Air Quality Evaluation - Saint-François de Madawaska

Interim Report

Department of Environment and
Local Government
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Errata

The May 23, 2019 revisions address an error in the processing of data from the industry-operated fence line particulate monitor (DusTrak). Original averages calculated from this data were not subjected to the necessary data completeness criteria (75%).

The corrections resulted in changes to four values in Table 2, one value in Table 3, the replacement of Figure 6, and the replacement of three figures in Appendix F. Text related to these values was also modified in Section 1.0, subsection 5.4.1, and Section 6.0.

The report is unchanged in all other respects.

Data for this study was collected in partnership with Environment and Climate Change Canada using equipment provided through the National Air Pollution Surveillance (NAPS) program.

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1.0 Executive Summary

In 2016 the Department of Environment and Local Government (DELG) began receiving air quality complaints from homeowners in the Saint-François de Madawaska area of the Rural Community of Haut-Madawaska, New Brunswick. A fertilizer plant in the community was identified by the complainants as the source of the air quality problem. The fertilizer plant implemented mitigative actions in 2017 in response to the complaints. However, this did not resolve the issue.

Air quality monitoring equipment was deployed to the area on April 6, 2018 to assess local air quality. Continuous air quality measurements were undertaken for a variety of common air contaminants. This report provides interim results and analysis of the findings from this monitoring work in support of a Health Risk Assessment that is being undertaken by the Office of the Chief Medical Officer of Health. The monitoring work is ongoing.

To date, monitoring has identified a number of events involving particulate matter (suspended dust/smoke). The two most significant particulate events involved exceedances of standard/guideline values. One was due to a road resurfacing project. The cause of the second could not be determined.

It was also found that the particulate concentrations at the property line of the fertilizer plant exceeded its permitted limit (as specified in its Certificate of Approval to Operate) on seven occasions.

Analysis of the collected pollutant data, along with corresponding wind data, the reported operating hours for the fertilizer plant, and citizen complaint data, suggests a relationship between particulate emissions from the fertilizer plant and the odour/health issues reported by the community.

To further explore this relationship, future investigations should include efforts to better characterize the chemical composition of the emissions (especially the chemical composition of particulate emissions) from the fertilizer plant via emissions testing.

2.0 Introduction

2.1 Background

In 2016 the Department of Environment and Local Government (DELG) began receiving air quality complaints from homeowners in the Saint-François de Madawaska area of the Rural Community of Haut-Madawaska, New Brunswick. The primary issue reported was odour. However, a variety of health impacts were also described.

Area residents indicated that the source of the air quality issue was the operation of a nearby fertilizer plant, which produces fertilizer by drying poultry bedding waste (a mixture of wood shavings and poultry manure). The facility burns wood waste to produce the necessary heat for the drying of the product.

Although the fertilizer plant has been in operation since 2003, citizen complaints did not begin until 2016. Available information about the plant suggests that their process did not change at that time. The plant changed its fuel source from poultry bedding waste to wood waste in 2017, but citizen complaints were not affected.

2.2 Area Emission Sources

Air pollution sources in the Saint-François de Madawaska area include a fertilizer plant, poultry farms, a poultry manure storage and handling facility, vehicle traffic, wood smoke, and wind-blown dust from dirt roads and soil tilling/disturbance.

There is a chicken processing plant approximately 4 kilometers east of the area, and other industrial activities approximately 10 kilometers east. These facilities are considered unlikely to be significantly impacting air quality in the affected area.

As is the case for all of New Brunswick, the Saint-François de Madawaska area also receives long-range (transboundary) air pollution impacts (primarily fine particulates and ground level ozone) from pollution sources elsewhere in the World.

Although there are several air pollution emissions sources affecting the area, the fertilizer plant is the only facility that is required to obtain, and operate in accordance with, an Air Quality Approval issued by DELG. Through the regulatory requirements of the *Clean Air Act*, DELG has access to information about this facility that is not available for other area emissions sources. This includes operational and design details, emissions testing data, and air quality monitoring data from equipment on the plant property. This provides opportunity for analyses involving this air pollution source that are not possible for other air pollution sources in the area.

Emissions from the fertilizer plant include combustion products from the furnace, exhaust gases from the drying process, vehicle (trucking) exhaust, and windblown dust from the property.

2.3 Project Design and Location

Based on a review of the facility design for the fertilizer plant, and consideration of other nearby emission sources, a broad suite of common air contaminants was selected for inclusion in the evaluation. A list of the included pollutant parameters is provided in Appendix A along with the rationale for the inclusion of each.

The work was carried out in the Saint-François de Madawaska area, which is part of the Rural Community of Haut-Madawaska, in Madawaska County, New Brunswick. This is a rural, lightly populated, agricultural area with significant forest cover.

The monitoring location was selected to be representative of the local community based on prevailing wind patterns, the pattern of complaints received from the area, and input from local residents and DELG regional personnel.

The DELG mobile air quality monitoring unit was positioned at the project site (approximately 47°14'48.65"N 68°46'12.94"W), which is approximately 1,700 meters South Southeast of the previously mentioned fertilizer plant. The site is within the river valley of Crocs River, which runs approximately northwest to southeast at this location. The project site and surrounding area is pictured in Figure 1.

2.4 Project Timing

DELG deployed its mobile air quality monitoring unit to the Saint-François de Madawaska area in March 2018, and data collection for most parameters began on April 6, 2018. As described below, additional parameters were added to the project in response to initial findings. This report examines all data collected during the April 6 to September 6, 2018 period.

3.0 Methodology

3.1 Meteorology Equipment

Meteorological equipment (Vaisala model WXT520) was deployed at the project site to provide wind speed and wind direction data. The meteorological unit also collected relative humidity, temperature, and barometric pressure parameters.

All monitored meteorological parameters were logged as five-minute averages and retrieved automatically on an hourly basis.

3.2 Continuous Air Quality Monitoring Equipment

Continuous monitors provide objective measurements of air quality at all times, and do not rely on modelling or statistical approximations. With the exception of brief, intermittent, calibration cycles and occasional malfunctions, there are no gaps in coverage. Air is constantly drawn through the monitors.

Continuous monitoring equipment was deployed to measure ambient (outside air) concentrations of nitrogen dioxide (NO_2), ground level ozone (O_3), sulphur dioxide (SO_2), total reduced sulphur (TRS), and carbon monoxide (CO). These parameters were logged as five-minute averages. Monitoring of these parameters began on April 6, 2018 and continued through September 6, 2018.

Equipment was also deployed to continuously measure ambient concentrations of particulate matter. Fine particulate matter ($PM_{2.5}$) was logged as hourly averages from April 6 until May 31, 2018, and then as five minute averages (via a different instrument) through September 6, 2018. Total suspended particulate (TSP) was logged as hourly averages from May 31 through September 6, 2018. Respirable particulate (PM_{10}) was logged as

Figure 1. Project Site and Surrounding Area (Image courtesy of Google Earth)

five-minute averages from May 31 through September 6, 2018.

The noted additions (PM_{10} and TSP) to particulate monitoring (on May 31, 2018) were undertaken in response to a particulate event that was experienced by DELG staff while on site, but which was not detected by the $PM_{2.5}$ monitor (or other non-particulate monitors).

A monitor was also deployed to continuously measure ambient concentrations of ammonia (NH_3). This data was logged as five-minute averages, and began on June 1, 2018 and continued through September 6, 2018.

Data was retrieved automatically on an hourly basis for all continuous parameters.

Technical specifications for all continuous instruments are provided in Appendix B.

3.3 Integrated Sampling of Ammonia

Integrated sampling involves the collection of a single sample over an extended period of time. These samples are subsequently analyzed by a laboratory. The collected values represent the "average" concentration of the monitored contaminant experienced over the exposure period. This method offers the benefit of lower detection limits as compared to the continuous method described above for ammonia. However, any short-term events are "averaged in" to the integrated samples.

An Ogawa Passive Monitoring Sampler with a rain shelter was deployed to collect ammonia concentration samples from ambient air via passive absorption. Samples were exposed to ambient air for two-week periods. A total of six samples (plus duplicates) were collected. Sample collection began on April 6, 2018 and concluded on June 28, 2018.

Collected samples were analyzed for NH_3 concentration by Maxxam Analytics International Corporation via method PTC SOP-00157, which incorporates American Society for Testing and Materials method D6919.

3.4 Other Data Sources

Particulate data was collected at the fertilizer plant by the facility operator during the reporting period (April 6, 2018 to September 6, 2018). A DELG particulate monitor was also installed at this location from May 2 until July 31, 2018. This location is illustrated in Figure 1 and is referred to as the "property line" monitoring location throughout this report.

Complaints to the DELG regional office, and to the Regional Medical Officer of Health were logged throughout the study period with as much specificity as possible (regarding date and timing of event). Complaint data was edited for duplicates (complaints reported to both Departments for the same event from the same complainant, or if several people from a single household complained).

The hours of operation for the fertilizer plant were logged by the facility operator.

3.5 Excluded Parameters

Local residents identified arsenic emissions as a potential issue, as it has been identified as a contaminant of concern from similar fertilizer facilities in other parts of the world. However, this parameter is not included in the current evaluation because the potential for arsenic

emissions from this particular facility is extremely low. This is because arsenic is banned from poultry feed in Canada, and the wood fuel used by the facility is not treated with arsenic. Consideration was also given to the monitoring of Volatile Organic Compounds (VOCs). Although the fertilizer facility will generate VOCs, the emissions potential for specific problematic VOC species is low. It was also noted that the primary impact of VOC emissions, in aggregate, would be their contribution to the formation of ground level ozone (O_3), which is a key component of smog. As this end product (O_3) is already included in the parameter list, this concern is already suitably addressed.

Dioxins and furans (as a component of particulate emissions) were considered for inclusion but rejected due to low potential for emissions (equivalent to other wood fired boilers). Also, it was noted that the potential health impact from these contaminants is via oxidative stress. Fine particulate matter ($PM_{2.5}$) is included as a surrogate for all particulate-bound chemical species causing oxidative stress.

3.6 Quality Assurance

Data collection and validation for DELG-operated equipment was conducted in accordance with the *National Air Pollution Surveillance (NAPS) network quality assurance and quality control guidelines* (*Environment Canada Report No.* AAQD 2004-1). DELG is periodically audited by Environment and Climate Change Canada to ensure that operations throughout its network remain consistent with these guidelines.

4.0 Results

4.1 Meteorology - Wind at Project Site

Winds at the project site originated generally from the North and North Northwest during the study period. North and North Northwesterly winds (i.e., blowing from the direction of the fertilizer plant toward the study site) were frequent, occurring 48% of the time.

A distinct “time of day” effect was also noted wherein winds originated from the North more often during nighttime hours. During the overnight period (8:00 PM to 8:00 AM) winds were northerly 62% of the time, whereas winds were northerly only 37% of the time during daylight hours (8:00 AM to 8:00 PM).

Wind data is further illustrated in Appendix C.

4.2 Continuous Monitors at Project Site

Summary statistics for each of the continuously monitored parameters at the project site are provided in Table 1.

Additional data for each parameter is illustrated graphically in Appendix D.

4.3 Integrated Sampling at Project Site

The average ammonia concentration at the project site over the April 6 to June 28, 2018 period was 12 ppb. The lowest 2-week average value was 6.4 ppb, and the highest 2-week average value was 22 ppb.

The full data set for the integrated ammonia sampling is provided in Appendix E.

Table 1: Summary Statistics - Continuously Monitored Parameters at Project Site

Parameter	Average Concentration (5 Month)	Peak Concentration (24-hour average)	Peak Concentration (1-hour average)	Peak Concentration (5-minute average)
Sulphur Dioxide (SO_2)	<0.1 ppb	2.6 ppb	3.3 ppb	29.0 ppb
Total Reduced Sulphur (TRS)	0.1 ppb	0.4 ppb	0.9 ppb	2.4 ppb
Nitrogen Dioxide (NO_2)	1.2 ppb	3.6 ppb	23.1 ppb	43.2 ppb
Ground Level Ozone (O_3)	23.6 ppb	45.0 ppb	60.0 ppb	60.5 ppb
Carbon Monoxide (CO)	0.2 ppb	0.4 ppb	0.5 ppb	1.0 ppb
Ammonia (NH_3)	<1 ppm (See note 1)	<1 ppm (See note 1)	<1 ppm (See note 1)	<1 ppm (See note 1)
Fine Particulate ($PM_{2.5}$)	7 µg/m^3 (See note 2)	22 µg/m^3 (See note 2)	62 µg/m^3 (See note 2)	74 µg/m^3 (See note 3)
Respirable Particulate (PM_{10})	21 µg/m^3 (See note 4)	138 µg/m^3	534 µg/m^3	1222 µg/m^3
Total Suspended Particulate (TSP)	25 µg/m^3 (See note 4)	241 µg/m^3	>985 µg/m^3 (See note 5)	NA (See note 6)

Note 1: All values at or below the lower detection limit for the instrument (1 ppm).
Note 2: This represents the combined data from two different instruments (instrument change occurred on May 31, 2018).
Note 3: Peak value recorded from May 31, 2018 to September 6, 2018. The instrument in place prior to this period was not capable of producing 5-minute averages.
Note 4: Three-month average. This instrument was added on May 31, 2018.
Note 5: On three occasions (August 13, 2018 at 20:00, August 14, 2018 at 09:00, and August 14, 2018 at 18:00) concentrations exceeded the upper detection limit for the instrument (985 µg/m^3).
Note 6: This instrument cannot produce 5-minute averages.

4.4 Other Data

4.4.1 Particulate Concentrations at Fertilizer Plant Property Line

Summary statistics for each of the continuously monitored parameters at the property line site are provided in Table 2. Please note that baseline (zero) correction was applied to the data for the industry-run monitor based on zero data from the DELG monitor. Additional data for each parameter is illustrated graphically in Appendix F.

Table 2: Summary Statistics - Continuously Monitored Parameters at Fertilizer Plant Property Line

Parameter	Average Concentration (5 Month)	Peak Concentration (24-hour average)	Peak Concentration (1-hour average)	Peak Concentration (5-minute average)
Fine Particulate ($PM_{2.5}$) (DELG Monitor)	14 µg/m^3 (See Note 1)	137 µg/m^3	433 µg/m^3	NA (See note 2)
Fine Particulate ($PM_{2.5}$) (Industry Monitor)	18 µg/m^3	181 µg/m^3	805 µg/m^3	1380 µg/m^3
Respirable Particulate (PM_{10}) (Industry Monitor)	23 µg/m^3	245 µg/m^3	1166 µg/m^3	1820 µg/m^3
Total Suspended Particulate (TSP) (Industry Monitor)	23 µg/m^3	251 µg/m^3	1224 µg/m^3	1870 µg/m^3

Note 1: Three-month average. This instrument operated from May 2, 2018 to July 31, 2018.
Note 2: This instrument cannot produce 5-minute averages.

As indicated in Tables 1 and 2, particulate levels measured by the industry-run monitor at the property line location were markedly different (higher) than the levels measured at the project site. However, these levels were also much higher than the levels detected at the collocated DELG monitor at the property line (comparing only $PM_{2.5}$ values for both monitors, as this is the only fraction available for the DELG monitor). This is particularly evident during peak events wherein the industry-run monitor reported $PM_{2.5}$ values approximately 20% to 100% higher than the DELG monitor.

There was close agreement between the DELG and industry-run monitor with respect to the timing (but not the magnitude) of peak events. This level of agreement provides confidence that the data from the industry-run monitor accurately identifies peak events.

The DELG monitor is certified by the United States Environmental Protection Agency (USEPA) for this type of work, whereas the industry-run (DusTrak) monitor is not. Due to the limitations of the DusTrak data the analysis of particulate levels at the property line location will rely primarily on the DELG monitor.

4.4.2 Observational Data (Citizen Complaints)

A total of 173 complaints were logged by 11 households during the April 6 to September 6, 2018 reporting period. This corresponds to an average of approximately 8 complaints per week. The daily complaint log is provided along with a graphical illustration in Appendix G.

4.4.3 Fertilizer Plant Operating Hours

From April 6, 2018 through May 31, 2018 the fertilizer plant typically operated Monday to Thursday, running 10 to 18 hour shifts each day. Shifts typically began in the 6:30 AM to 8:30 AM period and ended in the 12:30 AM to 2:00 AM period.

On May 31, 2018 the plant restricted its operating hours upon the recommendation of the Department of Health. From June 1, 2018 to September 6, 2018 the plant's operational hours were more irregular, but still typically running Monday to Thursdays. However, the shifts were shorter (5 to 9 hours), and occurred both during the daytime and the night. On average, the facility operated 60.6 hours per week from April 6, 2018 to May 31, 2018. Following the change, the average weekly operating hours fell to 27.3 hours per week.

Daily and weekly hours of operation data for the fertilizer plant are illustrated graphically in Appendix H.

5.0 Analysis and Discussion

5.1 Comparisons to Standards and Guidelines

The following analysis compares the monitored values against objective ambient air quality standards. New Brunswick has adopted "Maximum Permissible Ground Level Concentrations" under the *Air Quality Regulation* (New Brunswick Regulation #97-133) - *Clean Air Act* for several contaminants. However, the Regulation does not address all contaminants. In these cases, concentrations are evaluated against standard or guideline values that have been adopted by policy (*e.g.*, national standards, standards adopted by other jurisdictions, or guidelines adopted by various national or international agencies).

Note that air quality standards take a variety of statistical forms (*e.g.*, hourly averages, daily averages, annual averages, daily maximum, etc.). These various forms have been crafted to support specific environmental or public health goals. However, it is beyond the scope of this report to explore the underlying rationale for each. Rather, this analysis will focus on a simple comparison against the standards and guidelines that are relevant to the evaluation.

In order to compare results against regulated standards and guidelines the data must be converted into the correct form. For instance, by averaging 12 five-minute averages together to create a 1-hour average. In some cases the data collected cannot be converted into the appropriate form. However, approximations can sometimes be applied (*e.g.*, comparing data collected over 5 months against a standard that is based on annual average conditions).

Monitoring results from the project site are compared against regulated standards and guideline values in Table 3.

Table 3: Comparisons to Standards and Guidelines

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Sulphur Dioxide (SO_2)	339 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	3.3 ppb (Highest 1-hour value recorded)	
	113 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	2.6 ppb (Highest 24-hour value recorded)	
	23 ppb (Annual average)	N.B. Reg. 97-133, *Clean Air Act*	<0.1 ppb (5-month average)	The standard is based on average conditions measured over 1 year, whereas only 5 months of data is available.
Total Reduced Sulphur (TRS)	11 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.9 ppb (Highest 1-hour value recorded)	These standards are for one specific reduced sulphur compound - Hydrogen Sulphide.
	3.5 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.4 ppb (Highest 24-hour value recorded)	
Nitrogen Dioxide (NO_2)	210 ppb (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	23.1 ppb (Highest 1-hour value Recorded)	
	105 ppb (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	3.6 ppb (Highest 24-hour value Recorded)	
	52 ppb (Annual average)	N.B. Reg. 97-133, *Clean Air Act*	1.2 ppb (5-month average)	The standard is based on average conditions measured over 1 year, whereas only 5 months of data is available.
Ground Level Ozone (O_3)	63 ppb (Fourth worst daily 8-hour average, averaged over three years)	Canadian Ambient Air Quality Standard	53 ppb (Fourth worst daily 8-hour average)	The standard is based on a statistic that requires three years of data collection, whereas only 5 months of data is available.

