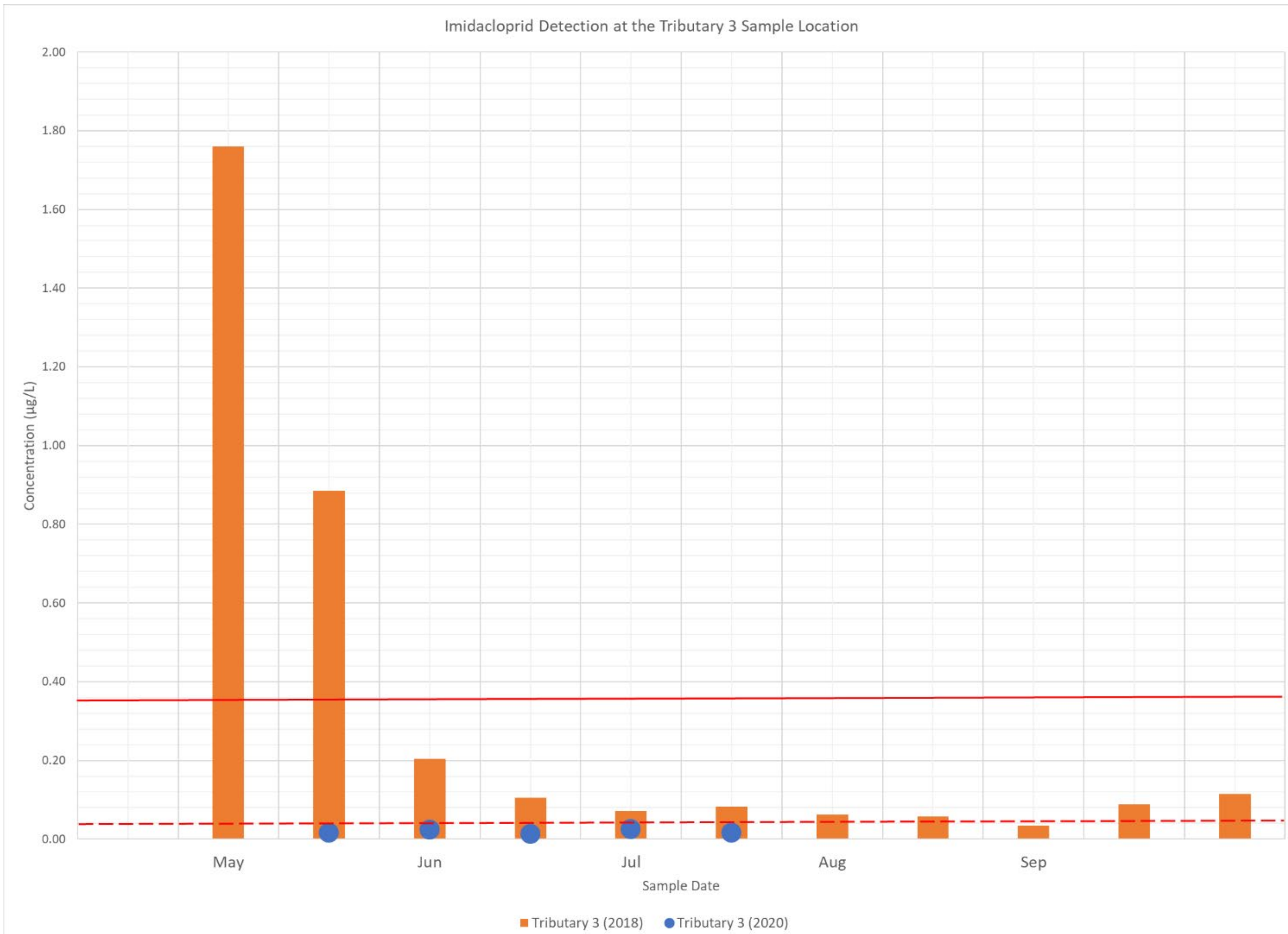

Figure C6: The concentration of imidacloprid detected at the Tributary 3 location during the 2018 and 2020 sampling years. The red line represents the PMRA acute endpoint at 0.36 µg/L. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

