Air Quality Evaluation Amos Street - Sainte-Anne, New Brunswick

Final Report

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1.0 Executive Summary

In early 2015, the Department of Environment and Local Government (DELG) received an air quality complaint from a homeowner on Amos Street in Sainte-Anne, New Brunswick concerning a "jet fuel odour" and dark-coloured residue on the siding of nearby homes. The Bathurst Regional Airport is just north of Amos Street and it was identified by the complainant as a potential source of these issues.

The DELG mobile air quality monitoring unit was deployed to the area from July to November 2015 to assess the air quality. Continuous air quality measurements were undertaken to obtain actual ambient air quality concentrations at a fixed site. These were compared to air quality concentrations at other sites in the province and with regulated standards and guidelines. The key pollutants associated with airports were included.

Dustfall samples were also collected in October 2015. 72-hour samples were collected from outside surfaces and residue from a soffit vent on one of the area homes. These samples were analyzed using a variety of microscopy techniques to determine the constitution of the dustfall experienced at this location.

Air quality in the Amos Street area was found to be good for all parameters monitored. There were no recorded exceedances of air quality objectives or guidelines for any of the pollutants measured during the monitoring program. Study results were compared to results for parameters collected at the nearby Rough Waters Drive (Bathurst) air quality monitoring station for the same period. Air quality at the study location was found to be generally better than the Rough Waters Drive location.

Results for Volatile Organic Compounds (VOCs) were compared against the provincial background reference site at Point Lepreau and an urban residential site (Forest Hills, Saint John). Three of the VOCs were detected at higher levels at the study site than results typically detected at the Forest Hills site. These were: methylcyclopentane, acetylene, and 2,3,4 trimethylpentane. These compounds are associated with gasoline, jet fuel, and in the case of acetylene, metal welding and cutting. Nevertheless, concentrations were always well below (*i.e*. better than) available air quality guidelines and standards.

None of the dustfall samples identified particulate types that would implicate the airport or aircraft. The particulate types that accumulated in the area are typical of a rural residential neighbourhood and suggest that the black residue issue in the area is primarily mould growth.

Overall, air quality in the study area was found to be very good. Under worst-case conditions it may be possible for people living in this area to detect the characteristic jet fuel (kerosene) odour, but there is no environmental concern with the VOC levels associated with these odours.

It should be noted that there is some health risk associated with any level of air pollution. However, these risks are considered extremely small for this location, based on the concentrations measured.

2.0 Introduction

2.1 Background

In early 2015 the Department of Environment and Local Government (DELG) received an air quality complaint from a homeowner on Amos Street in Sainte-Anne, New Brunswick. At issue was "jet fuel odour" and dark-coloured residue on the siding of nearby homes. Residents indicated that they had been subjected to these impacts for a long (but unspecified) period of time, and suspected the airport as the source of these issues.

2.2 Area Emission Sources

The Amos Street neighbourhood is characterized as lightly populated, rural, and residential. There is significant forest cover in the area.

Potential emissions sources in the immediate area (within 1 kilometer) include the Bathurst Regional Airport (north), two semi-active gravel pits (southwest), and agricultural operations (south). Additionally, it is expected that there would be intermittent emissions from the residential activities in the area (light vehicle traffic, all terrain vehicle traffic, wood smoke, etc.).

There are no large industrial emission sources in the area. However, the site could potentially receive long-range pollution impacts from small industrial facilities operating in Bathurst (approximately 6 kilometers east of the site). There are also large industrial emitters in the Belledune area (approximately 27 kilometers north of the site) that could influence air quality in this area.

Based on the size and intensity of operations for the various emissions sources identified, significant air pollution impacts at this location would not be expected.

2.3 Potential Air Quality Impacts From Airport Operations

Aircraft exhaust emissions in Canada are regulated by Transport Canada in accordance with international standards established by the International Civil Aviation Organization (ICAO), which is an agency of the United Nations. As such, it is expected that exhaust characteristics for aircraft at the Bathurst Regional Airport would be similar in character to emissions from other airports in New Brunswick, Canada, and the World.

Studies from a variety of different airports suggest that airports and associated aircraft can emit a variety of combustion-related pollutants, all of which carry some level of human health risk. Of these, fine particulate matter ($PM_{2.5}$), and its ultrafine fraction (particles less than 100 nanometers in diameter), is considered the key health-related contaminant.[1]

In general, the risks associated with high levels of fine particulates (regardless of source) include cancer, exacerbations of existing cardiovascular conditions, and premature death. However, epidemiological studies rarely associate aviation-related $PM_{2.5}$ with health outcomes because the contribution from aviation to ambient air quality is generally small.[1]

It should also be noted that most epidemiological and source characterization studies involving airports focus on larger, high-traffic, urban airports. These airports would handle hundreds of

[1] Understanding Airport Air Quality and Public Health Studies Related to Airports, Airport Cooperative Research Program, Report #135, Transportation Research Board of the National Academies, Sponsored by the United States Federal Aviation Administration, Washington DC, 2015.

flights per day, involving the largest commercial jet aircraft. By comparison, the Bathurst Regional Airport, which was identified in the initial complaint, is very small. It operates a single runway, and typically handles only 5 to 7 aircraft per day. Approximately half of these aircraft are small to medium sized turbo-prop aircraft. The remainder are smaller piston-driven aircraft.