Table 3 Continued: Comparisons to Standards and Guidelines

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Carbon Monoxide (CO)	30 ppm (1-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.5 ppm (Highest 1-hour value recorded)	
	13 ppm (8-hour average)	N.B. Reg. 97-133, *Clean Air Act*	0.4 ppm (Highest 8-hour value recorded)	
Ammonia - Integrated Sampling (NH_3)	142 ppb (24-hour average)	Ontario Ambient Air Quality Criteria	22 ppb (Highest two-week value recorded)	The two-week integrated samples do not allow calculation of 24-hour values for direct comparison to the standard.
Ammonia - Continuous Monitoring (NH_3)	25 ppm (Time-Weighted Average - short term exposure)	National (US) Institute for Occupational Health and Safety-Recommended Exposure Limit	<1 ppm (All values)	A comparable time-weighted average cannot be calculated from the monitoring data, as no values were recorded above the detection threshold for the instrument.
Total Suspended Particulate (TSP) At Project Site	120 µg/m^3 (24-hour average)	N.B. Reg. 97-133, *Clean Air Act*	241 µg/m^3 (Highest 24-hour value recorded)	
	70 µg/m^3 (Annual geometric mean)	N.B. Reg. 97-133, *Clean Air Act*	23 µg/m^3 (3-month geometric mean)	The standard is based on average conditions measured over 1 year, whereas only 3 months of data is available.
Respirable Particulate (PM_{10}) At Project Site	50 µg/m^3 (24-hour average)	Ontario Ambient Air Quality Criteria	138 µg/m^3 (Highest 24-hour value recorded)	
Fine Particulate ($PM_{2.5}$) At Project Site	28 µg/m^3 98th percentile daily average	Canadian Ambient Air Quality Standard	15 µg/m^3 98th percentile daily average	These standards are based on statistics that require three years of data collection, whereas only 5 months of data is available.
	10 µg/m^3 (3-year average)	Canadian Ambient Air Quality Standard	5.9 µg/m^3 (5-month average)	

Table 3 Continued: Comparisons to Standards and Guidelines

Parameter	Standard/Guideline Value	Standard/Guideline Source	Monitored Value	Notes
Fine Particulate ($PM_{2.5}$) (DELG Monitor at Fertilizer Plant Property Line)	120 µg/m^3 (24-hour average)	Property Line Limit Stipulated in the DELG Certificate of Approval to Operate (issued under the *Clean Air Act*)	137 µg/m^3 (Highest 24-hour value recorded)	The condition in the Certificate of Approval applies to Total Suspended Particulates. However, this instrument monitors only the $PM_{2.5}$ fraction.
Total Suspended Particulate (TSP) (Industry Monitor at Fertilizer Plant Property Line)	120 µg/m^3 (24-hour average)	Property Line Limit Stipulated in the DELG Certificate of Approval to Operate (issued under the *Clean Air Act*)	251 µg/m^3 (Highest 24-hour value recorded)	

5.2 Non-Impacting Parameters

As indicated in Table 3, monitoring results for SO_2, TRS, NO_2, O_3, CO, and NH_3 remained well below the relevant standards and guidelines for those parameters throughout the evaluation period. The measured values for these contaminants fall within the normal expected range of values for rural locations in New Brunswick (for comparison values please see “New Brunswick Department of Environment and Local Government Air Quality Monitoring Results - 2015” ISBN 978-1-4605-1409-2). As such, these parameters are excluded from further consideration with respect to the likely causative agents for odour or health impacts reported by the Saint-François de Madawaska community. No further analysis of these parameters will be undertaken.

5.3 Impacting Parameters

5.3.1 Total Suspended Particulate (TSP)

The running 24-hour average TSP concentration measured at the project site is illustrated in Figure 2. As shown, the relevant standard (120 µg/m^3) was exceeded on only one occasion, which spanned the August 13, 2018 to August 15, 2018 period. DELG staff were deployed to the area to investigate the event while it was ongoing and determined that the cause was road construction dust from the resurfacing of Rang 2 Road, which is immediately south of the project site.

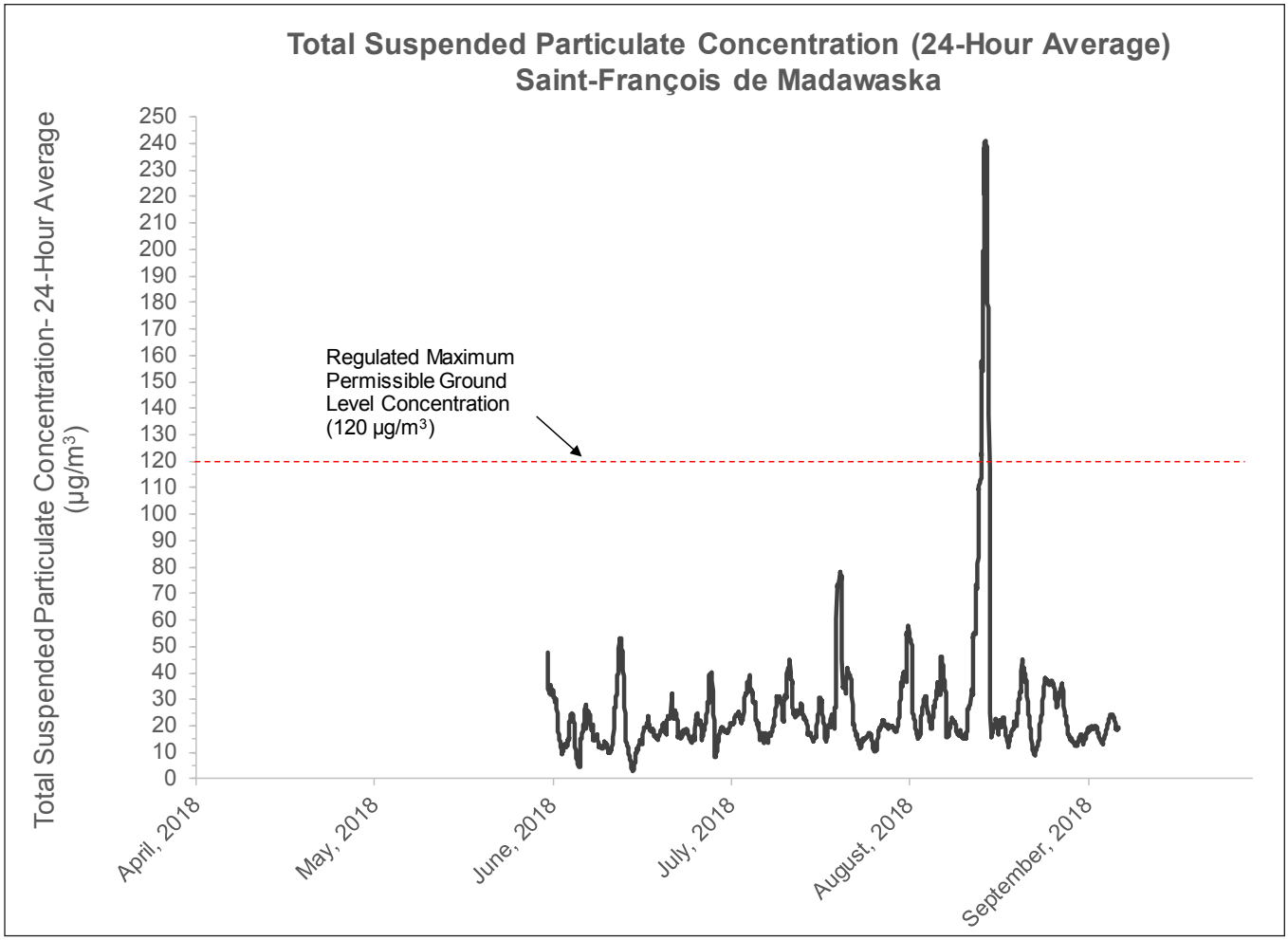

Figure 2: 24-Hour Average Total Suspended Particulate Concentration - Saint-François de Madawaska, May 31, 2018 to September 6, 2018.

5.3.2 Respirable Particulate (PM_{10})

The running 24-hour average PM_{10} concentration measured at the project site is illustrated in Figure 3. As illustrated, the relevant standard (50 $\mu g/m^3$) was exceeded on two occasions. The largest event spanned the August 13, 2018 to August 15, 2018 period. This corresponds to the road construction dust previously described. The other event occurred over the July 20, 2018 to July 21, 2018 period.

This other PM_{10} event is illustrated in detail in Figure 4, which depicts 5-minute average PM_{10} concentrations from 5:00 AM to 10:00 AM on July 20, 2018. As shown, this second event began at 5:45 AM on July 20, 2018, and reached its peak at 7:25 AM. The event concluded at approximately 9:00 AM.

A citizen complaint was received during this event at approximately 7:00 AM. The complainant suggested that the fertilizer plant was the source of the issue, and believed the plant to have operated very briefly that morning. However, data provided by the fertilizer plant and subsequently investigated by DELG, indicates that the fertilizer plant did not operate during this period. Available information suggests that it had last operated on July 9, 2018, and did not resume operations again until July 24, 2018. Also, particulate levels measured at the property line location remained relatively low during this period.

Weather data collected during the event indicate that winds originated from the North or North Northwest during the overnight and early morning hours, shifting to Westerly by 9:00 AM (when the event, as detected at the project site, concluded). This is strongly suggestive that the source of the particulate was located North or Northwest of the project site, which is the direction of the fertilizer plant. However, there are several other potential sources of PM_{10} in that area: a chicken farm, agricultural fields, an unpaved road, and a poultry manure processing/handling facility.

Based on the information available it is not possible to draw conclusions about the source of this PM_{10} event.

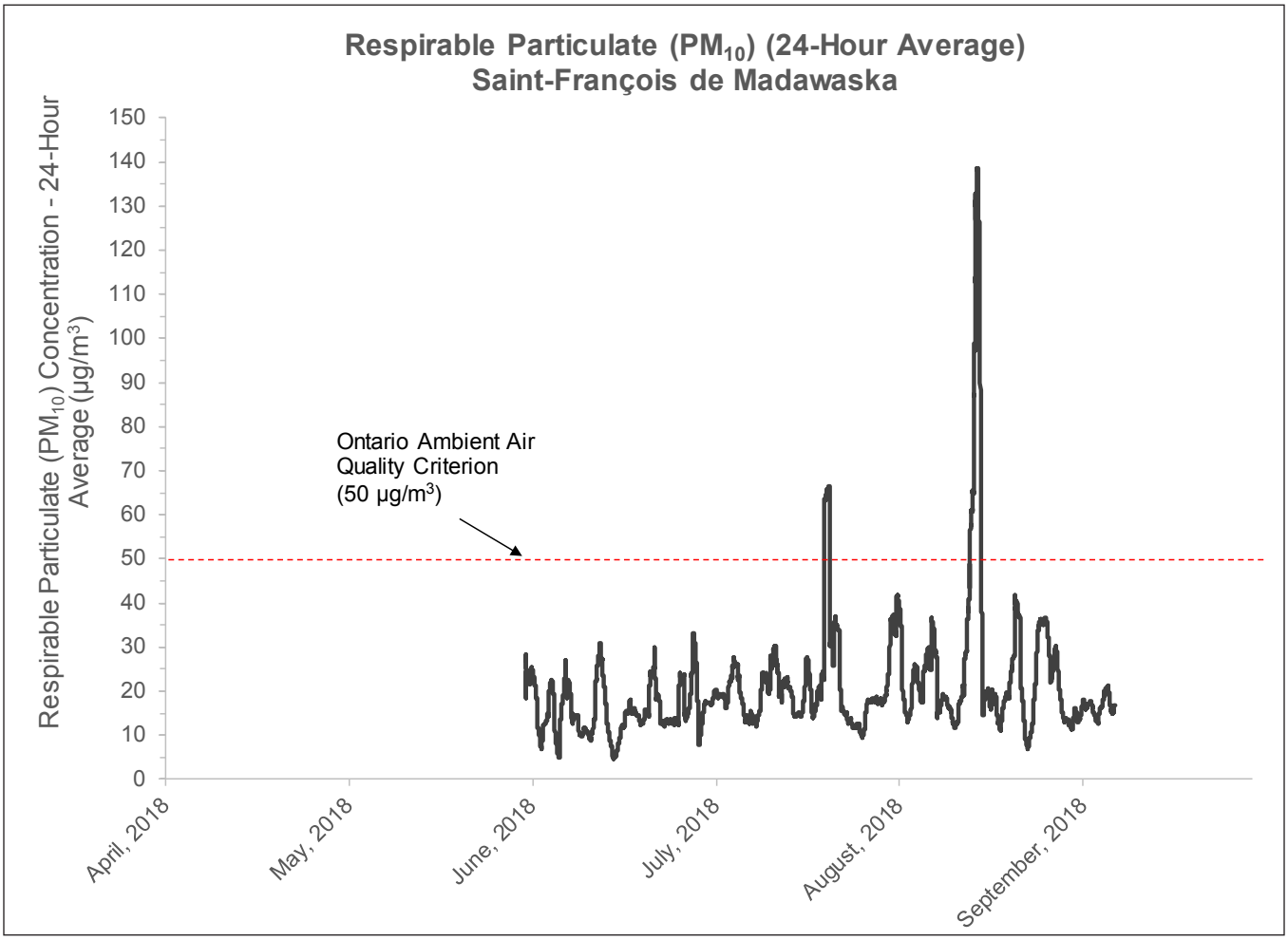

Figure 3: 24-Hour Average Respirable Particulate (PM_{10}) Concentration - Saint-François de Madawaska, May 31, 2018 to September 6, 2018.

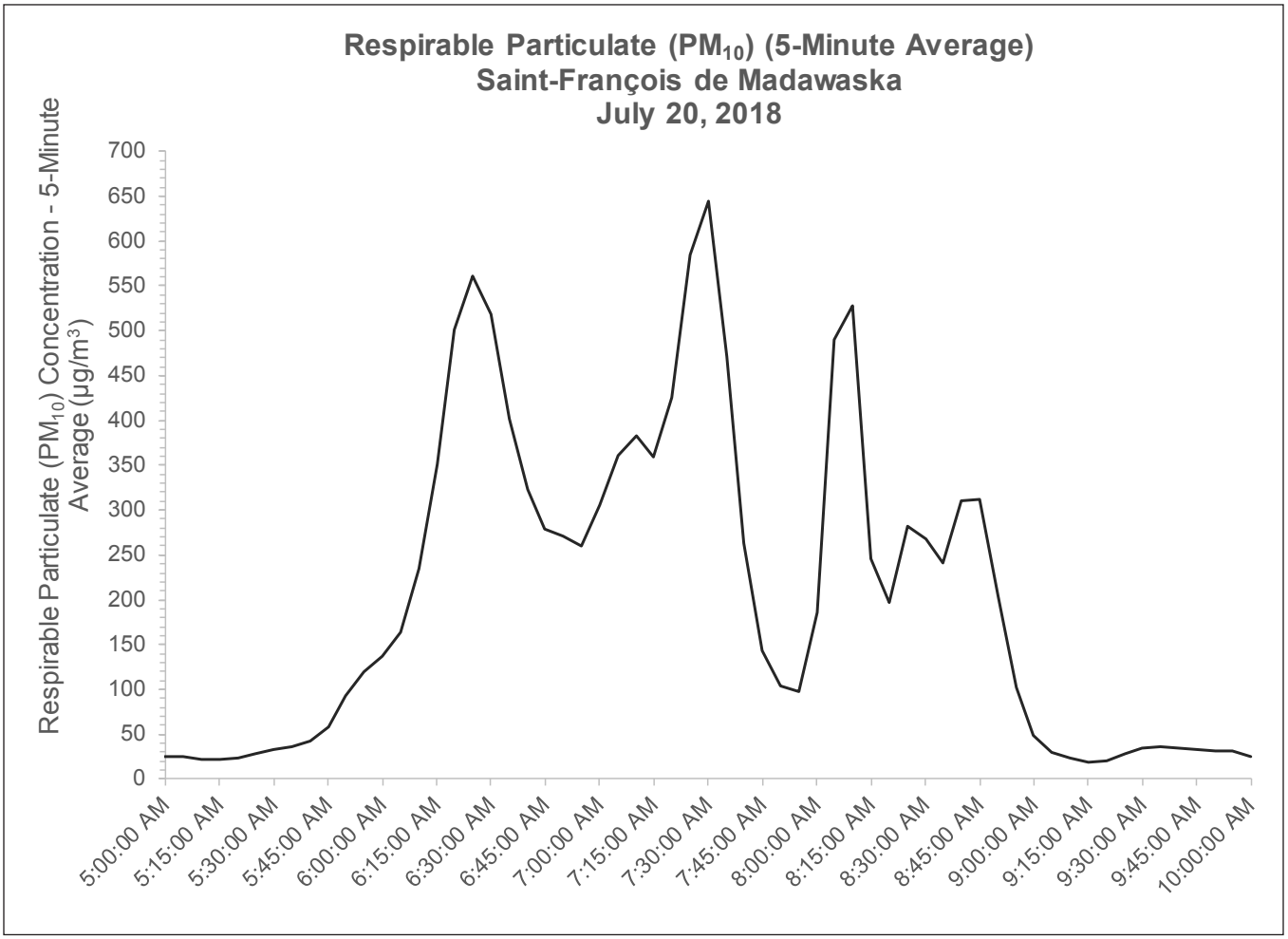

Figure 4: 5-Minute Average Respirable Particulate (PM_{10}) Concentration - Saint-François de Madawaska, July 20, 2018.

5.3.3 Respirable Particulate (PM_{10}) and Citizen Complaints

The July 20, 2018 event described above suggests that a relationship may exist between PM_{10} levels and the citizen complaints from this area. To explore this possibility further, the days during which complaints were received were compared against the days during which the hourly average PM_{10} concentrations were highest (exceeding the 90th percentile value).

The hourly PM_{10} concentration reached the 90th percentile value on 65 of the 99 days that the PM_{10} monitor was operating (May 31, 2018 to September 6, 2018), and there were 32 days during this same period that complaints were received. Of the 65 "high PM_{10}" days, only 26 (40%) involved complaints. This suggests that high PM_{10} values are not predictive of complaints.

However, considering only the 32 days in which complaints were received, 26 of them (81%) involved high (90th percentile hourly average) PM_{10} levels. Thus, complaints may be predictive of high PM_{10} values.

This discrepancy (the occurrence of higher PM_{10} levels without corresponding complaints) could be a consequence of the inherent limitations of the complaint data, which relies on voluntary reporting by observers that may not always be present. "Complaint-worthy" conditions may not always be noticed or reported. It is also possible that there are sources of PM_{10} in the area that contribute to the number of 90th percentile events, but do not produce particulates with the specific chemical characteristics that generate complaints. Further, the possibility cannot be excluded that this area simply experiences PM_{10} events from a variety of sources on a routine basis, and that the reported odour/health events are unrelated and coincidental.

5.3.4 Effect of Wind Direction on Respirable Particulate (PM_{10}) Levels

In further consideration of the potential relationship between PM_{10} levels and citizen complaints it is worthwhile to examine the wind direction data in relation to the PM_{10} data to determine the likely direction(s) of the source(s) relative to the project site.

Table 4 provides the average and median PM_{10} values experienced at the project site when winds originated from each of the four cardinal directions. As indicated, average and median PM_{10} levels were highest when winds originated from the North.

Table 4: Average and Median Respirable Particulate (PM_{10}) Concentrations by Wind Direction

Direction of Wind Origin	Average PM_{10} Concentration (3 Month Period)	Median PM_{10} Concentration (3 Month Period)
North	23 µg/m^3	16 µg/m^3
East	20 µg/m^3	15 µg/m^3
South	20 µg/m^3	14 µg/m^3
West	17 µg/m^3	14 µg/m^3

As also indicated in Table 4, the median PM_{10} values were lower than the respective average values. This suggests that the data is weighted toward lower PM_{10} values (i.e., there are fewer high value data points relative to the number of low value data points).