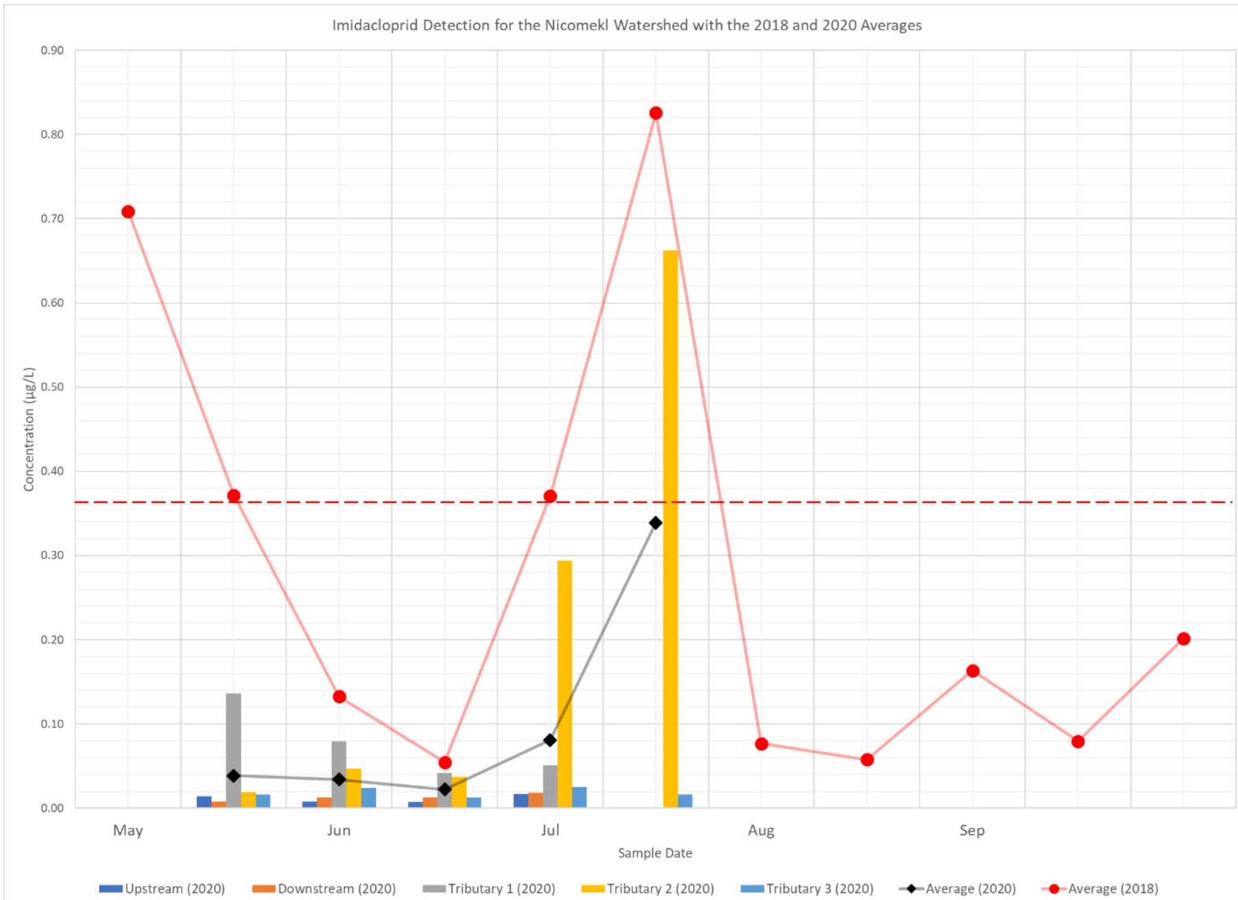

Figure C7: The concentration of imidacloprid for five of the sample locations in 2020 compared to the sample day average taken for imidacloprid in 2018 (solid red line). The black line represents the sample day average in 2020 for imidacloprid. The red dashed line represents the PMRA chronic endpoint at 0.041 µg/L.