Aviation and airport operations can also result in the emission of a variety of volatile organic compounds (VOCs). These are carbon-based compounds that evaporate readily into the air (e.g., solvents, gasoline, etc.). These can be emitted naturally (e.g., by vegetation and animals), but are more typically associated with fuel storage and use.[2]

Jet fuel is a complex mixture of hundreds of carbon-based compounds (hydrocarbons), many of which are VOCs.[3,4] The most common type of jet fuel used in Canada is Jet Fuel A-1, and this is the primary fuel type used at the Bathurst airport.[5] This is a kerosene-based fuel[4,6]. A small amount of Avgas fuel, which is similar to gasoline, is also used by the light aircraft at the airport.[5]

The hydrocarbons that make up these fuels can be released into the environment as VOCs via fugitive emissions (evaporation) from fuel storage and spills, and from the incomplete combustion of fuel during operation of aircraft and ground vehicles.

The health risks associated with VOC emissions from airports are not as great as those previously described for $PM_{2.5}$, but there is potential for aesthetic (odour) impacts from these contaminants.

2.4 Study Overview

DELG deployed its mobile air quality monitoring unit to the study area in July 2015 to conduct a general assessment of air quality. As the full nature and extent of air quality issues in the area was not well understood, monitors for all common air quality contaminants were deployed.

Monitoring of most parameters was carried out for a period of approximately four months (July – November, 2015) to ensure that a wide variety of air quality and weather conditions were captured.

During October and November 2015 an instrument was deployed to gather periodic composite air samples for 50 of the most common VOCs associated with jet fuel and aircraft emissions.

A general overview of air contaminants, their sources, and effects are provided in Appendix A.

Additionally, in October 2015 DELG collected dustfall samples in the area for microscopic analysis to determine the composition of the dustfall that is being experienced at this location.

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[2] Environment Canada (2015) Retrieved from http://www.ec.gc.ca/cov-voc/

[3] Irving Jet Fuel A-1 Material Safety Data Sheet (2015) Retrieved from https://www.irvingoilcommercial.com/ProductsandServices/SpecialtyFuels/JetFuel.aspx

[4] Colket, Meredith, et al. "Development of an experimental database and kinetic models for surrogate jet fuels." 45th AIAA Aerospace Sciences Meeting and Exhibit. 2007.

[5] Jennifer Henry, Executive Director, Bathurst Regional Airport, Personal Communication, January 12, 2016.

[6] Maisol and Harrison "Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review." Atmospheric Environment Volume 95, October 2014, Pages 409–455

3.0 Methodology

3.1 Meteorology Equipment

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

Wind direction data from the Vaisala monitor was lost due to a software error in the data management system. Consequently, wind direction data was obtained from Environment Canada's weather station at the Bathurst Regional Airport.

All meteorological parameters, except Environment Canada wind data, were logged as five minute averages and retrieved automatically on an hourly basis.

Wind data from Environment Canada was logged as two minute averages for the two minutes preceding the hourly timestamp for each measurement.

3.2 Continuous Air Quality Monitoring Equipment

Monitoring equipment was deployed to continuously measure ambient (outside air) concentrations of: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), total reduced sulphur (TRS), ground level ozone (O_3), total suspended particulate (TSP), and fine particulate ($PM_{2.5}$). Technical specifications for these instruments are provided in Appendix B.

Monitoring of continuous parameters began on July 16, 2015 and concluded on November 30, 2015.

All continuous parameters except for the two particulate parameters were logged as five minute averages. Total suspended particulate and fine particulate data was logged as hourly averages. Data for continuous parameters was retrieved automatically on an hourly basis.

3.3 Volatile Organic Compound (VOC) Monitoring Equipment

Ambient (outside air) concentrations of Volatile Organic Compounds (VOCs) were monitored using an AMA Instruments GmbH Online Gas Chromatograph, Model GC 5000 BTX + VOC. This is a two-unit (two-part) analyzer. The first unit (BTX) measures the following VOCs:

2,2-Dimethylbutane
3-Methylpentane
1-Hexene
n-Hexane
Benzene
Cyclohexane
2-Methylhexane
2,3-Dimethylpentane
3-Methylhexane
2,2,4-Trimethylpentane
n-Heptane
Methylcyclohexane
2,3,4-Trimethylpentane
Toluene
2-Methylheptane
3-Methylheptane
n-Octane
Ethylbenzene
m,p-Xylene
Styrene
o-Xylene
n-Nonane
i-Propylbenzene
n-Propylbenzene
m-Ethyltoluene
p-Ethyltoluene
1,3,5-Trimethylbenzene
o-Ethyltoluene
1,2,4-Trimethylbenzene
n-Decane
1,2,3-Trimethylbenzene
m-Diethylbenzene
p-Diethylbenzene
n-Undecane

The second unit (VOC) measures the following additional VOCs:

Ethane	trans-2-Butene	2,3-Dimethylbutane
Ethene	cis-2-Butene	2-Methylpentane
Propane	i-Pentane	Isoprene
Propene	trans-2-Pentene	2,4-Dimethylpentane
i-Butane	cis-2-Pentene	
Acetylene	Methylcyclopentane	

All VOC data was logged as 15 minute averages every 1 hour and 15 minutes (total sample cycle period of 1 hour and 30 minutes). The analyzer draws a sample for a period of 15 minutes, then analyses the sample for 1 hour and fifteen minutes before drawing the next sample.