To explore the effect of wind direction on higher value events, an analysis of peak values was undertaken by excluding all 5-minute average data less than the 90th percentile value (32 µg/m^3). Also, the previously noted PM_{10} event on August 13 to August 15, 2018 was excluded because it is known to have been caused by temporary road construction activities.

70.3% of the peak (>90th percentile) 5-minute average values occurred while winds were originating from the North, while 15.2% occurred while winds were originating from South. 10.1% were from the West, and 4.4% were from the East. This suggests that although there are PM_{10} sources in all directions of the project site, the sources to the North are principally responsible for peak (90th percentile) PM_{10} events experienced at this location.

5.3.5 Effect of Wind on Citizen Complaints

Although some of the complaint data is detailed and time-specific (identifying a specific date and time), much of the available complaint data is not. Rather, complaints were logged identifying only the day (24-hour period), or identifying a non-precise timespan such as “evening”. In other cases a precise time is recorded, but it is not clear if the conditions also preceded or extended beyond that time. As wind direction can change rapidly and frequently, this imprecision and variability in the complaint data prevents broad statistical analyses of the complaints received versus the direction of wind origin.

An attempt was made to analyze the prevailing winds during days (24 hour periods) during which complaints were received. However, this was not informative because there were very few days when winds did not originate from each direction, at least briefly, at some time.

It should also be noted that the residences of the citizens reporting complaints are located at various positions to the East and West of the project site. As such, their positions relative to area emissions sources are slightly different than the project site (and each other). A wind direction that may correlate with impacts at one location may not at another. Thus, a strong correlation between odour/health complaints in the community and wind direction and at the project site would not be expected.

5.3.6 Relationship Between Fertilizer Plant Operations and Citizen Complaints

The fertilizer plant operated (during any period from midnight to midnight) on 83 days of the 154-day evaluation period, and complaints were received on 56 (67%) of those (operating) days. There were 10 “complaint days” that did not coincide with “operating days” (15%). Considering only the days that complaints were received (66), 56 of them (85%) coincided with days that the plant operated. This suggests a relationship between the operation of the fertilizer plant and citizen complaints. This is illustrated graphically in Figure 5. The occurrence of complaints on a small number of non-operating days (15%) suggests that there may be other sources in the area that contribute. The operational status of other potential sources was not monitored.

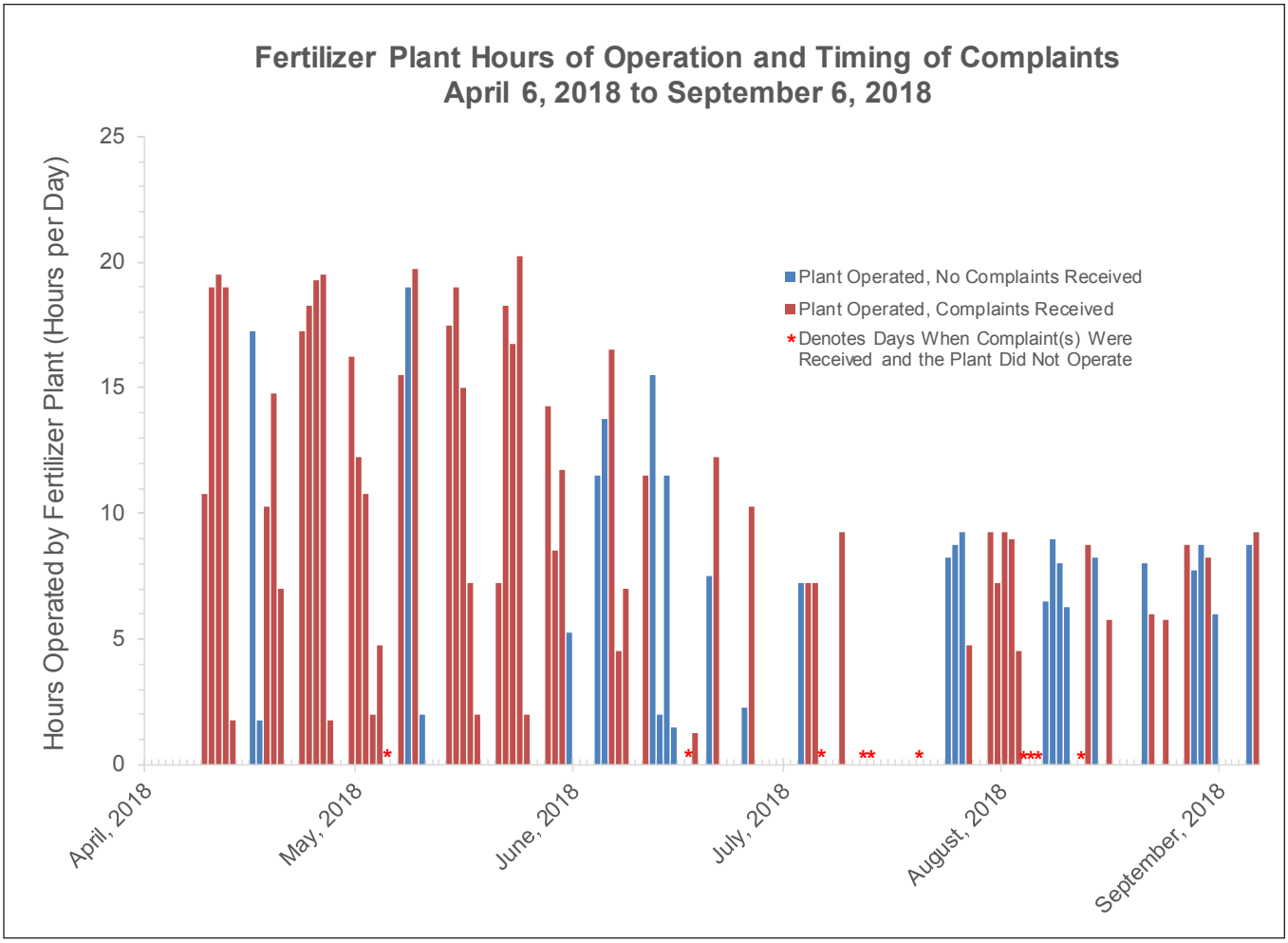

Figure 5: Daily Odour Complaints Reported in Saint-François de Madawaska Compared Against the Hours of Operation for the Nearby Fertilizer Plant, April 6, 2018 to September 6, 2018.

5.4 Fertilizer Plant Property Line Particulates

The particulate monitoring data from the fertilizer plant property line provides additional information with respect to the emission sources associated with fluctuations in particulate levels and citizen complaints.

5.4.1 Suspended Particulates (TSP and $PM_{2.5}$) - Fertilizer Plant Property Line

The running 24-hour average TSP concentration measured at the fertilizer plant property line is illustrated in Figure 6. As shown, the property line concentration limit specified in the facility's DELG Certificate of Approval to Operate (120 µg/m^3) was exceeded on seven occasions, spanning 100 cumulative hours over the project period.

As previously discussed, the property line TSP monitor was found to be inaccurate when reporting higher values. As such, it is worthwhile to also consider data from the DELG monitor that was collocated at this location for three months. The running 24-hour average $PM_{2.5}$ concentration measured using the DELG monitor at the fertilizer plant property line is illustrated in Figure 7. As shown, the relevant concentration limit (120 µg/m^3) was exceeded on two occasions, spanning 24 cumulative hours over the three-month collocation period

It should be noted that the collocated DELG instrument monitored only the $PM_{2.5}$ fraction of suspended particulates. This provides a very conservative assessment against the TSP concentration limit (which includes all fractions). As illustrated in Figure 7 there were several other $PM_{2.5}$ peaks that may represent additional exceedances of the TSP concentration limit. This supports the validity of the exceedances detected by the industry-operated TSP monitor.

In comparing between the two data sets (property line TSP and $PM_{2.5}$), it is notable that the fine particulate fraction ($PM_{2.5}$) comprises a large proportion of TSP events. As noted, on two occasions the $PM_{2.5}$ fraction alone was sufficient to exceed the TSP concentration limit.

As $PM_{2.5}$ is generally associated with combustion sources (rather than windblown dust)[1,2,3], and in consideration of the lack of other significant combustion sources in the immediate area, and also considering that similar $PM_{2.5}$ peaks were not observed further from the fertilizer plant (*i.e.*, at the project site), the fertilizer plant stack is considered the most likely source for these emissions.

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[1] Sources and processes affecting concentrations of PM_{10} and $PM_{2.5}$ particulate matter in Birmingham (U.K.). Atmospheric Environment. Vol. 31. Iss. 24. 1997.

[2] Comparative PM_{10}–$PM_{2.5}$ source contribution study at rural, urban and industrial sites during PM episodes in Eastern Spain. Science of the Total Environment. Vol. 328 Iss. 1-3. 2004.

[3] Chemical characterization and source identification/apportionment of fine and coarse air particles in Thessaloniki, Greece. Atmospheric Environment. Vol. 36. Iss. 6. 2002.

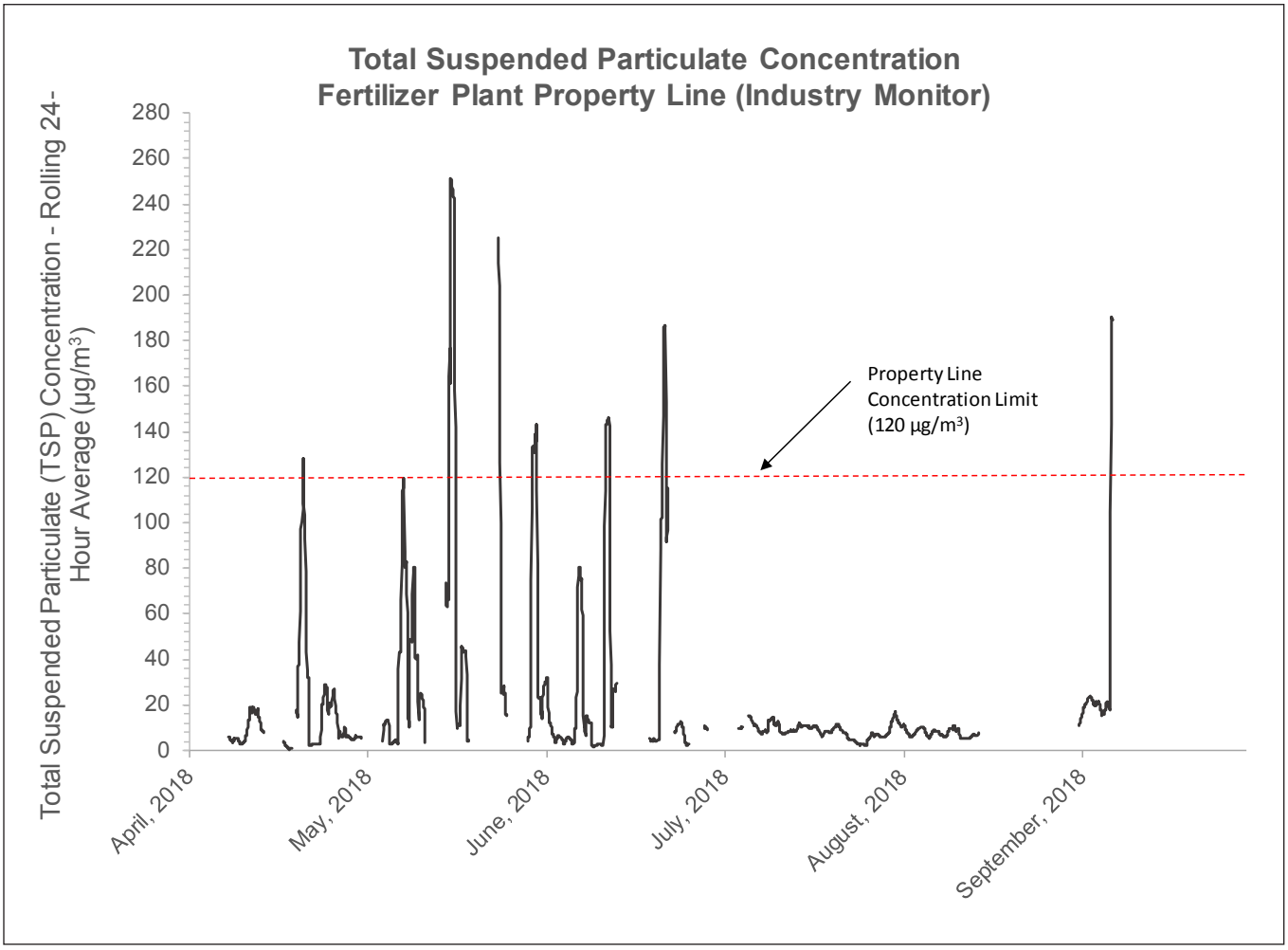

Figure 6: 24-Hour Average Total Suspended Particulate Concentration - Fertilizer Plant Property Line, Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

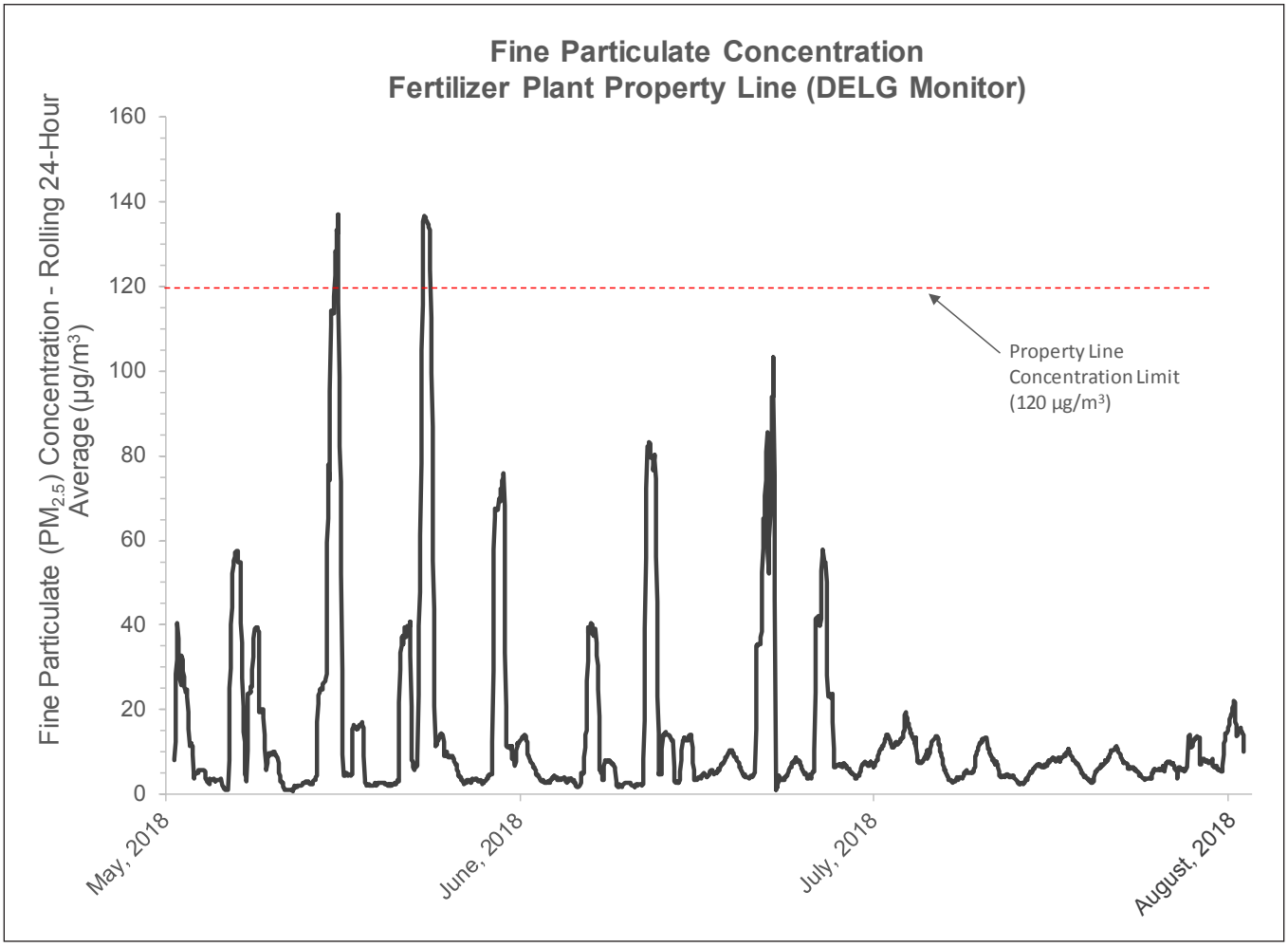

Figure 7: 24-Hour Average Fine Particulate Concentration - Fertilizer Plant Property Line, Saint-François de Madawaska, May 2, 2018 to September 6, 2018.

5.4.2 Comparison of Property Line and Project Site Particulate Trends

Other than the fertilizer plant, the only potentially significant particulate sources North of the property line monitoring site are windblown dust and pollen. Pollen is typically larger than 10 microns in diameter and is not well represented in $PM_{2.5}$ and PM_{10} particulate fractions. There are dirt roads north of the fertilizer plant that may occasionally contribute to particulate levels. Although the extent of this potential contribution is not known, it is not expected to be significant. Thus, any significant PM_{10} or $PM_{2.5}$ events detected at this location while winds were originating from Northerly directions are likely to be associated with the fertilizer plant property.

Hourly average fine particulate ($PM_{2.5}$) concentrations for both the project site and the property line location, for the period during which monitors were in place at both locations, are illustrated in Figure 8. As shown, there is no clear relationship between peak $PM_{2.5}$ events detected at the property line location and the levels detected at the project site. Although there were several high value events at the property line location, levels remained relatively uniform and low at the project site.

Although there was no clear relationship between the fine particulate ($PM_{2.5}$) levels at the two locations, there is an association between $PM_{2.5}$ levels at the property line location and respirable particulate (PM_{10}) values at the project site. This is illustrated in Figure 9. As shown, several of the $PM_{2.5}$ peaks detected at the property line location coincided with similar PM_{10} peaks at the project site.

As illustrated in Figure 9, the three highest peak $PM_{2.5}$ events detected at the property line location coincided with PM_{10} peaks at the project site. On each of these three occasions winds were Northerly (originating from the North), the fertilizer plant was recorded as operating, and citizen complaints were received. Additional details for each of these events are provided in Appendix I.

To further explore this relationship, the daily maximum 1-hour concentrations were calculated for each parameter ($PM_{2.5}$ and PM_{10}) at each respective site and compared against the operational status of the fertilizer plant. It was found that the operational status of the plant impacted the overall average daily maximum values (average of all daily maximum 1-hour values on days when the plant operated versus average of all daily maximum 1-hour values on days when the plant did not operate). These values are provided in Table 5, and the effect is illustrated graphically in Figures 10 and 11, along with complaint information for the same period. As indicated, the effect was much more pronounced, and the relationship with complaint data more clear, in the property line $PM_{2.5}$ data.