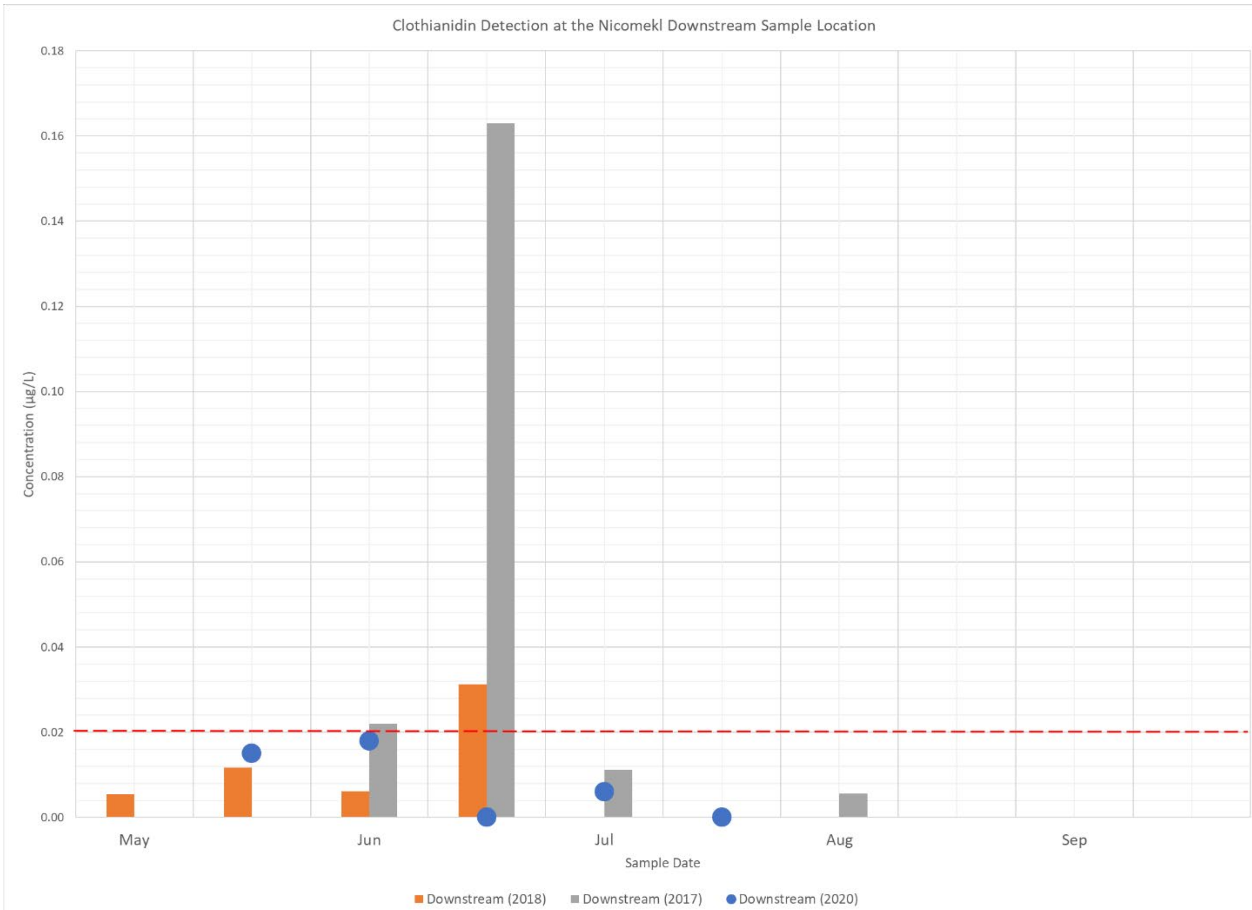

Figure C8: The concentration of clothianidin detected at the Nicomekl Downstream location during the 2017, 2018, and 2020 sampling years. The red dashed line represents the PMRA chronic endpoint at 0.02 µg/L. The solid black line represents the labs detection limit at 0.005 µg/L.