The lower detection limit (LDL) for the AMA Instruments Gas Chromatograph is recalculated against a new calibration sequence for each sample. The upper limit (worst case) for the LDL is 30 parts per trillion (ppt).

Monitoring of parameters with the "BTX" part of the instrument occurred from October 15, 2015 to November 1, 2015, and from November 5, 2015 to November 30, 2015. Data was not collected during the November 1 through November 5 period due to a malfunction. A total of 630 measurements were taken for each of these parameters over this period.

Monitoring of parameters with the "VOC" part of the unit occurred from October 15, 2015 to November 1, 2015, and from November 25, 2015 to November 30, 2015. Data was not collected during the November 1 through November 25 period due to a malfunction. A total of 319 measurements were taken for each of these parameters over this period.

Data was retrieved by technicians during site visits.

3.4 Dustfall Collection Procedures

The composition of dustfall near the study site was determined via polarized light microscopy, scanning electron microscopy, and energy dispersive x-ray spectroscopy, which was carried out under contract with Microvision Laboratories, Inc. of Chelmsford, Massachusetts.

Dustfall samples were collected from three, flat, horizontal surfaces within 100 meters of the study site (a plate glass surface, a piece of aluminum sheeting, and a painted metal surface).

Each surface was cleaned three days (72 hours) prior to sampling using GhostWipe brand vinyl copolymer wipes, which were pre-wetted with de-ionized water.

Samples were collected via a "tape lift off" sampling method wherein consumer-grade clear plastic adhesive tape was applied to the area and lifted off, thereby capturing the dust sample on the glued surface. This tape was then applied to another clear plastic surface to secure the sample for transport.

A fourth sample was collected from a soffit vent on one of the area homes. This area contained an abundance of the black residue that was the subject of homeowner complaints. This area was sampled "as is" without cleaning, via the previously described tape lift-off method.

All dust samples were collected on October 9, 2015.

3.5 Study Location

The work was carried out in the area of Amos Street, in Sainte-Anne, New Brunswick (approximately 47°37'38.9"N 65°44'33.6"W). This is a rural, forested, residential area, approximately 190 meters south of the runway and apron of the Bathurst Regional Airport. The study area is pictured in Figure 1.

3.6 Other Data Sources

Detailed aircraft activity records were provided by the Bathurst Regional Airport (Northern New Brunswick Airport Authority Inc.).

For comparison purposes, data was also collected from the nearest permanent air quality monitoring station to the study site, which is located on Rough Waters Drive, Bathurst. Similarly, VOC data was collected from the provincial background reference site for VOCs, which is located at Point Lepreau, New Brunswick. VOC data was also collected from another residential area in the province (Forest Hills, Saint John).