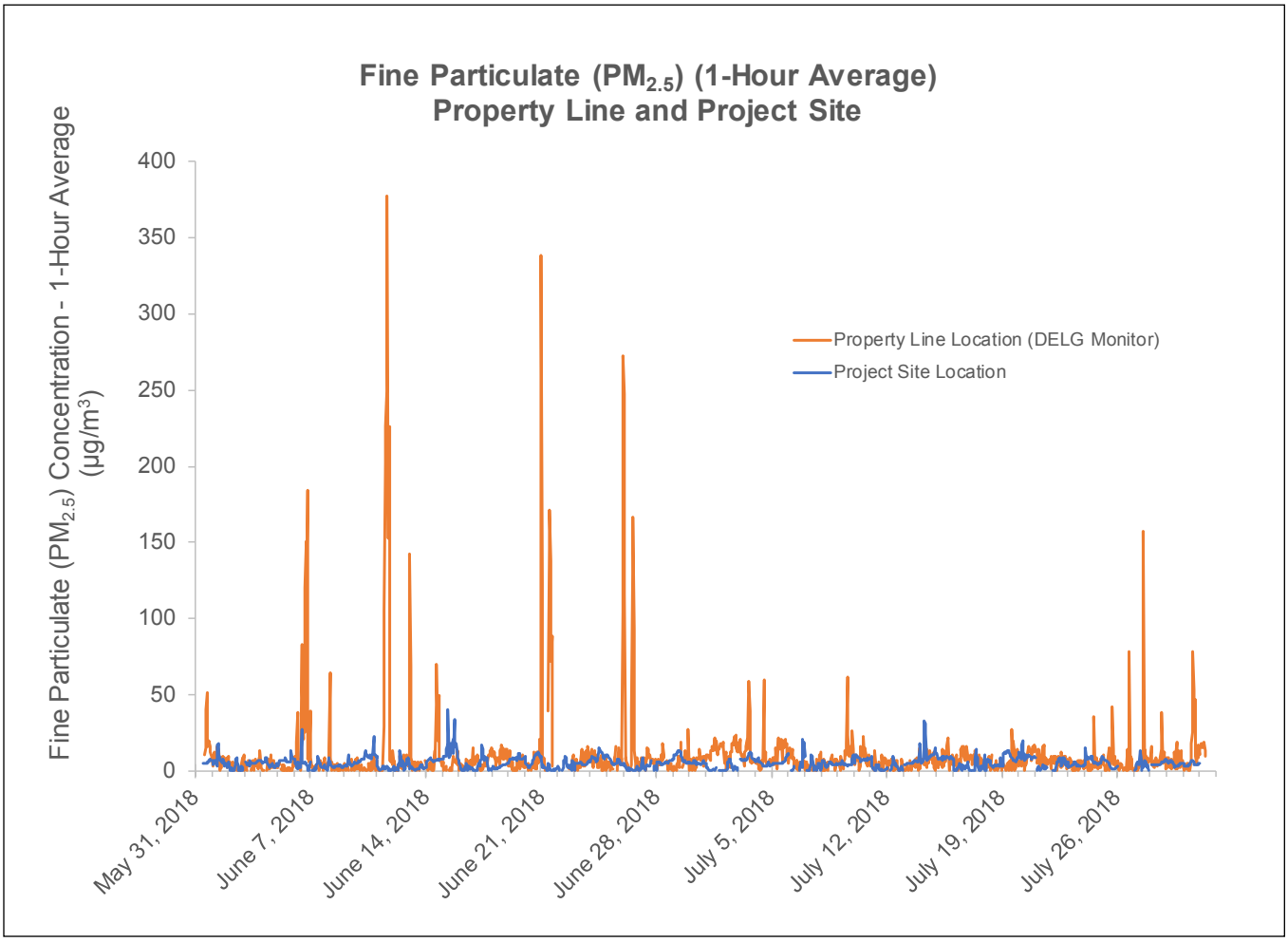

Figure 8: Comparison of 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentrations - Fertilizer Plant Property Line and Project Site - Saint-François de Madawaska, May 31, 2018 to July 31, 2018.

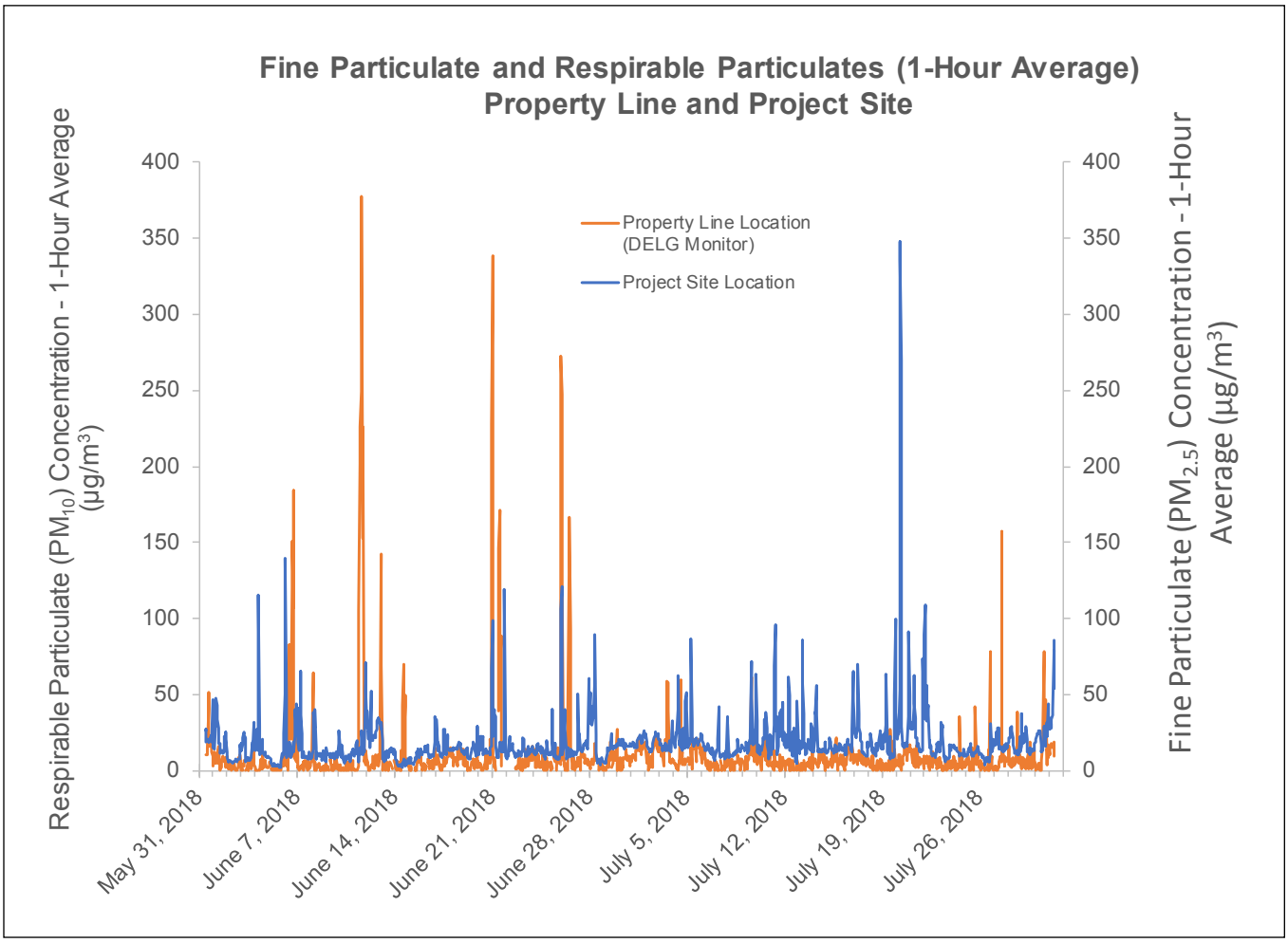

Figure 9: Comparison of 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentrations - Fertilizer Plant Property Line and Respirable Particulate (PM_{10}) Project Site - Saint-François de Madawaska, May 31, 2018 to July 31, 2018.

Table 5: Average Daily Maximum Property Line $PM_{2.5}$ and Project Site PM_{10} During Periods of Fertilizer Plant Operation and Non-Operation

Operational Status of Fertilizer Plant	Average Daily Maximum $PM_{2.5}$ Concentration at Property Line (3 Month Period)	Average Daily Maximum PM_{10} Concentration at the Project Site (3 Month Period)
Operating	125 µg/m^3	75 µg/m^3
Not Operating	15 µg/m^3	52 µg/m^3

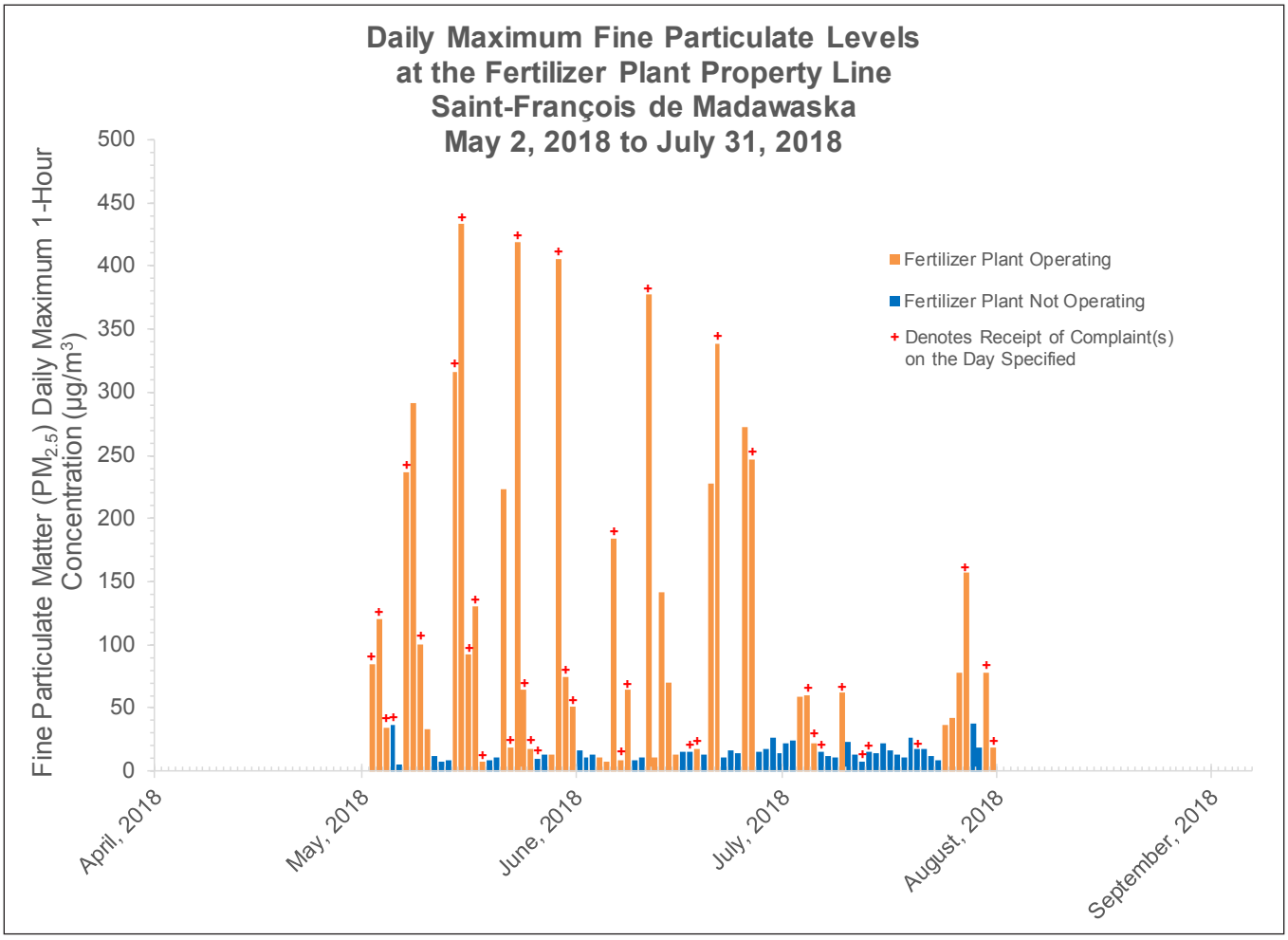

Figure 10: Comparison of Daily Maximum 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentrations and Fertilizer Plant Operational Status - Fertilizer Plant Property Line - Saint-François de Madawaska, May 2, 2018 to July 31, 2018.

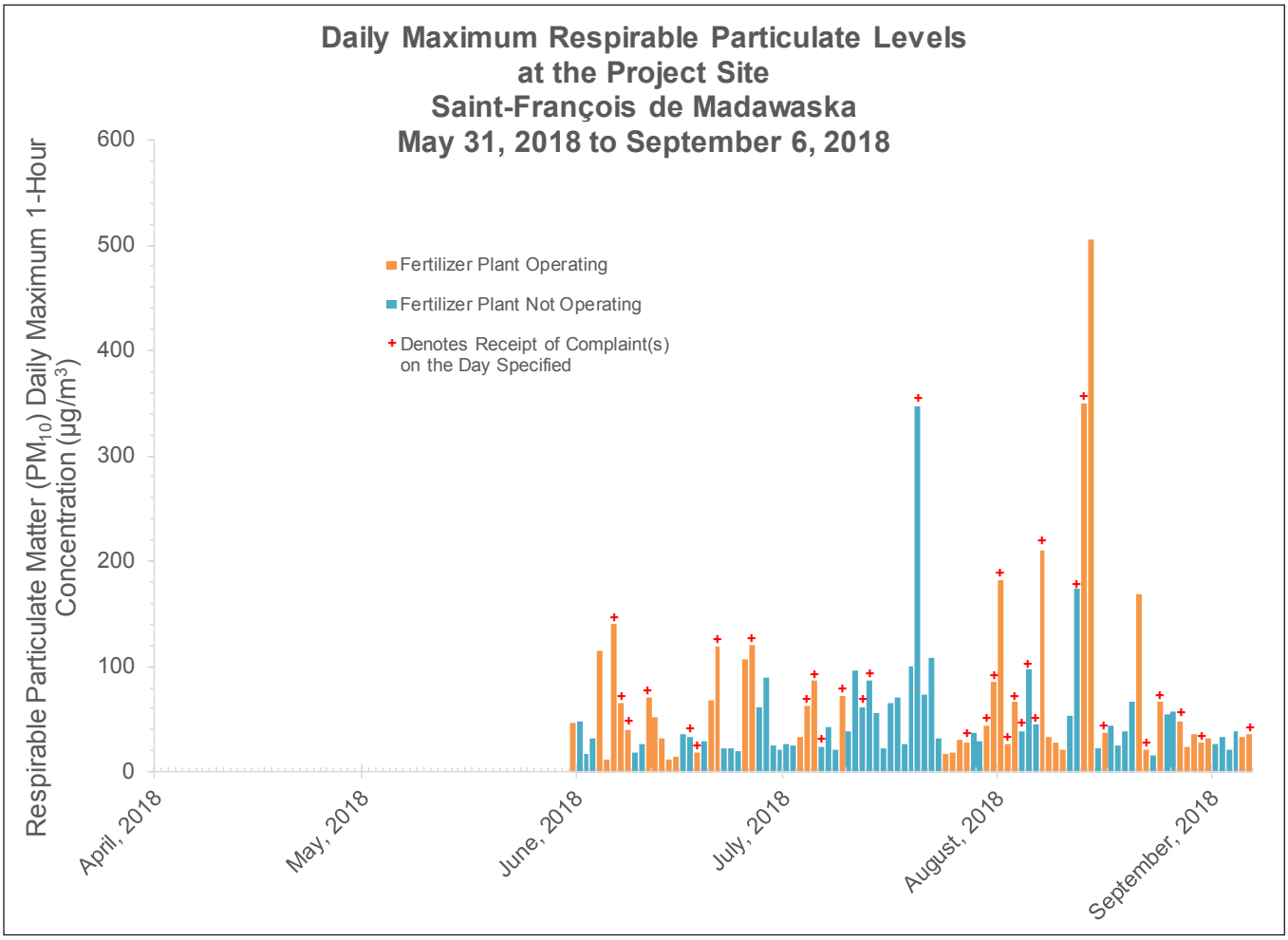

Figure 11: Comparison of Daily Maximum 1-Hour Average Respirable Particulate (PM_{10}) Concentrations and Fertilizer Plant Operational Status - Project Site - Saint-François de Madawaska, May 31, 2018 to September 6, 2018.

6.0 Conclusions

For the majority of pollutants monitored, with the exception of particulates, concentrations detected in the Saint-François community were found to be typical of rural New Brunswick communities.

Particulate levels were found to exceed standard/guideline values on two occasions. The cause of the first exceedance (July 20, 2018 to July 21, 2018) is unclear, but based on available wind data, the source was likely to the North of the project site. A complaint was logged during the event, which suggests that the source may be associated with the ongoing air quality issues reported by the community. Possible sources include a fertilizer plant, a poultry farm, a poultry manure handling/processing site, and windblown dust from unpaved roads. Windblown road dust is a common occurrence in New Brunswick, but is not typically associated with the type of odour/health complaints received in this area.

The second exceedance (August 13, 2018 to August 15, 2018) was likely caused by windblown dust from a road resurfacing project that took place immediately south of the project location. This assessment is based on the proximity of the project, wind direction (southerly), observations by project personnel, and the absence of citizen complaints during the affected time period.

Particulate concentrations measured at the fertilizer plant property line exceeded the 24-hour limit specified in the facility's DELG Certificate of Approval to Operate on seven occasions spanning 100 cumulative hours. These exceedances were corroborated by the collocation of industry-operated and DELG instruments. These particulate events were dominated by the fine particulate ($PM_{2.5}$) fraction, which is suggestive of the influence of a large combustion source.

An association was found between reported complaints, northerly winds, the operating hours of the fertilizer plant, $PM_{2.5}$ levels measured at the fertilizer plant, and PM_{10} levels measured at the project site. This is supported by separate analyses of the effect of wind direction and fertilizer plant operation on complaints received; analysis of the effect of fertilizer plant operations on particulate levels at the property line location and the project site; and, the analysis of three "coinciding events" wherein particulate levels at both sites rose simultaneously, during periods when complaints were received, winds originated from the north, and the fertilizer plant was operating.

It is notable that during the three "coinciding events" there were significant $PM_{2.5}$ peaks at the property line location, but no corresponding $PM_{2.5}$ peaks at the project site. Rather, at the project site the peaks were most evident in the PM_{10} fraction. This may be due to "aerosol growth" of the $PM_{2.5}$ particulates while in transit between the two locations.

For greater certainty, the noted suggestion of a causative link between $PM_{2.5}$ emissions from the fertilizer plant, subsequent PM_{10} levels downwind, and complaints could be explored further through emissions characterization work focusing on the chemical constituents of the particulate emissions from the fertilizer plant.

The preceding analysis has identified a relationship between an emissions source, a monitored contaminant (particulates), and citizen complaints. A small number of complaints were also recorded when the fertilizer plant was not operating, and when particulate levels were relatively low. This suggests that other contaminants and other emissions sources may sometimes contribute to the conditions that result in odour/health issues in the community.

Monitoring for the air quality evaluation is ongoing. The conclusions described above should be considered tentative, pending completion of data collection and analysis, which will be presented in one or more subsequent reports.

7.0 Data Limitations

The data collected represents conditions during the evaluation period and does not reflect all possible variations in ambient air quality conditions that may be possible at this location.

This project involved the collection of ambient air quality data under field conditions. Consequently, unforeseen and unavoidable disruptions (e.g., weather, electrical power failures, equipment malfunctions, etc.) resulted in brief data interruptions at various points throughout the evaluation period.

The project analyzed air quality at two fixed locations. As such, the results provide a quantitative assessment of air quality at these locations only. Inferences can be made about air quality at other nearby locations, but certainty decreases with distance from the monitoring sites.