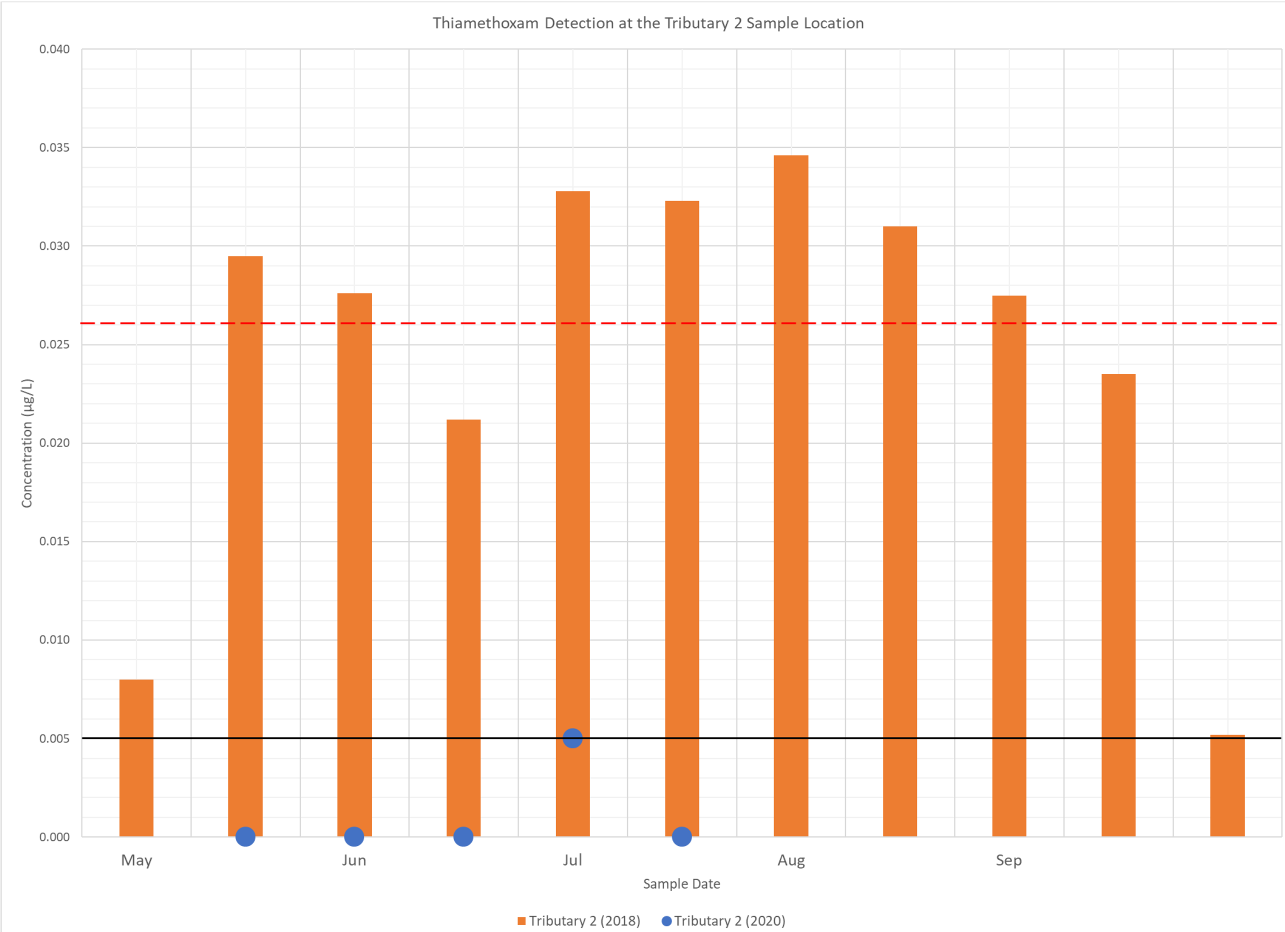

Figure C9: The concentration of thiamethoxam detected at the Tributary 2 location during the 2018 and 2020 sampling years. The red dashed line represents the PMRA chronic endpoint at 0.026 µg/L. The solid black line represents the labs detection limit at 0.005 µg/L.