3.7 Quality Assurance

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

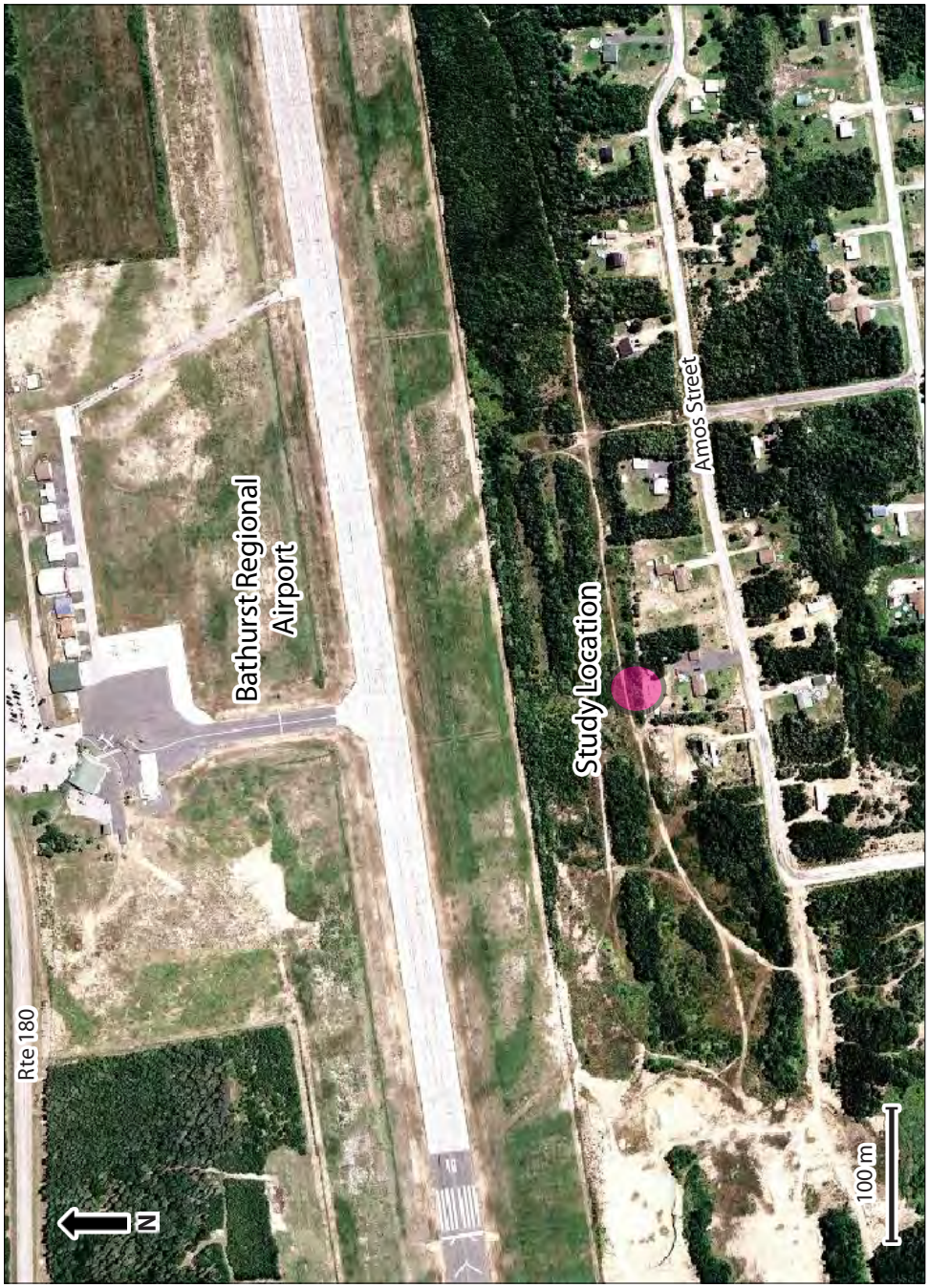

Figure 1. Location of Study (Image courtesy of GeoNB)

4.0 Results and Discussion

The following analysis will rely heavily on comparisons against objective ambient air quality standards. Note that New Brunswick has not adopted standards for all contaminants in law. In these cases, concentrations are evaluated against standard or guideline values that have been adopted by policy. Where no guideline exists in policy, concentrations are compared against the most stringent standard currently available in the World.

It should also be noted that air quality standards can be adopted for a variety of different purposes. With respect to New Brunswick's regulated standards, and the guidelines that have been adopted by policy, the threshold levels are designed to be protective of human health and the environment. However, for other contaminants (primarily the less common VOCs) robust health and environment based guidelines may not be available. In these cases, the referenced standards may be based on aesthetic (odour) impacts. In the following analysis, health and environment based objectives are prioritized and used if available.

4.1 Meteorology - Wind

Winds at the study site originated generally from south/westerly directions during the study period. Northerly winds (i.e., blowing from the direction of the airport toward the study site) were less frequent, occurring 12.7% of the time. Including winds originating in a broader northerly area (northeasterly, northerly, and northwesterly), the total is 34.7%.

Northerly winds (*i.e.*, originating from the direction of the airport) were relatively weak, averaging 5.2 km/hr.)

Wind data is further illustrated in Appendix C.

4.2 Continuously Monitored Parameters

The following analysis examines the results of continuously monitored parameters. It should be understood that this type of monitoring provides the best representation of air quality that is currently achievable. With the exception of brief, intermittent calibration cycles, there are no gaps in coverage, as air is constantly being drawn through the machines. These monitors provide objective measurements of actual air quality at all times, and do not rely on modelling or statistical approximations.

Although these instruments monitor air quality on a continuous basis, in order to compare results against regulated standards and guidelines, the results must be mathematically converted into the correct form. For instance, by averaging twelve 5-minute averages together to create a 1-hour average. This section provides many such comparisons.

Note that regulated standards take a wide variety of statistical forms (e.g., hourly averages, daily averages, annual averages, etc.). Each of these forms has been crafted to achieve specific environmental or public health goals. However, it is beyond the scope of this report to explore each in detail. Rather, this analysis will focus on a simple comparison against the standards and guidelines that are relevant to the study.

Average and maximum concentrations observed for each of the continuously monitored parameters are provided in Table 1. Results are then compared against regulated standards and guideline values in Table 2. As indicated, contaminant levels remained well below the regulated limits and guideline values throughout the study period.

The full data set for each parameter is illustrated graphically in Appendix C.