The project location may have been impacted by air pollutants from multiple sources during the evaluation period. Meteorology data can suggest likely sources for the contaminants detected during a given period. However, the data is insufficient for comprehensive “source apportionment” (i.e., discerning and quantifying the impacts of individual pollution sources).

Data was collected for a period of five months. However, some comparisons are made to standard or guideline values that require a longer observation period (e.g., 1 year or 3 years).

8.0 Glossary of Abbreviations

CO	Carbon Monoxide
DELG	Department of Environment and Local Government
km/hr	Kilometers per hour
NAPS	National Air Pollution Surveillance (program)
NH_3	Ammonia
NO_2	Nitrogen dioxide
O_3	Ozone (ground level ozone)
$PM_{2.5}$	Fine particulate (particulates with a diameter ≤ 2.5 microns)
PM_{10}	Respirable Particulate (particulates with a diameter ≤ 10 microns)
PPB	Parts per billion
PPM	Parts per million
SO_2	Sulphur dioxide
TRS	Total Reduced Sulphur
TSP	Total Suspended Particulates
$\mu g/m^3$	Micrograms per cubic meter
µm	Microns (also micrometers)

Appendix A: Pollutant Parameters

Table A1: Rationale for Inclusion of Monitored Parameters

Air Contaminant	Rationale for Inclusion
Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2)	Emissions monitoring (stack testing) for the fertilizer plant indicates that SO_2 and NO_2 are being emitted from the facility. Inclusion of these parameters in the study provides quantification of off-site impacts from these emissions. Complaints received from the local community make reference to irritation of the eyes, throat, and lungs. These are some of the known health impacts of exposure to sulphur dioxide and nitrogen dioxide. However, it should be noted that there are other pollutants that can cause similar effects.
Carbon Monoxide (CO)	The reported health effects in the complaints received from the area are not consistent with CO exposure. However, emissions monitoring (stack testing) for the fertilizer plant indicates that carbon monoxide is being emitted from the facility. Inclusion of this parameter in the study provides quantification of off-site impacts from these emissions.
Total Reduced Sulphur (TRS) and Ammonia (NH_3)	Emissions monitoring (stack testing) for the fertilizer plant indicates that SO_2 is being emitted from the facility. The existence of SO_2 within the exhaust gases suggests that other sulphur compounds (including reduced sulphur compounds) could also be emitted. Although emissions monitoring (stack testing) for ammonia has not been carried out, based on the chemical constituents of poultry manure, it is likely that the fertilizer facility emits some quantity of ammonia. Also, there are other significant ammonia sources (poultry farms) in the area. Complaints received from the local community routinely include references to noxious odours. Reduced sulphur compounds and ammonia are potential sources of odours in air pollutant emissions. Also, ammonia is an upper respiratory tract irritant, consistent with health effects reported from area residents.
Ground Level Ozone (O_3)	Ozone is not directly emitted by pollution sources. Rather, it is formed in the air by reactions between certain pollutants (principally volatile organic compounds and nitrogen dioxide). Ground level ozone concentrations change in predictable ways in response to the presence of these other contaminants. Monitoring this parameter along with NO_2 allows inferences to be made about local volatile organic compound emissions. This parameter (along with $PM_{2.5}$ and NO_2) is necessary in order to calculate the Air Quality Health Index (AQHI).
Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)	Complaints received from the local community make reference to irritation of the throat and lungs. These are some of the known health impacts of airborne particulate matter. Combustion of organic materials (such as wood) generates significant amounts of particulate matter. It is therefore expected that the fertilizer plant would emit this contaminant. Also, emissions monitoring (stack testing) for the fertilizer plant indicates that particulate matter is being emitted from the facility. Inclusion of these parameters in the study provides quantification of off-site impacts from these emissions. Monitoring for particulates also provides a surrogate for a variety of other contaminants that can be generated by combustion and drying operations. These other pollutants react with other chemicals and water in the air to form “secondary aerosols” which contribute to the amount of particulates detected.

Appendix B: Technical Specifications - Continuous Monitors

Table B1: Technical Specifications of Continuous Air Quality Monitors

Parameter	Instrument	Lower Detection Limit	Resolution
Sulphur Dioxide (SO_2)	Thermo Environmental Instruments Pulsed Fluorescence SO_2 Analyzer, Model 43*i*.	1 ppb (60 second average of 300 millisecond samples)	± 0.5 ppb (noise) ± 1.0 ppb (precision)
Nitrogen Dioxide (NO_2)	Thermo Environmental Instruments Chemiluminescence NO-NO_2-NO_X Analyzer, Model 42*i*.	0.4 ppb	± 0.2 ppb (noise) ± 0.4 ppb (precision)
Carbon Monoxide (CO)	Thermo Environmental Instruments Gas Filter Correlation CO Analyzer, Model 48C.	0.04 ppm	± 0.1 ppm (noise)
Total Reduced Sulphur (TRS)	Thermo Environmental Instruments Pulsed Fluorescence SO_2 Analyzer, Model 43i, modified for TRS measurement using a CD Nova-Tech Inc. Thermal Oxidizer, Model CDN-101 operated at 850°C.	1 ppb (60 second average of 300 millisecond samples)	± 0.5 ppb (noise) ± 1.0 ppb (precision)
Ground Level Ozone (O_3)	Thermo Environmental Instruments Ultraviolet Photometric Ozone Gas Analyzer, Model 49*i*.	0.5 ppb	± 0.25 ppb (noise) ± 1.0 ppb (precision)
Fine Particulate Matter ($PM_{2.5}$)	Met-One Instruments Inc. Continuous Particle Monitor, model BAM-1020, outfitted with a fine particulate head and cyclone.	4.8 µg/m^3 (hourly) 1.0 µg/m^3 (daily)	± 0.2 µg/m^3
Fine Particulate Matter (at property line) ($PM_{2.5}$)	Met-One Instruments Inc. Continuous Particle Monitor, model EBAMPlus, outfitted with a fine particulate head and cyclone.	10 µg/m^3 (hourly) 2 µg/m^3 (daily)	± 1.0 µg/m^3
Total Suspended Particulate (TSP)	Met-One Instruments Inc. Continuous Particle Monitor, model BAM-1020, outfitted with a total suspended particulate head.	4.8 µg/m^3 (hourly) 1.0 µg/m^3 (daily)	± 0.2 µg/m^3
Fine and Respirable Particulate Matter ($PM_{2.5}$ and PM_{10})	Teledyne API Model T640 Mass Monitor	0.1 µg/m^3 (hourly)	± 0.5 µg/m^3
Ammonia (NH_3)	Dräger Polytron 5100 Oxygen / Toxic Gas Detector, outfitted with a Dräger NH_3 (type TL) sensor.	~1 ppm (varies with ambient meteorological conditions)	± 5% of measured value (sensitivity)

Appendix C: Wind Data

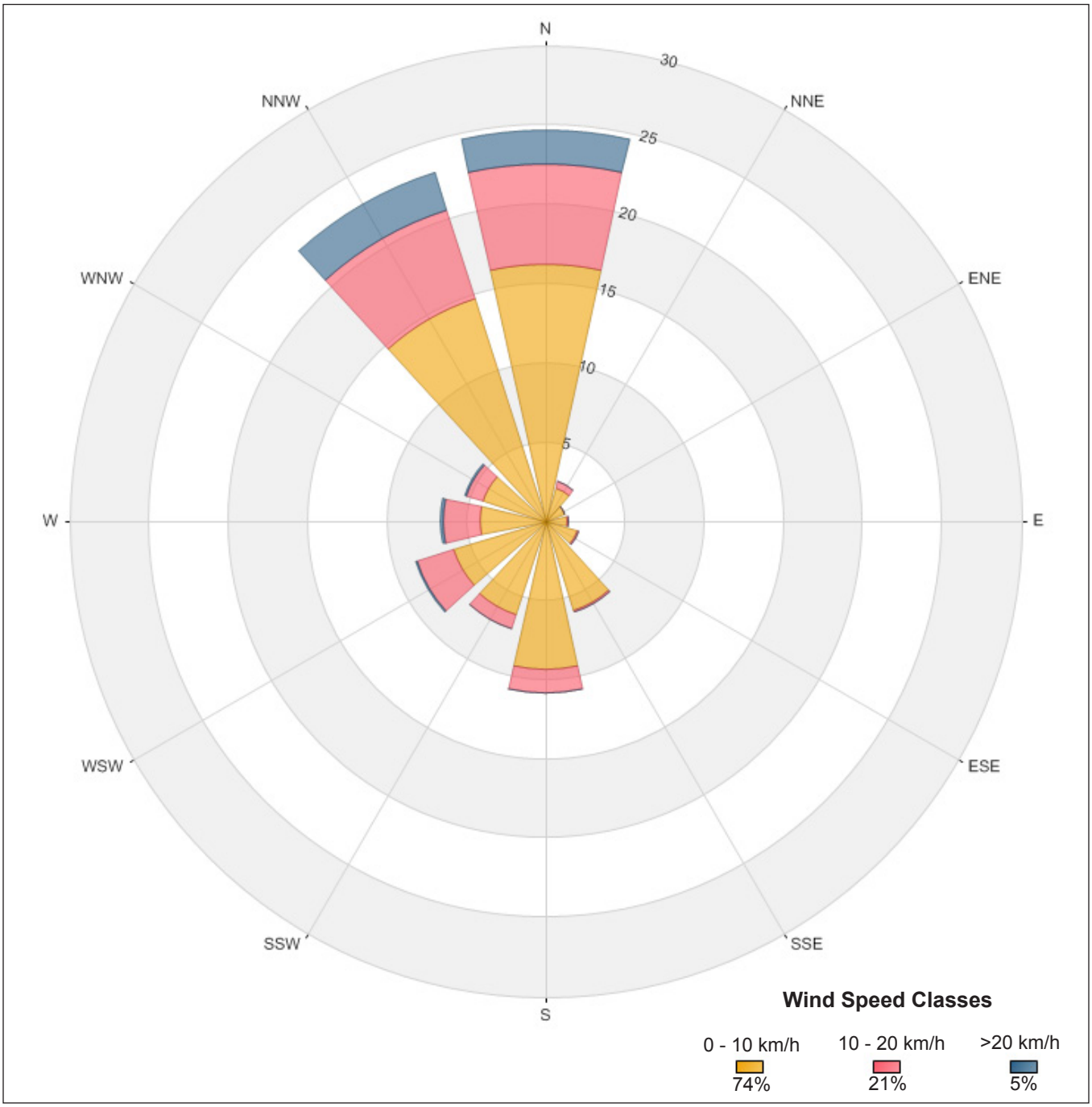

Figure C1: Wind Rose Diagram (Direction of Wind Origin) - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

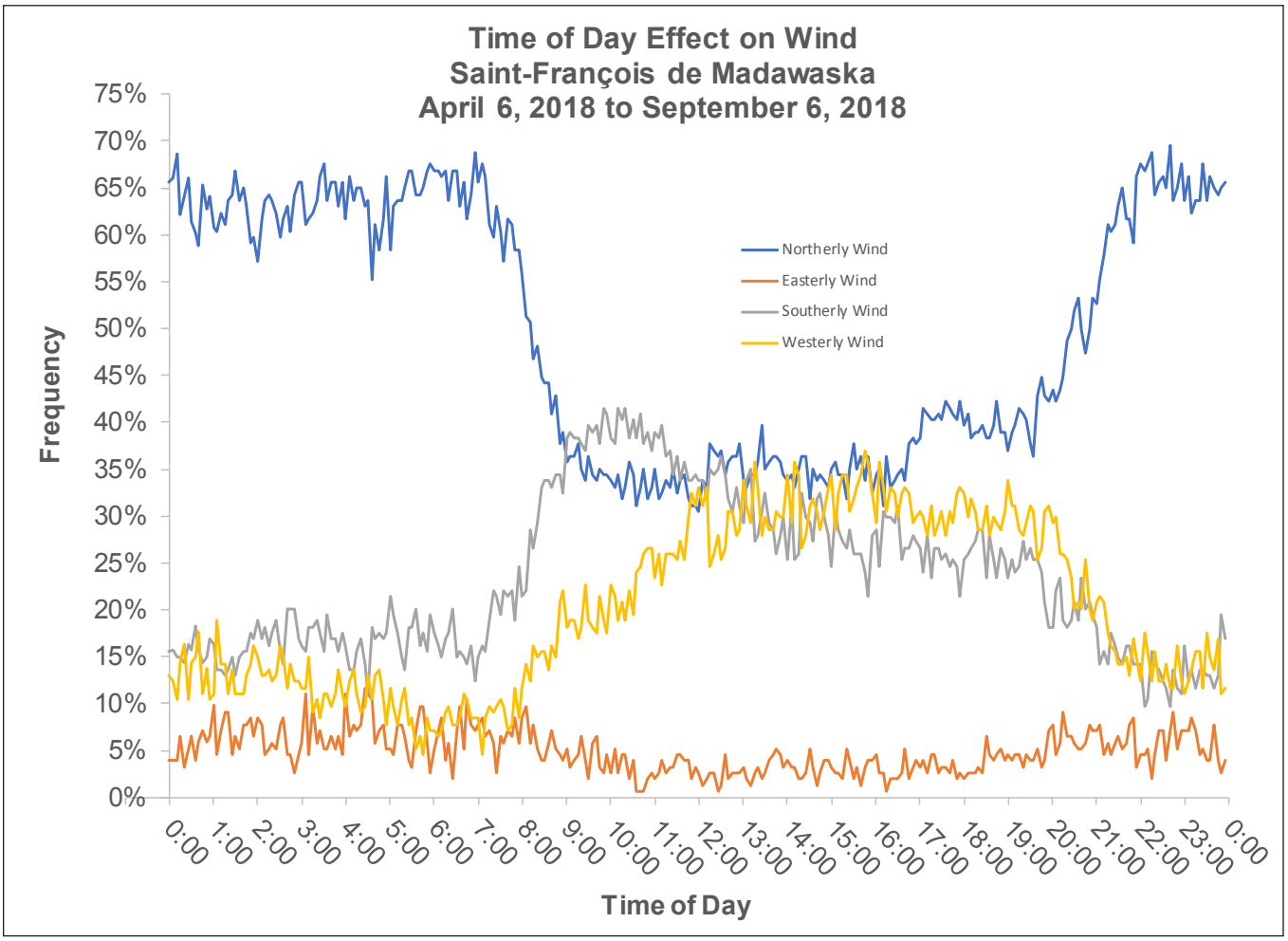

Figure C2: Relative Frequency of Direction of Wind Origin Versus Time of Day - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix D: Project Site Continuous Monitors - Additional Data

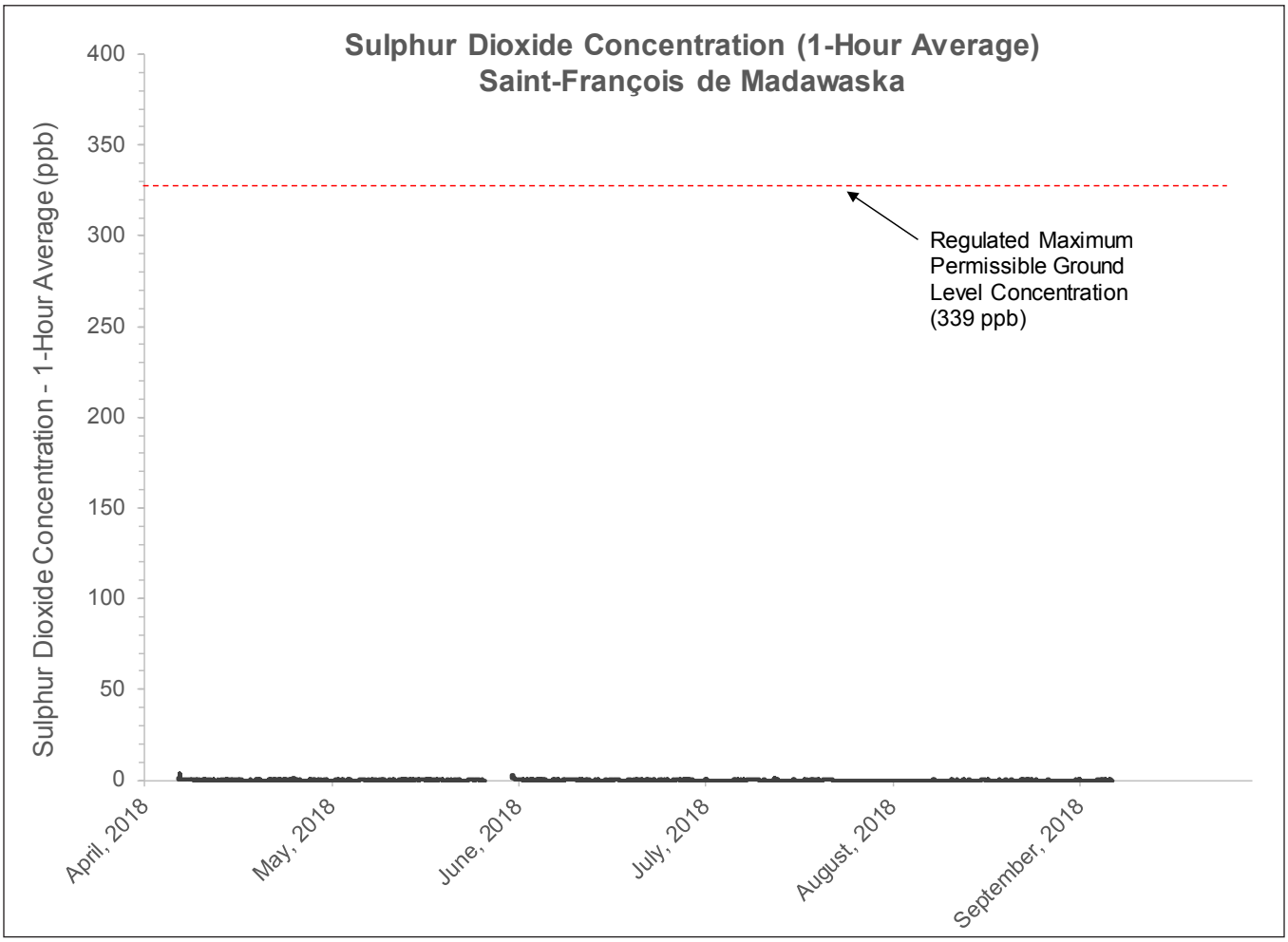

Figure D1: Hourly Average Sulphur Dioxide Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