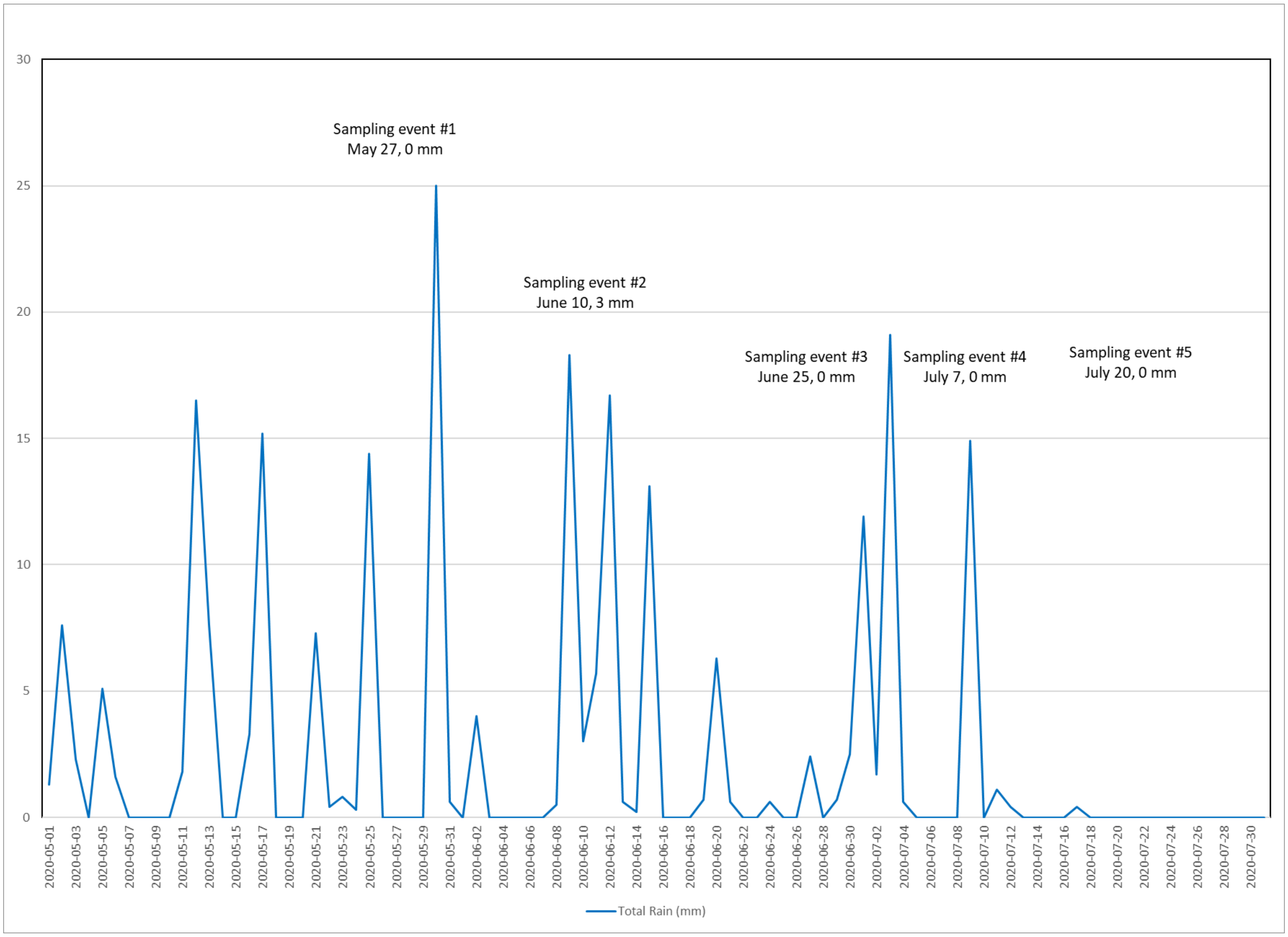

Figure C10: Rainfall data between May and July 2020 at the Abbotsford A station (Environment Canada).