Table 1: Summary of Results - Continuously Monitored Parameters

Parameter	Average Concentration (4 Month)	Peak Concentration
Sulphur Dioxide (SO_2)	0.2 ppb	26 ppb (5 minute average) (November 10, 2015)
Nitrogen Dioxide (NO_2)	0.6 ppb	9.9 ppb (5 minute average) (October 28, 2015)
Carbon Monoxide (CO)	0.2 ppm	2.2 ppm (5 minute average) (July 27, 2015)
Total Reduced Sulphur (TRS)	0.1 ppb	2 ppb (5 minute average) November 10, 2015.
Ground Level Ozone (O_3)	21 ppb	58 ppb (5 minute average) September 19, 2015
Total Suspended Particulate (TSP)	7 µg/m^3	68 µg/m^3 (1 hour average) (November 12, 2015)
Fine Particulate ($PM_{2.5}$)	4.9 µg/m^3	24 µg/m^3 (1 hour average) (September 5, 2015)

Table 2: Continuous Parameters Comparisons to Standards and Guidelines

Parameter	Standard/Guideline Value	Study Result	Notes
Sulphur Dioxide	339 ppb (hourly average)*	16 ppb (maximum hourly average detected)	-
	113 ppb (24 hour average)*	2 ppb (maximum 24 hour average detected)	-
	23 ppb (annual average)*	0.2 ppb (4 month average)	Provided for illustration purposes. A proper comparison would require collecting a full year of data at the study site.
Nitrogen Dioxide	210 ppb (hourly average)*	7 ppb (maximum hourly average detected)	-
	105 ppb (24 hour average)*	2 ppb (maximum 24 hour average detected)	-
	52 ppb (annual average)*	0.6 ppb (4 month average)	Provided for illustration purposes. A proper comparison would require collecting a full year of data at the study site.

Table 2: Continuous Parameters Comparisons to Standards and Guidelines (continued)

Parameter	Standard/Guideline Value	Study Result	Notes
Carbon Monoxide	30 ppm (hourly average)*	0.5 ppm (maximum hourly average detected)	-
	13 ppm (8 hour average)*	0.4 ppm (maximum 8 hour average detected)	-
Total Reduced Sulphur	11 ppb (hourly average)*	1.0 ppb (maximum hourly average detected)	The TRS standard is based on the Regulated standard for Hydrogen Sulfide.
	3.5 ppb (24 hour average)*	0.1 ppb (maximum 24 hour average detected)	
Ground Level Ozone	80 ppb (hourly average)**	56 ppb (maximum hourly average detected)	-
	63 ppb (Fourth worst daily maximum 8 hour average, averaged over three years)***	48 ppb (maximum 8 hour average detected)	Provided for illustration purposes. A proper comparison would require collecting three years of data at the study site.

Table 2: Continuous Parameters Comparisons to Standards and Guidelines (continued)

Parameter	Standard/Guideline Value	Study Result	Notes
Total Suspended Particulate	120 µg/m^3 (24 hour average)*	19 µg/m^3 (maximum 24 hour average detected)	-
	70 µg/m^3 (annual geometric mean)*	5.5 µg/m^3 (4 month geometric mean)	Provided for illustration purposes. A proper comparison would require collecting a full year of data at the study site.
Fine Particulate	28 µg/m^3 (98th percentile daily maximum 24 hour average, averaged over three years)***	14 µg/m^3 (maximum 24 hour average detected)	Provided for illustration purposes. A proper comparison would require collecting three years of data at the study site.
	10 µg/m^3 (3 year average)***	4.9 µg/m^3 (4 month average)	Provided for illustration purposes. A proper comparison would require collecting three years of data at the study site.

* New Brunswick Air Quality Standards, as prescribed under *New Brunswick Regulation* 97-133, *Clean Air Act*.
** Ontario Ambient Air Quality Criteria.
*** Canadian Ambient Air Quality Standard.

4.3 Continuously Monitored Parameters - Comparisons to Bathurst Station

Results from the study site are compared to results for the three parameters currently monitored at the nearby Bathurst air quality monitoring station (located on Rough Waters Drive, Bathurst), in Figures 2, 3, and 4. These comparisons provide an indication of the air quality at the study site versus typical, or "normal", values for this region.

As illustrated in Figures 2 and 3, fine particulate matter and nitrogen dioxide levels were lower at the study site than at Rough Waters Drive over the same period.

As illustrated in Figure 4, ground level ozone levels were slightly higher at the study site. However this is likely due to chemical interactions between ozone and nitrogen oxides.

Ground level ozone is formed when nitrogen oxides react chemically with VOCs in the presence of sunlight. However, in the absence of sunlight nitrogen oxides also react with and destroy ozone, which results in lower ground level ozone concentrations.[7]

As the VOC levels at the study site are very low, there is little opportunity for ground level ozone formation locally. Most ozone in this area is likely a result of long distance transport. As nitrogen oxide concentrations are also low, there is also little opportunity for ozone to be depleted at night. This contrasts against the Rough Waters Drive station where the higher nitrogen oxide concentrations can help to destroy ozone.

This behavior is not unusual for New Brunswick. Urban locations frequently experience lower ozone concentrations than rural areas, as there are typically larger concentrations of nitrogen oxides available to react with the ozone.