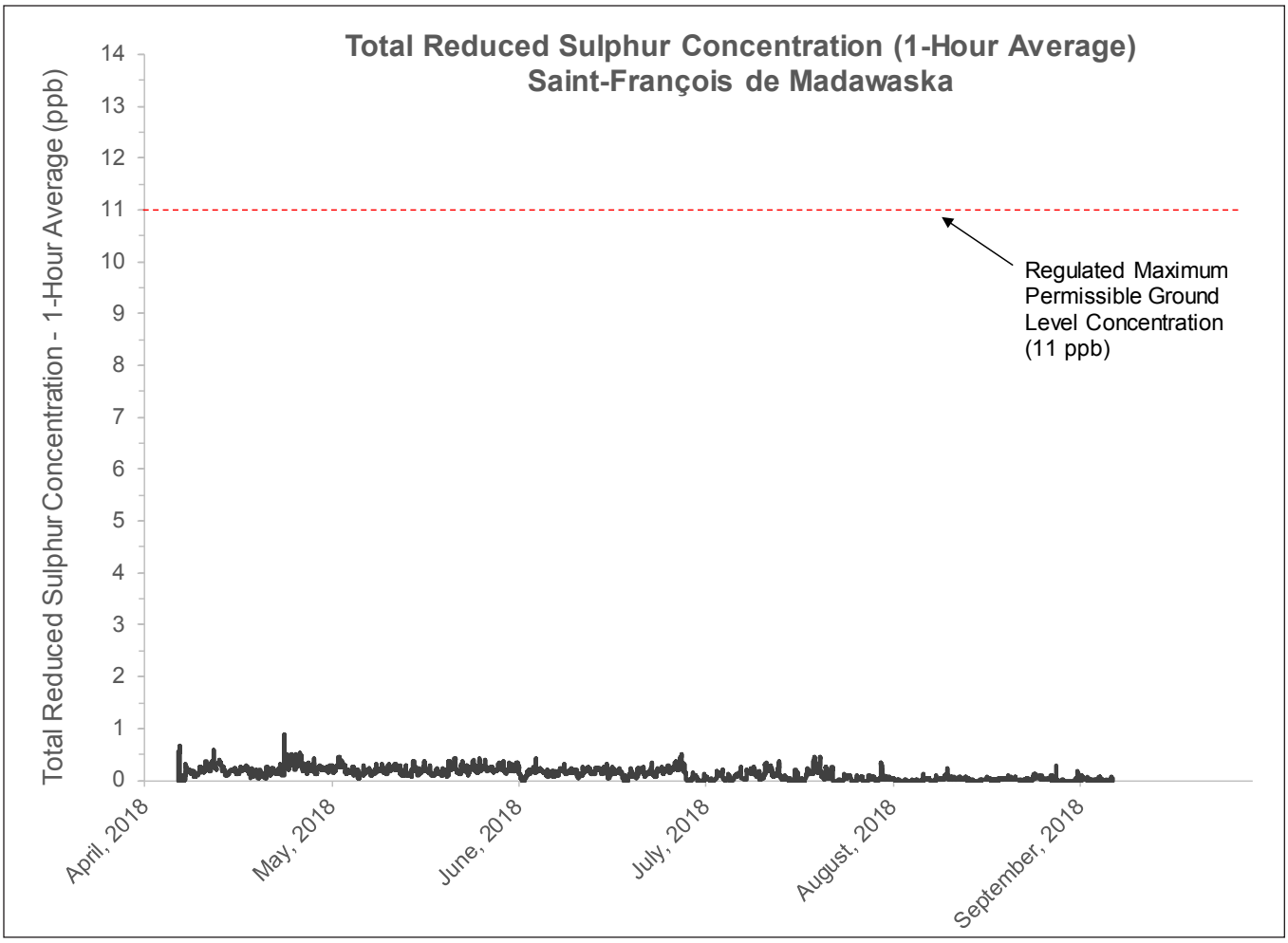

Figure D2: Hourly Average Total Reduced Sulphur Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

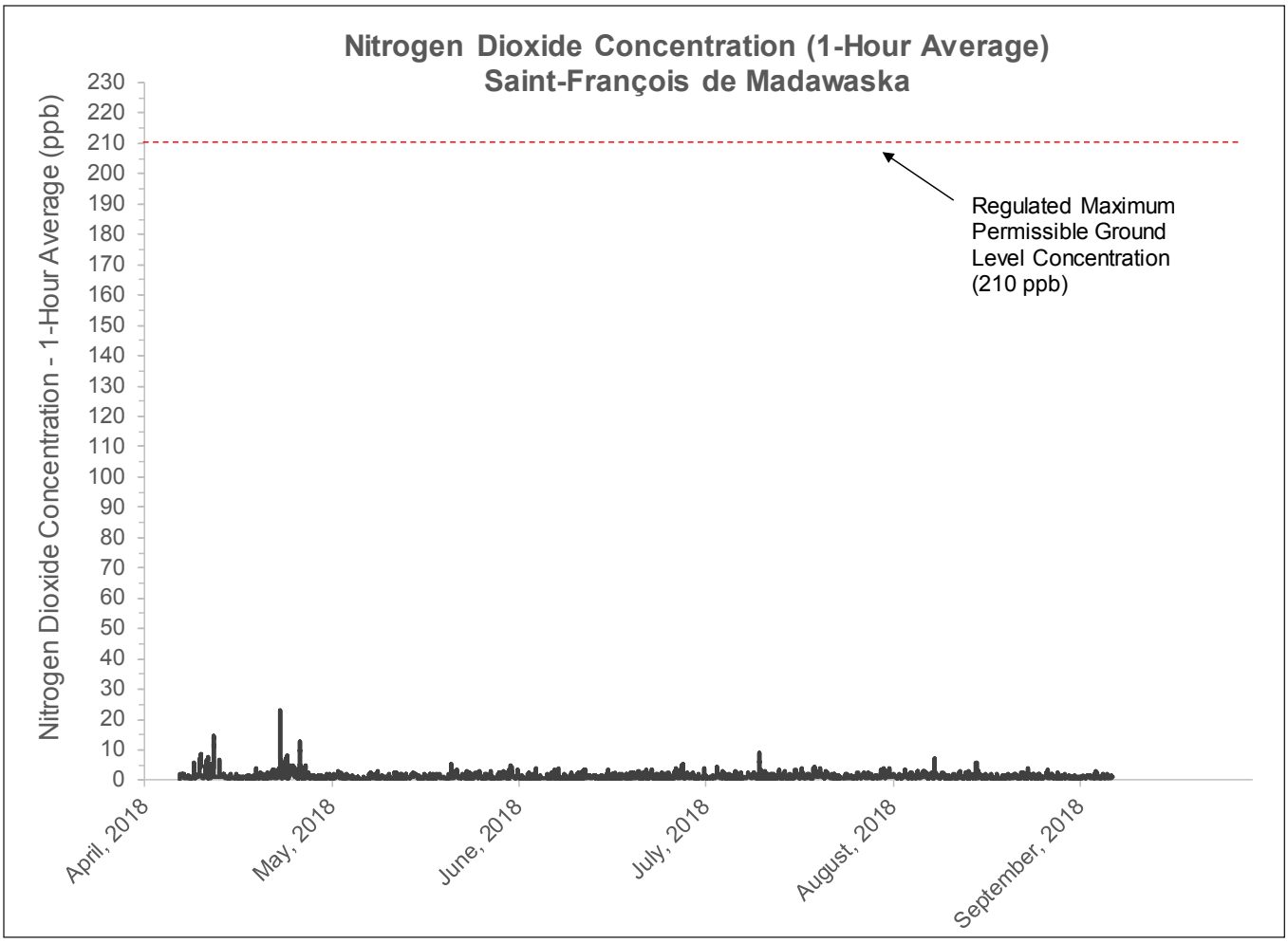

Figure D3: Hourly Average Nitrogen Dioxide Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

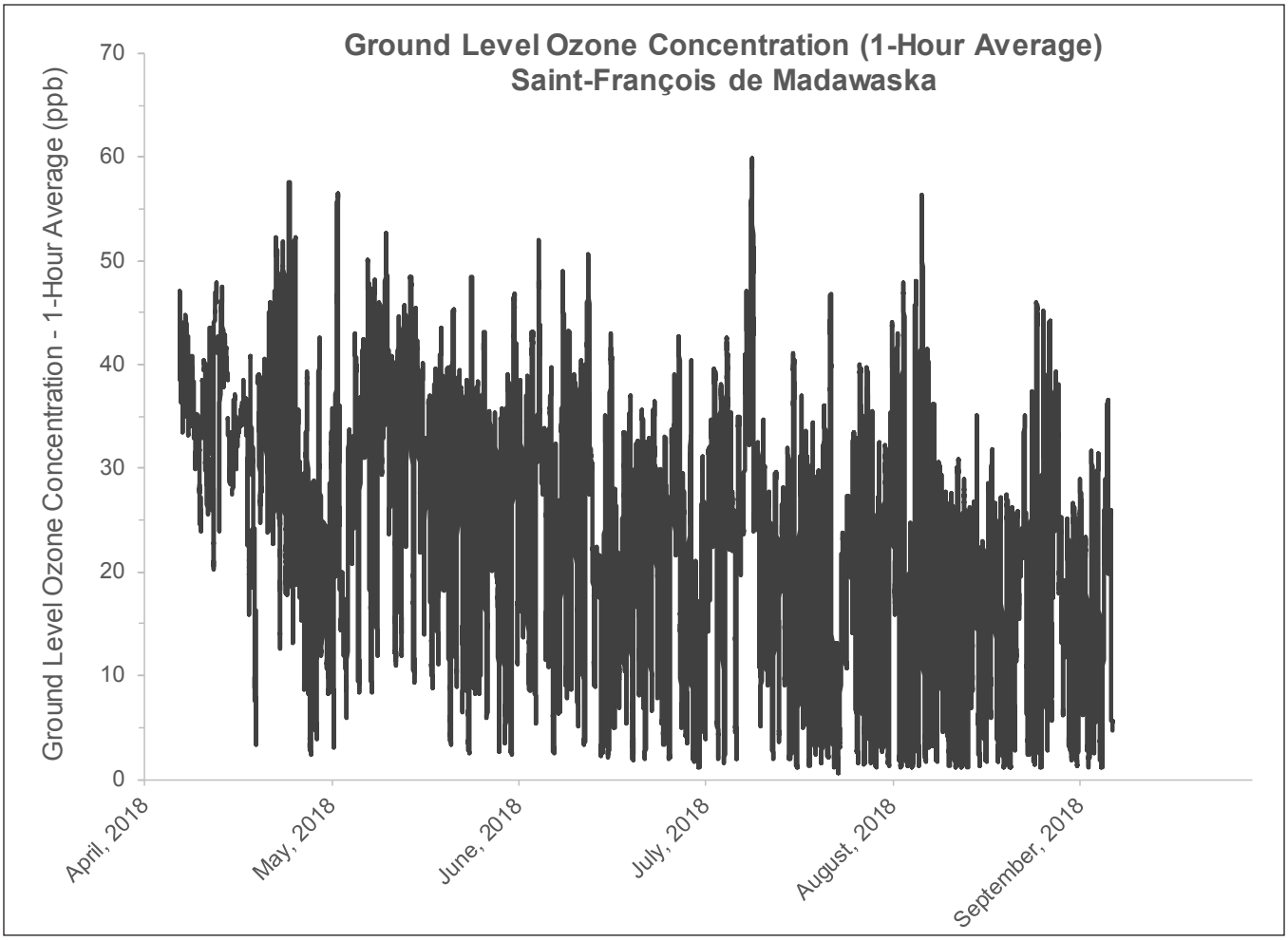

Figure D4: Hourly Average Ground Level Ozone Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

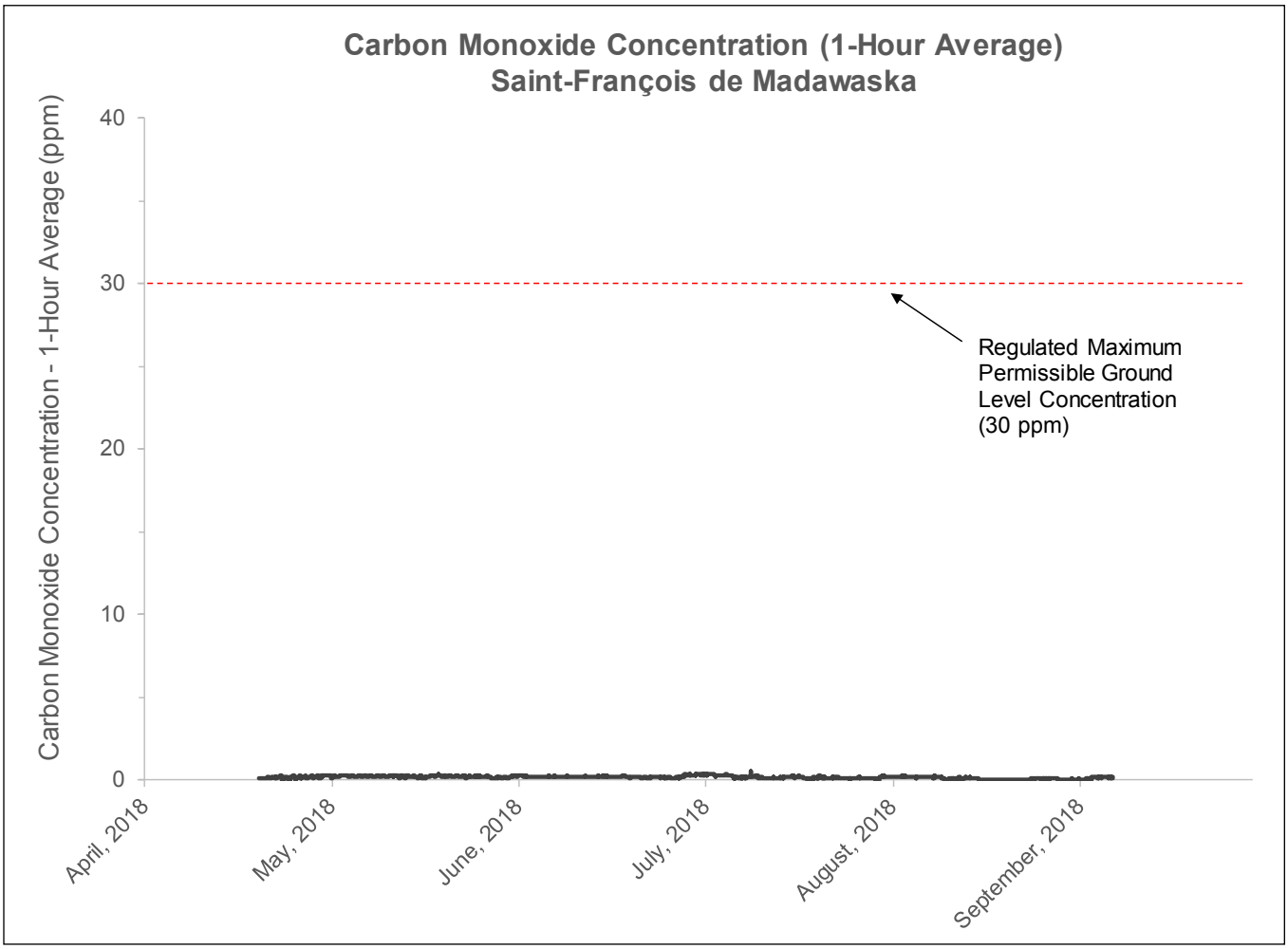

Figure D5: Hourly Average Carbon Monoxide Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

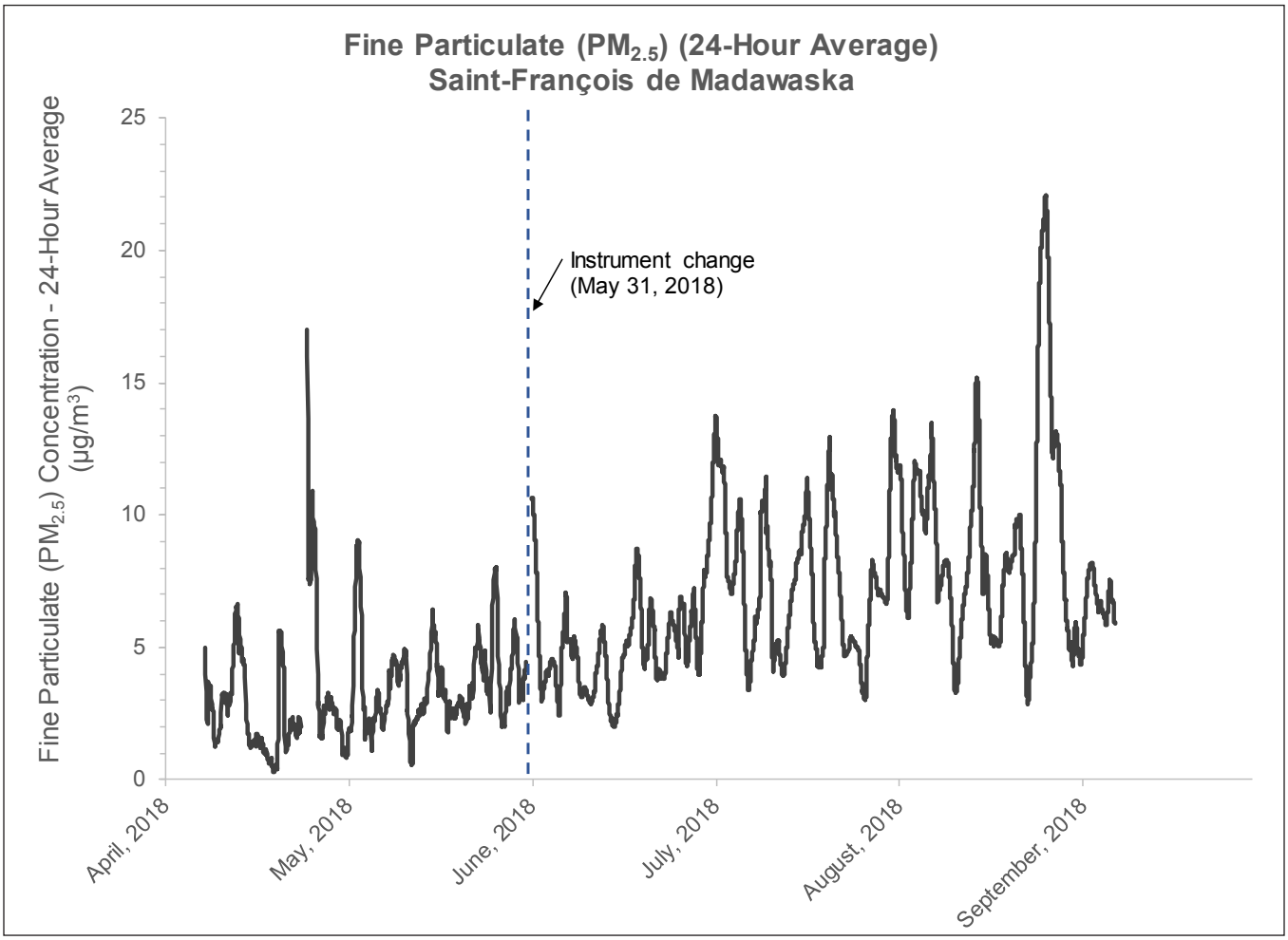

Figure D6: 24-Hour Average Fine Particulate ($PM_{2.5}$) Concentration - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix E: Integrated Ammonia Results

Table E1: Integrated (Two-Week) Ammonia Sampling Results. Saint-François de Madawaska, April 6, 2018 to June 28, 2018.

Sample Start Date	Sample Stop Date	Sample Result (ppb)	Duplicate Sample Result (ppb)	Mean Result (ppb)
April 6, 2018	April 19, 2018	19	17	**18**
April 19, 2018	May 3, 2018	11	12	**12**
May 3, 2018	May 17, 2018	6.4	6.5	**6.5**
May 17, 2018	May 31, 2018	22	21	**22**
May 31, 2018	June 15, 2018	8.2	7.6	**7.9**
June 15, 2018	June 28, 2018	6.9	5.8	**6.4**

Appendix F: Fertilizer Plant Property Line Site Continuous Monitors - Additional Data

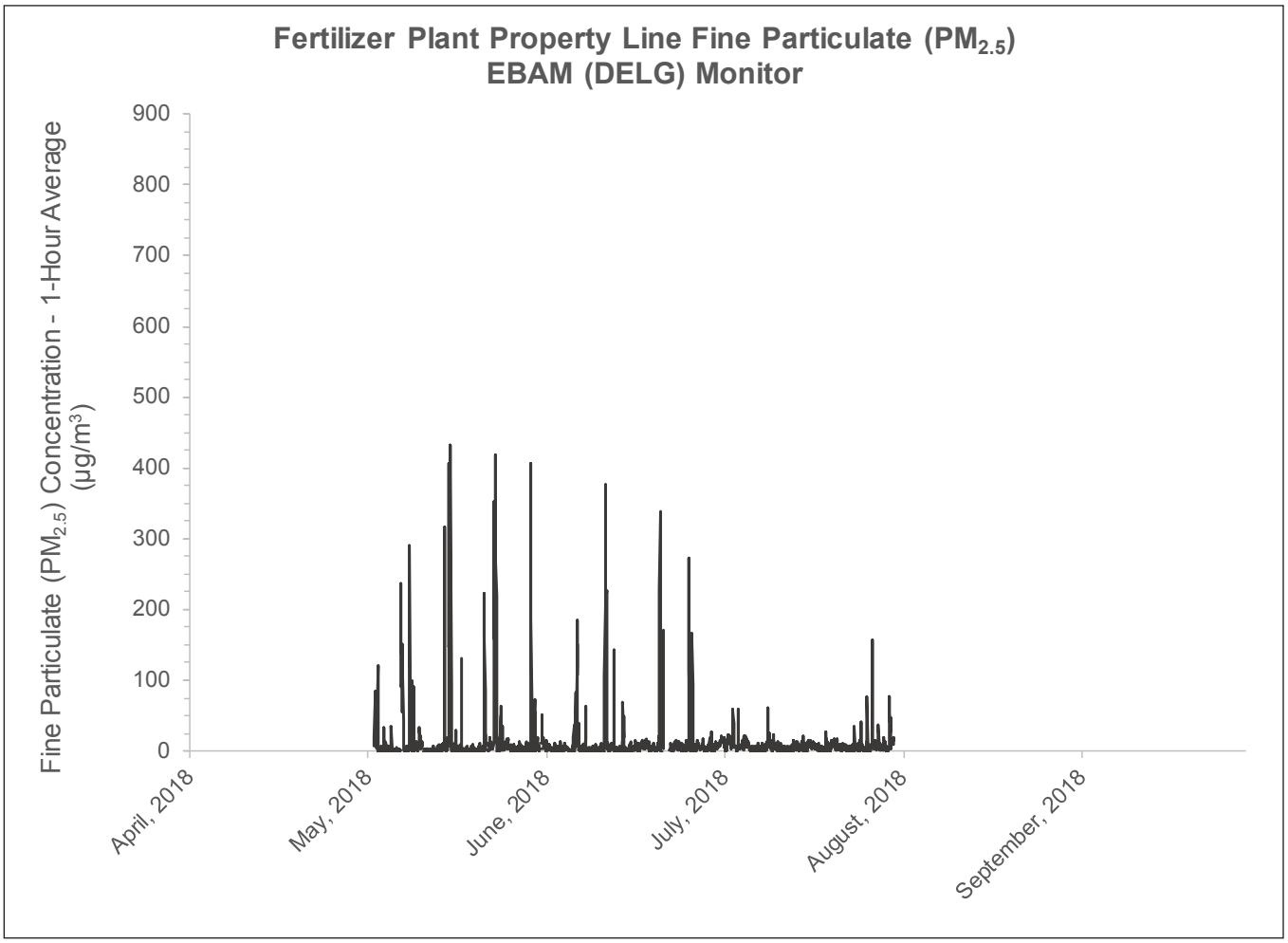

Figure F1: DELG Monitor. 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, May 2, 2018 to July 31, 2018.

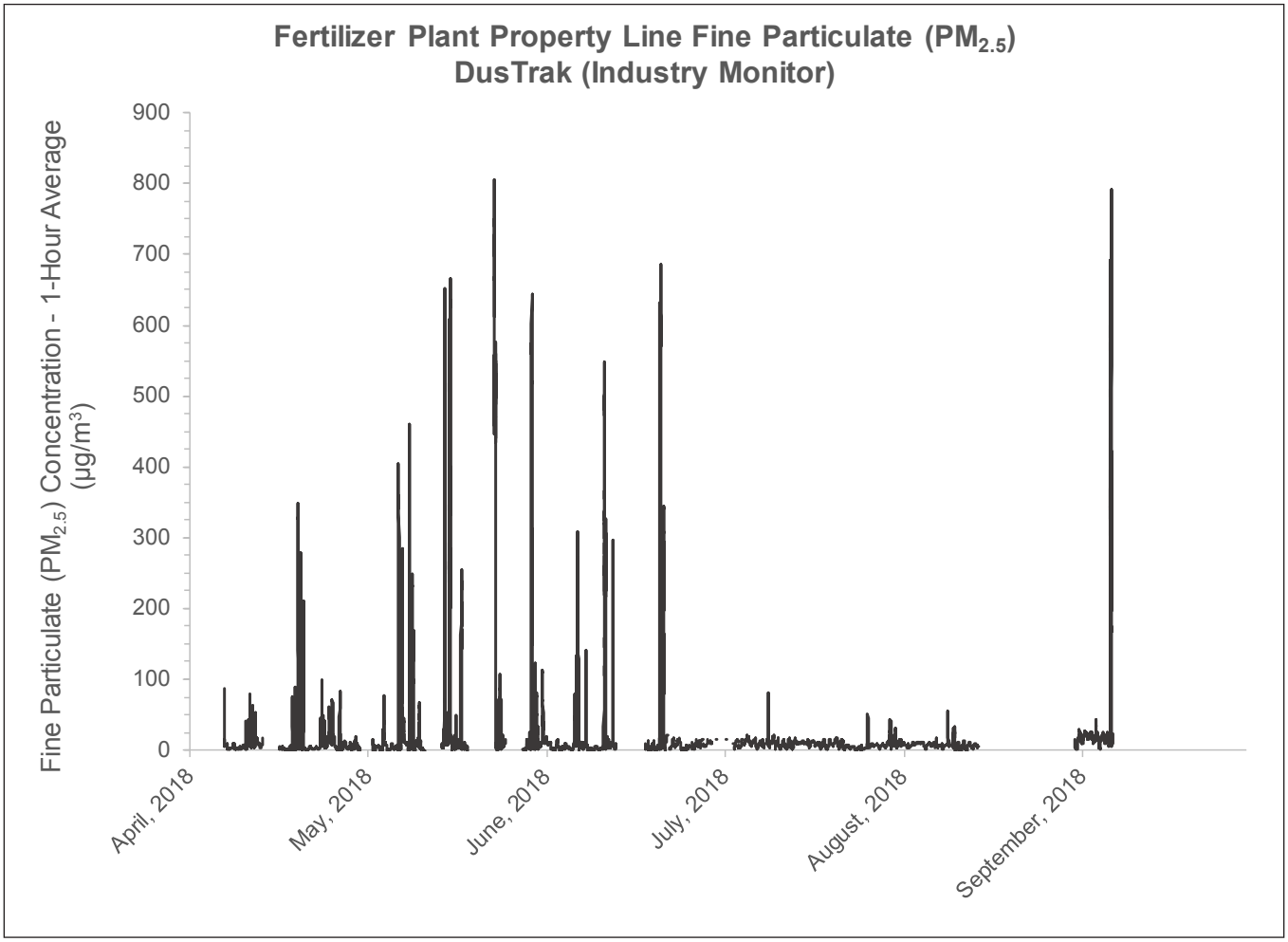

Figure F2: Industry-run Monitor. 1-Hour Average Fine Particulate ($PM_{2.5}$) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

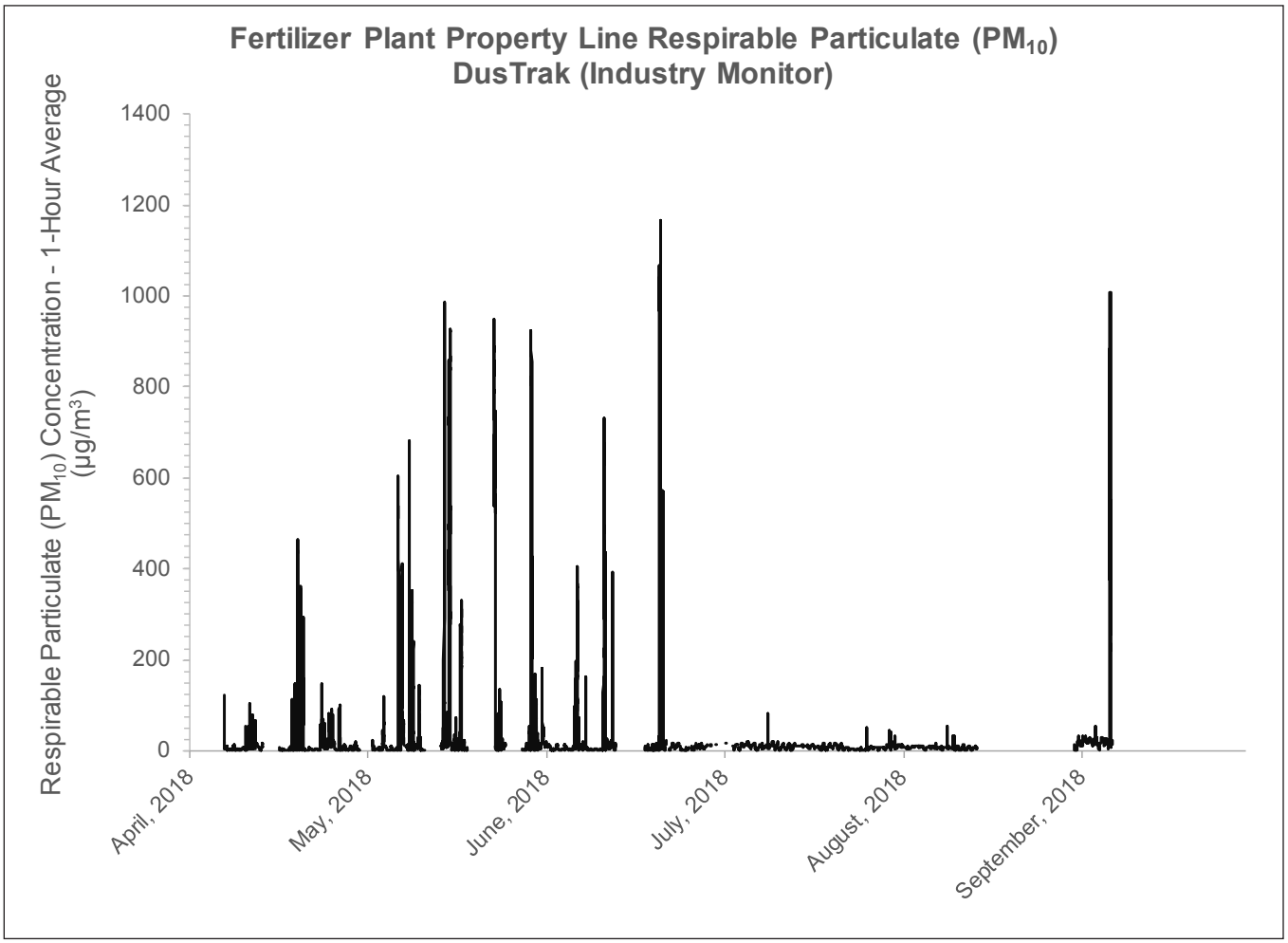

Figure F3: Industry-run Monitor. 1-Hour Average Respirable Particulate (PM_{10}) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

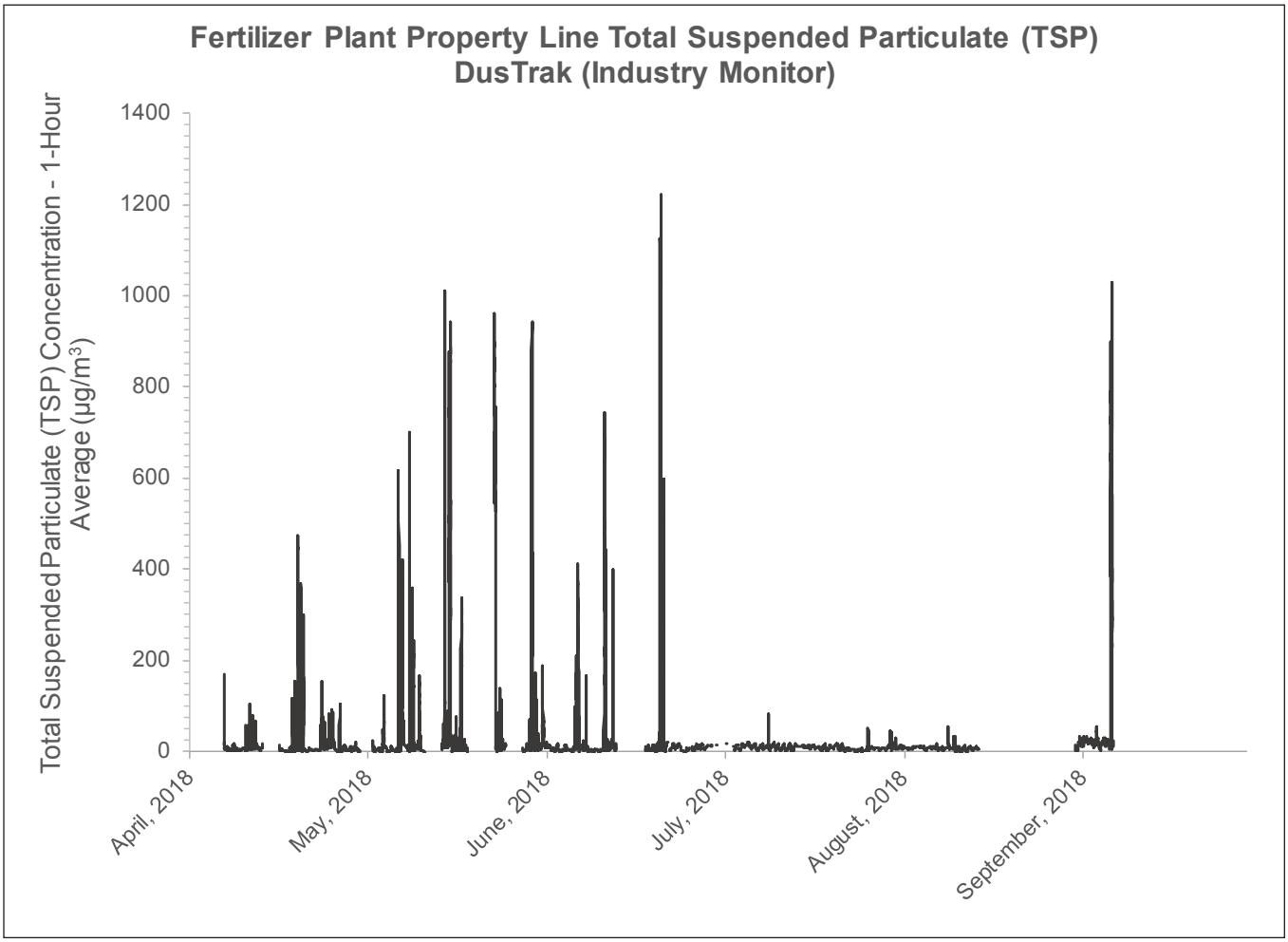

Figure F4: Industry-run Monitor. 1-Hour Average Total Suspended Particulate (TSP) Concentration - Fertilizer Plant Property Line - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix G: Odour/Health Complaint Data

Month	Day	Number of Complaints (Time of Day)
April	9	1 (PM Period), 1 (unspecified)
	10	1 (AM Period), 1 (PM Period), 2(unspecified)
	11	1 (7:30 AM), 1 (8:00 AM), 2 (unspecified)
	12	1 (8:30 AM), 2 (unspecified)
	13	1 (unspecified)
	18	1 (9:00 PM), 2 (PM Period)
	19	1 (7:00 PM), 1 (7:30 PM), 1 (9:00 PM), 1 (PM Period)
	20	1 (8:30 AM), 2 (AM Period)
	23	1 (8:00 AM), 1 (AM Period)
	24	1 (10:00 PM), 1 (PM Period)
	25	1 (AM Period), 1 (PM Period), 1 (unspecified)
	26	1 (8:30 AM), 1 (AM Period), 1 (PM Period)
	27	1 (AM Period)
	30	1 (4:45 PM)
May	1	1 (AM Period)
	2	1 (AM Period), 2 (PM Period), 2 (9:00 PM), 1 (9:30 PM), 1 (9:40), 1 (10:00 PM)
	3	1 (AM Period), 1 (10:15 AM), 2 (10:30 AM), 1 (11:25 AM), 1 (unspecified)
	4	1 (1:00 AM), 1 (AM Period)
	5	1 (unspecified)
	7	1 (4:45 PM), 1 (9:30 PM), 2 (10:30 PM), 1 (PM Period)
	9	1 (AM Period), 1 (8:45 PM), 1 (9:30 PM), 1 PM Period), I (unspecified)
	14	1 (7:30 PM), 1 (9:00 PM), 1 (9:15 PM), 1 (PM Period), 1 (8:30 PM to 2:30 AM on May 15)
	15	1 (4:00 PM), 1 (5:30 PM to 7:30 PM), 1 (9:00 PM), 1 (9:15 PM), 1 (9:30 PM), 1 (PM Period)
	16	1 (9:00 PM), 1 (9:15 PM), 5 (unspecified)
	17	1 (9:00 PM), 1 (9:15 PM), 1 (PM Period)
	18	3 (unspecified)
	21	3 (9:00 PM), 1 (11:00 PM)
	22	1 (7:00 AM)
	23	1 (AM Period), 1 (8:35 AM), 1 (7:00 PM), 1 (9:15 PM), 3 (10:00 PM), 1 (unspecified)
	24	1 (7:30 AM), 3 (unspecified)
	25	1 (unspecified)
	28	1 (10:20 PM), 1 (10:45 PM)
	29	2 (unspecified)
	30	1 (unspecified)
June	6	1 (2:30 PM), 1 (10:30 PM), 1 (11:00 PM), 2 (11:30 PM)
	7	1 (1:30 AM), 1 (2:00 AM), 2 (11:00 PM)
	8	2 (7:00 AM), 2 (unspecified)
	11	1 (10:00 PM)
	17	1 (unspecified)
	18	1 (unspecified)
	21	1 (7:15 AM), 1 (unspecified)
	26	1 (5:30 AM)
July	4	1 (5:30 AM)
	5	1 (6:45 AM), 1 (AM Period)
	6	1 (unspecified)
	9	1 (4:00 PM)
	12	2 (Late PM Period)
	13	1 (5:00 AM), 1 (Early AM Period)
	20	1 (7:00 AM)
	27	1 (unspecified)
	30	2 (unspecified)
	31	1 (9:00 PM), 2 (unspecified)
August	1	3 (unspecified)
	2	2 (unspecified)
	3	2 (unspecified)
	4	1 (11:13 AM)
	5	1 (After 10:00 PM), 1 (10:52 PM)
	6	2 (10:00 PM)
	7	1 (unspecified)
	12	1 (10:00 PM)
	13	1 (unspecified)
	16	1 (11:00 AM)
	22	1 (11:15 AM to 6:15 PM)
	24	1 (unspecified)
	27	1 (AM Period), 1 (PM Period), 2 (all day)
	30	1 (unspecified)
September	6	3 (AM Period), 1 (PM Period)