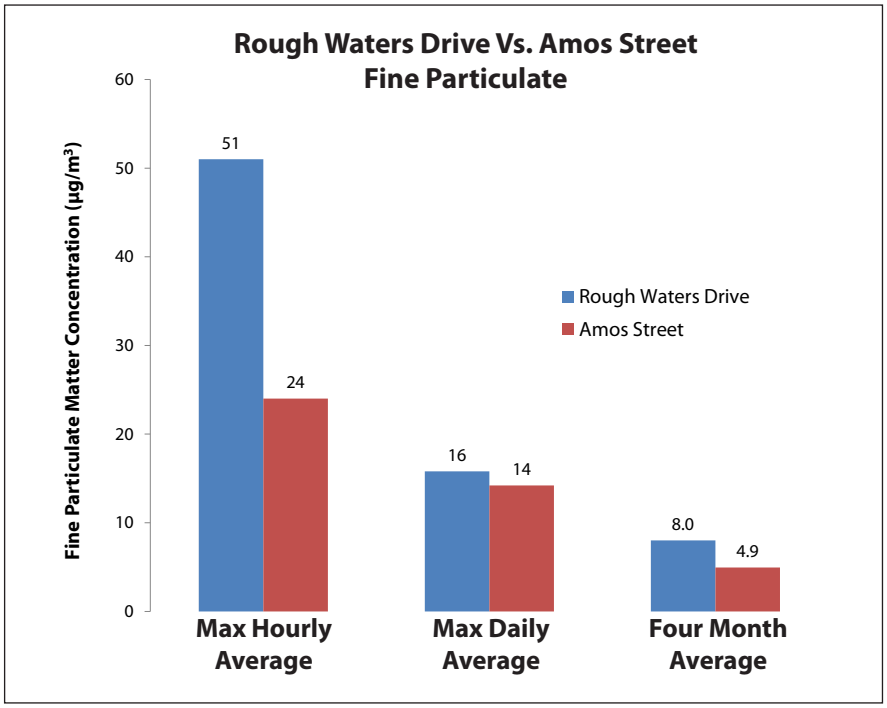

Figure 2. Fine Particulate Matter - Site Comparison

[7] Health Canada - National Ambient Air Quality Objectives for Ground Level Ozone - Summary - Science Assessment Document, July 1999.