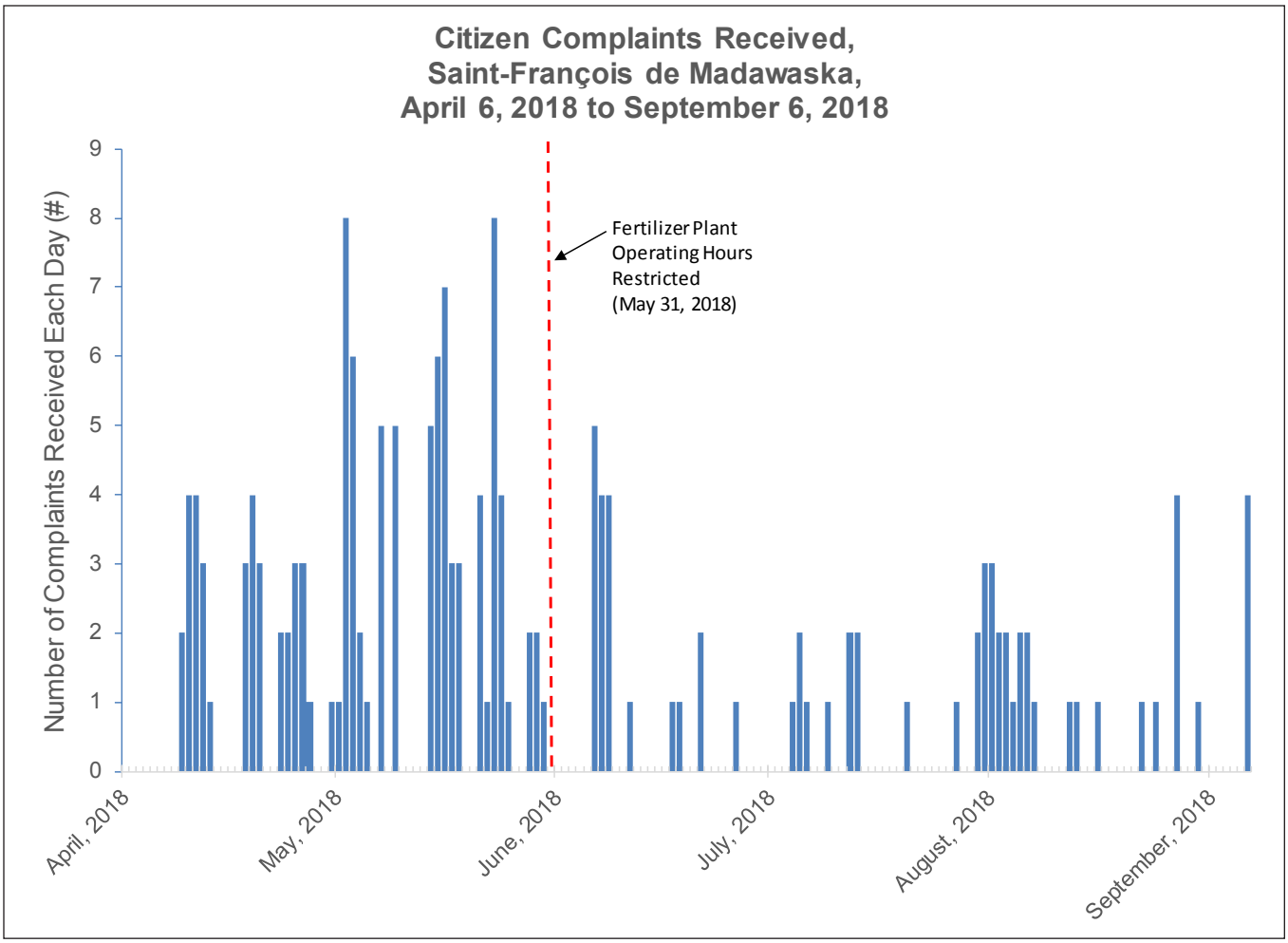

Figure G1: Citizen Complaints - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix H: Fertilizer Plant Operating Hours

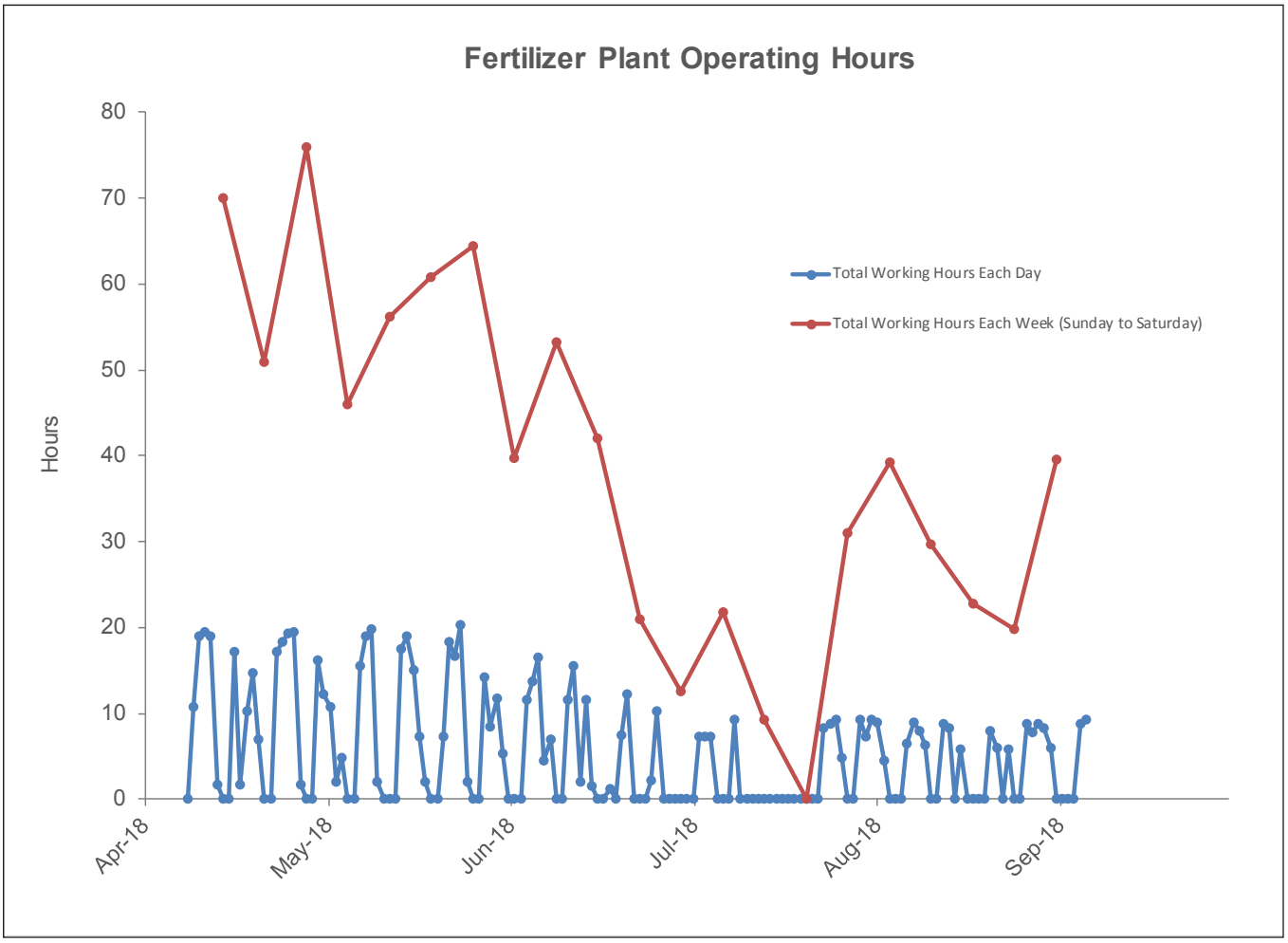

Figure H1: Daily and Weekly Total Operating Hours of the Fertilizer Plant - Saint-François de Madawaska, April 6, 2018 to September 6, 2018.

Appendix I: Three Coinciding Particulate Events

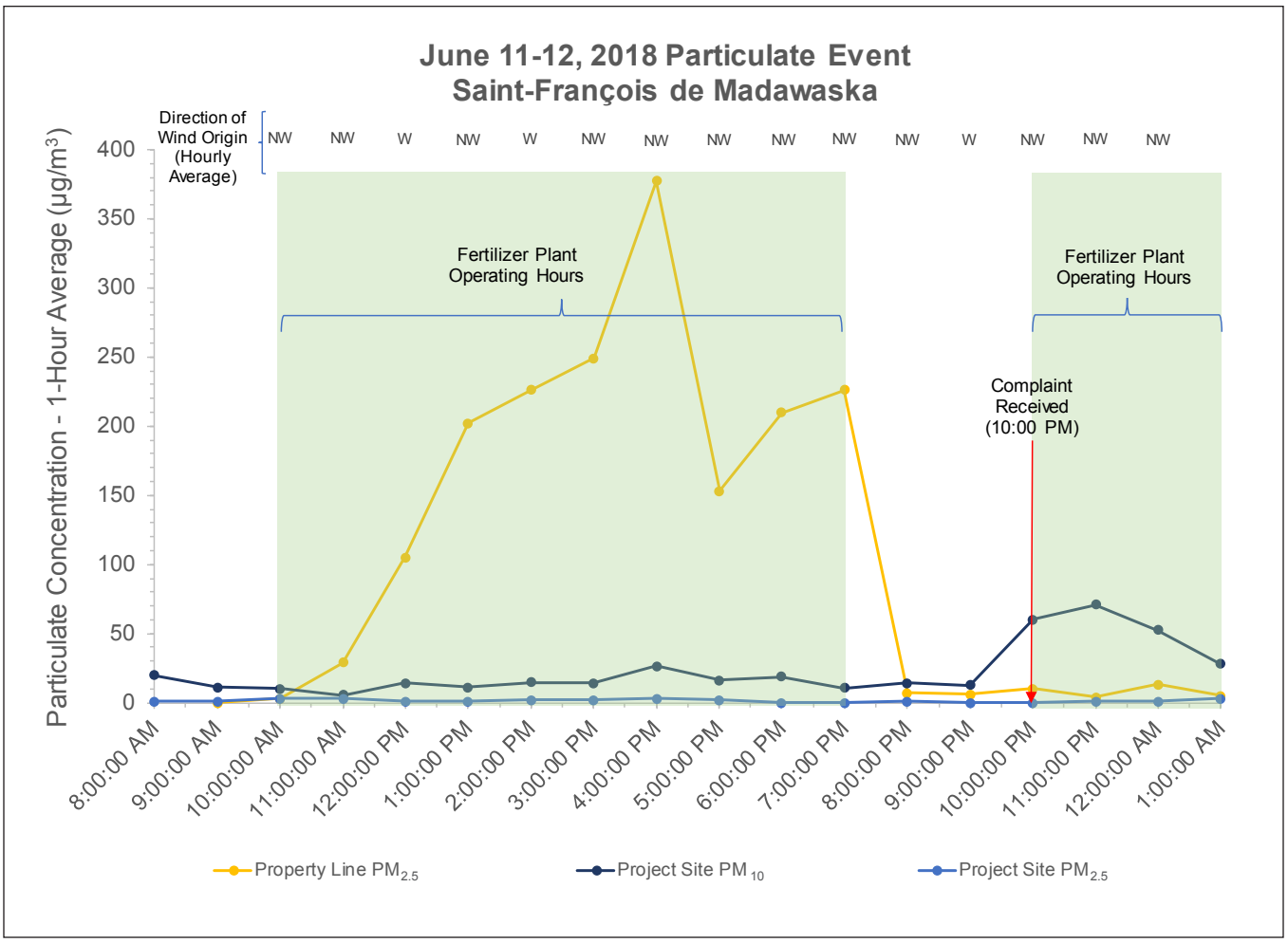

Figure I1: Coinciding Particulate Event. Fertilizer Plant Property Line Location and Project Site. Saint-François de Madawaska. June 11-12, 2018.

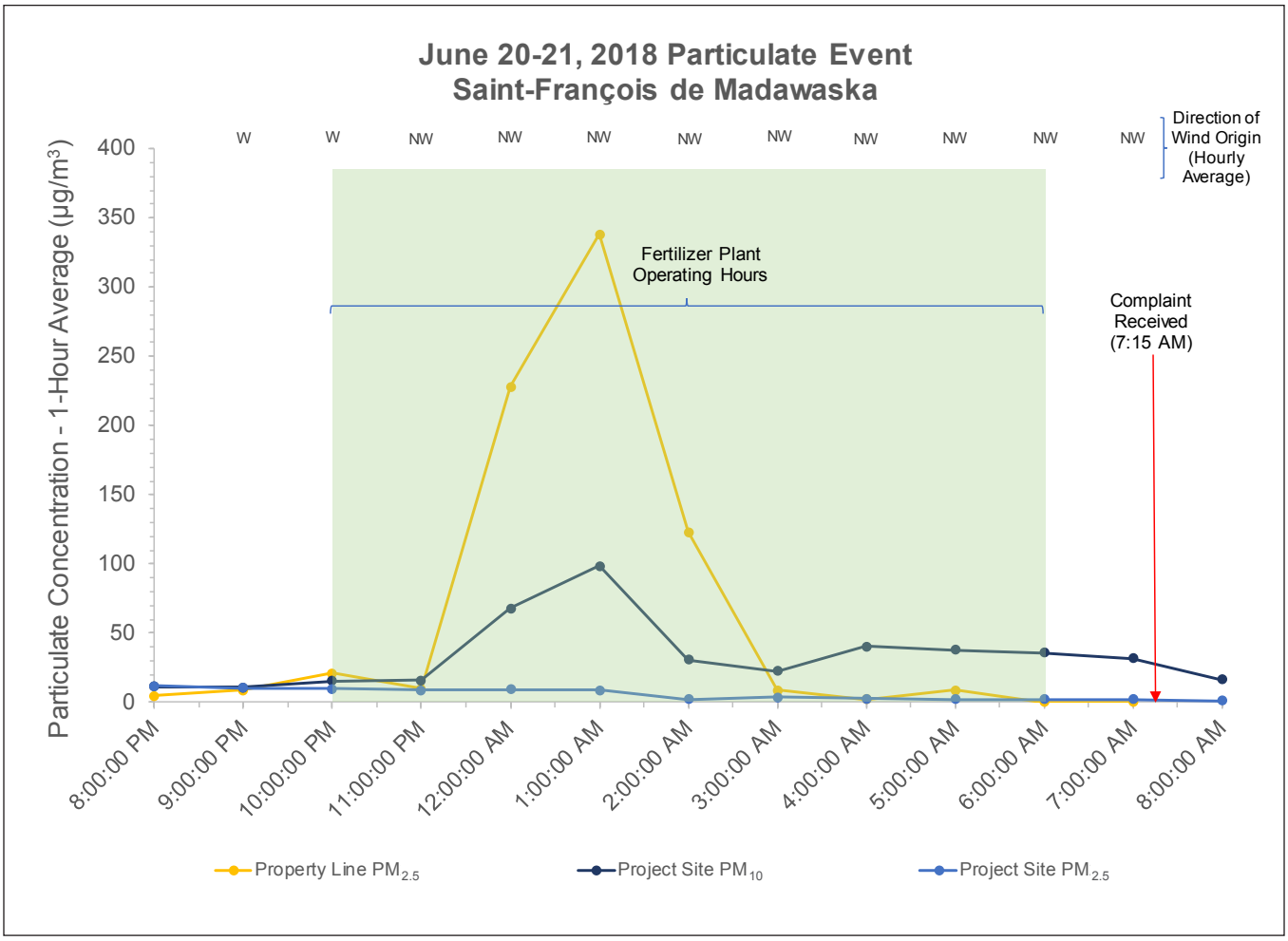

Figure I2: Coinciding Particulate Event. Fertilizer Plant Property Line Location and Project Site. Saint-François de Madawaska. June 20-21, 2018.

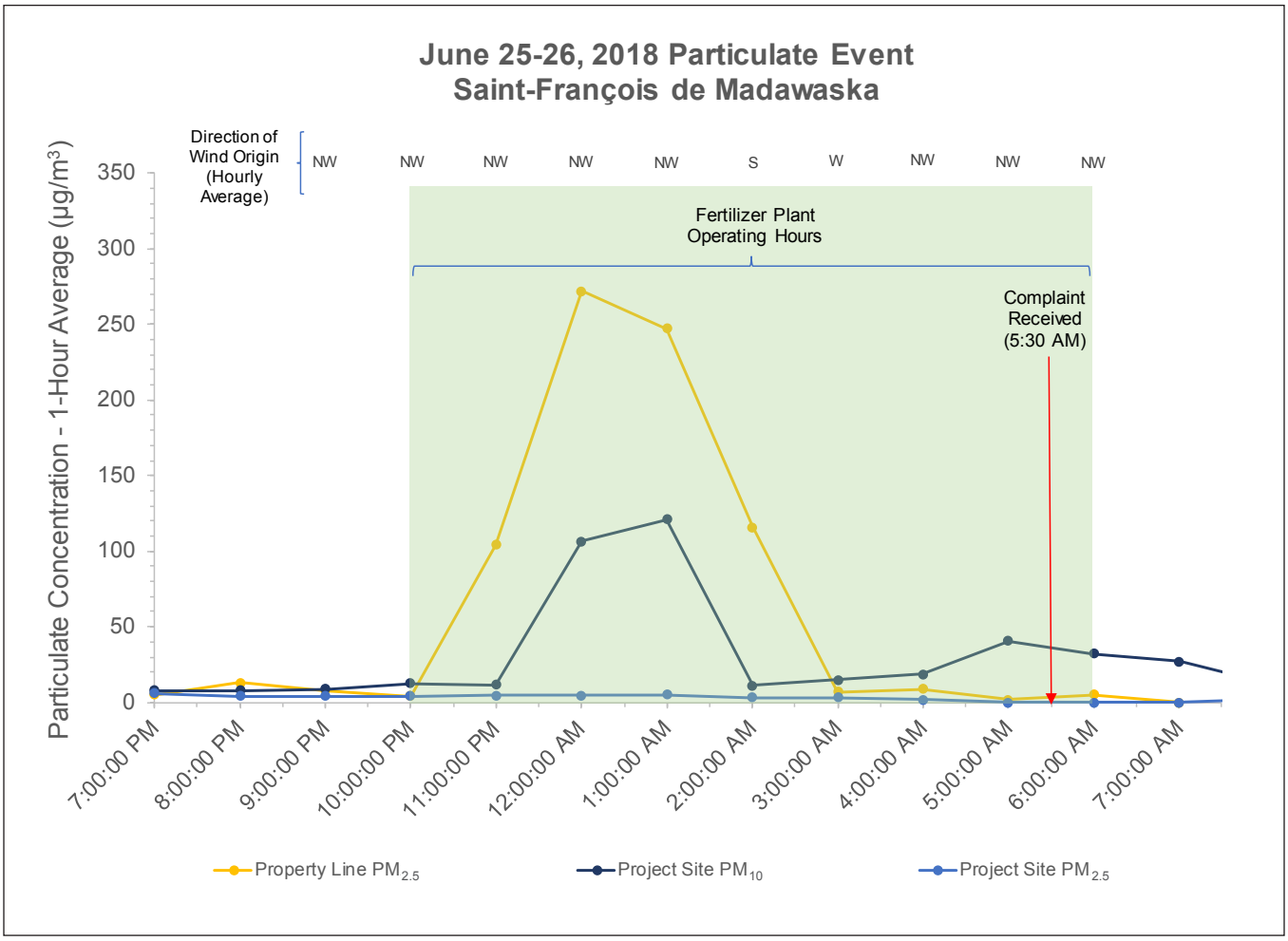

Figure I3: Coinciding Particulate Event. Fertilizer Plant Property Line Location and Project Site. Saint-François de Madawaska. June 25-26, 2018.