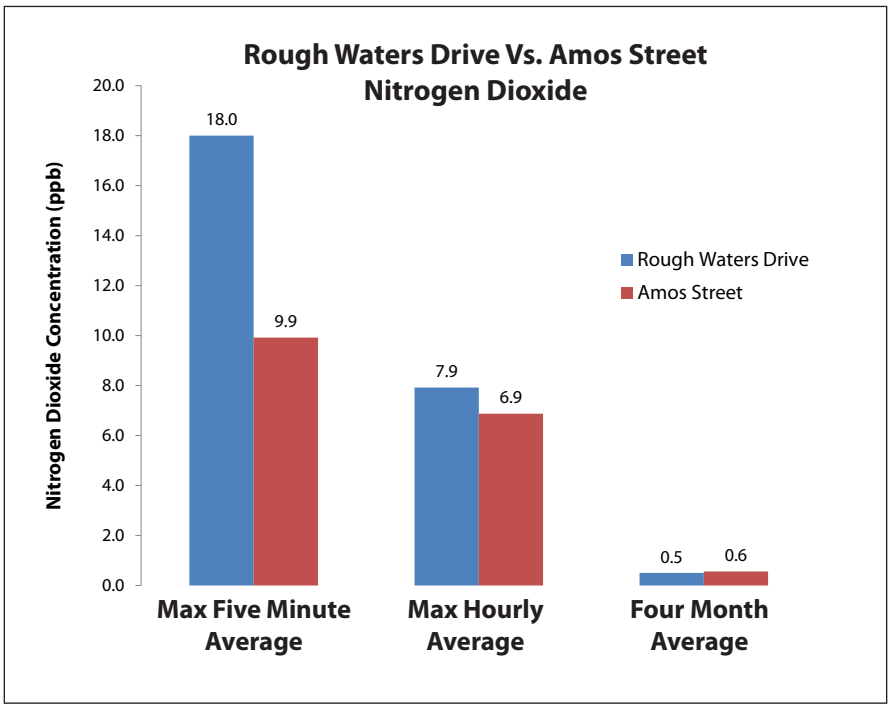

Figure 3. Nitrogen Dioxide - Site Comparison

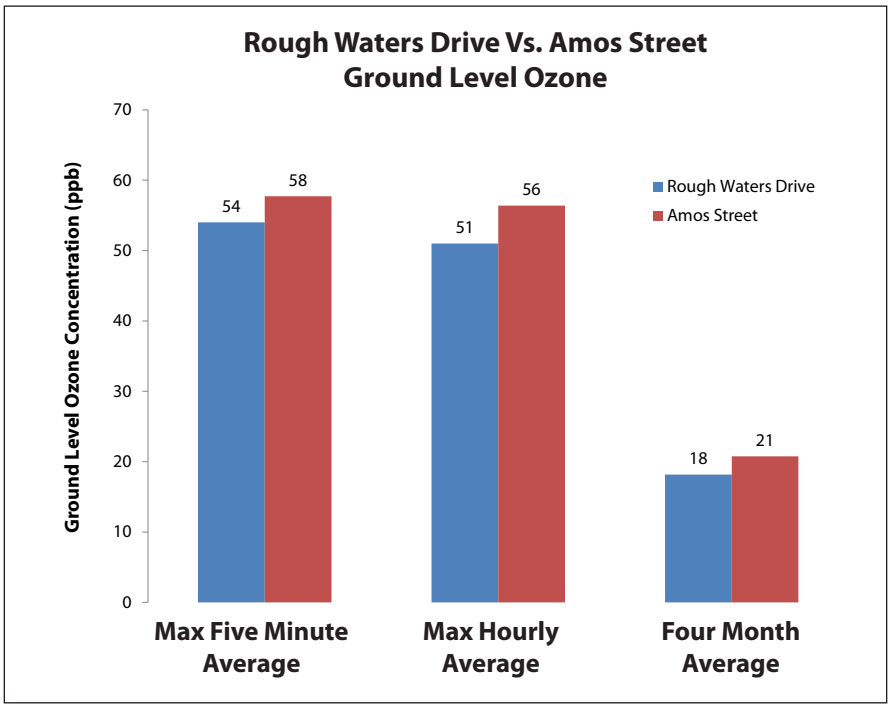

Figure 4. Ground Level Ozone - Site Comparison

4.4 Total Volatile Organic Compound (VOC) Concentration

As with the continuously monitored parameters, VOC results are compared against regulated standards and guidelines that take a variety of statistical forms. To enable these comparisons, the 15-minute sample results are mathematically converted as appropriate (e.g., averaging all of the 15-minute sample results from a 24 hour period to create a single 24-hour average).

Figure 5 provides a comparison between the total concentration of VOCs at the study site and two other VOC monitoring locations in New Brunswick. The two other locations are Forest Hills - Saint John, and Point Lepreau. The Forest Hills location provides an indication of typical values experienced in urban areas, as compared to the study site. It is one of only three stations in the province where VOCs are measured. The Point Lepreau station serves as the provincial background reference site for VOCs. It represents an "undeveloped and unimpacted" state for the purposes of comparison to the study site.

This comparison is restricted to the 50 VOC species that were monitored at the study site. Also, to ensure comparability between the locations, only data for the months of October and November were included, as VOC data collection at the study site only occurred during that period. As data for 2015 is not yet available for the two comparison sites, the comparison uses the most recent data currently available (2013).

Average and peak values for each of the 50 VOCs monitored are provided in Appendix D.

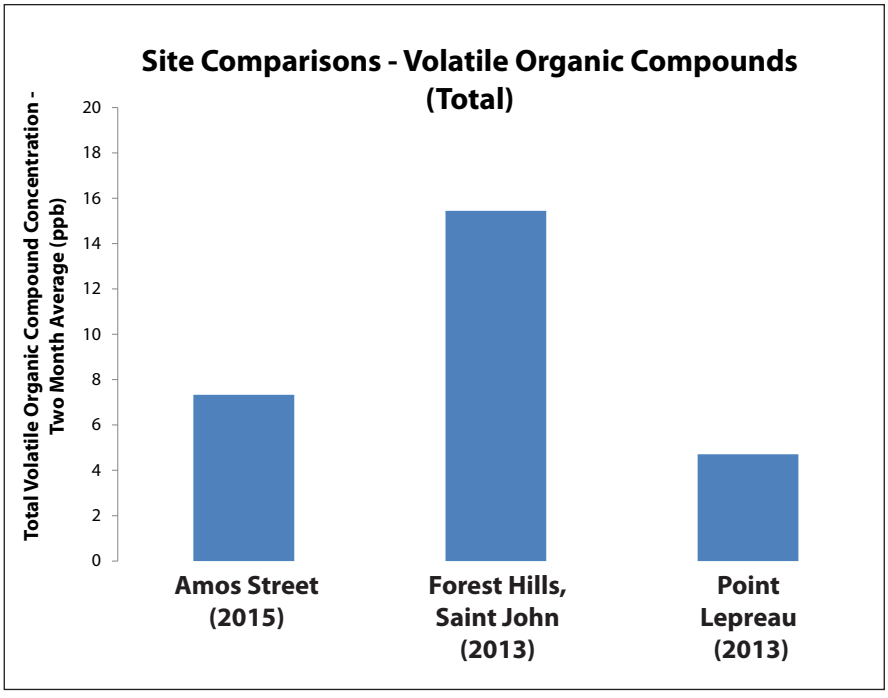

Figure 5. Total (of 50) Volatile Organic Compound Concentration-Site Comparison

As illustrated in Figure 5, the total VOC concentration at the study location was slightly higher than the Point Lepreau reference site, but much lower than concentrations experienced at the urban Saint John location. This is in keeping with expectations for the study location, as it is somewhat more developed than the Point Lepreau location, but still very rural in character.

4.5 "Air Toxic" Volatile Organic Compounds

Of the 50 VOCs measured during the study, five are particularly notable as they are included in the United States Environmental Protection Agency's list of "Air Toxic" pollutants. These are pollutants that, in sufficient concentrations, are known or suspected to cause cancer or other serious health effects.

The peak concentrations for "air toxic" VOCs at the study site are compared against regulated standards and guideline values in Table 3. As indicated, values at the study site were very low relative to the standard and guideline concentrations.

Table 3: "Air Toxic" VOC Comparisons to Standards and Guidelines

Parameter	Standard/Guideline Value	Study Result
Benzene	0.72 ppb 24-hour average*	0.17 ppb (maximum 24 hour average detected)
Ethylbenzene	460 ppb (hourly average)**	0.25 ppb (maximum 15 minute average detected)
m and p-Xylene	161 ppb 24-hour average*	0.14 ppb (maximum 24 hour average detected)
Styrene	96.8 ppb 24-hour average*	0.02 ppb (maximum 24 hour average detected)
Toluene	106 ppb 24-hour average*	0.01 ppb (maximum 24 hour average detected)

* Ontario Ambient Air Quality Criteria.
** Alberta Ambient Air Quality Objectives.

In the interests of providing additional context with respect to the concentration of "air toxic" VOCs at the study site, Figure 6 compares two month averages for these parameters to levels experienced at other monitoring locations in the province. As indicated in the figure, levels of these contaminants at the study site were much lower than elsewhere in the province. Most notably, lower than the provincial background/reference site at Point Lepreau.

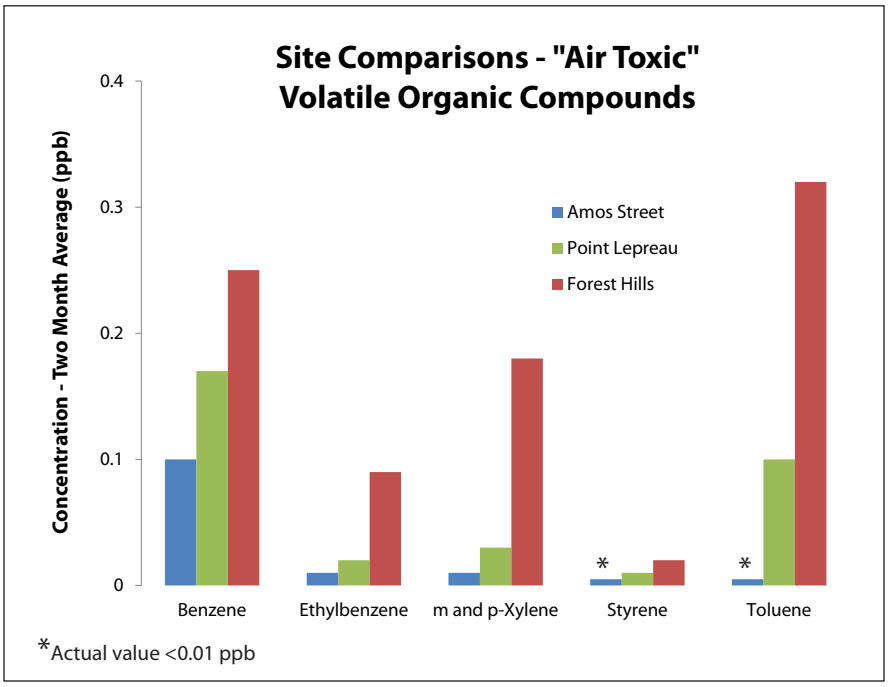

Figure 6. "Air Toxic" Volatile Organic Compound Concentrations - Site Comparison

4.6 Other Volatile Organic Compounds - Comparisons to Other Stations

Although most of the VOCs monitored at the study site are not considered "air toxic", it is still worthwhile to examine concentrations of these chemical species as they can serve as indicators or "markers" of certain types of natural phenomena (e.g., forest fires, and volcanoes) and anthropogenic emissions.

To identify any unusual levels of these VOCs at the study site, a comparison has been made against levels at other monitoring stations over the same two month period (albeit in different years). Full results of this analysis are provided in Appendix E. Average concentrations for individual VOCs were generally lower or within a similar range as the values recorded at Point Lepreau and Forest Hills. However, there are three notable exceptions:

1. Methylcyclopentane

Methylcyclopentane is one of the many hydrocarbons found in gasoline, diesel and jet fuel. It is also present in a variety household cleaners, lubricants, and finishes.[8] It has an odour similar to gasoline.[9]

[8] Sack TM, Steele DH; Indoor Air Pollutants from Household Product Sources US EPA Las Vegas, NV; USEPA/600/54-91/025; NTIS 92-136 837 pp. 157 (1991)

[9] U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Manual Two. Washington, DC: U.S. Government Printing Office, Oct., 1978.

The levels measured at the study site were higher than in Forest Hills, with a study average (2 month) value of 2.69 ppb versus 0.12 ppb.

Although the measured levels at the study site were higher than elsewhere in the province, they remain well below the guideline value of 75 ppb (annual average). Note that New Brunswick has not adopted an ambient air quality standard for this contaminant. The guideline value is taken from an air quality screening tool that is used by the Texas Commission on Environmental Quality, State of Texas, USA.[10]

2. Acetylene

Acetylene is commonly used as a metal welding and cutting gas.

The levels measured at the study site were higher than in Forest Hills, with a study average (2 month) of 1.20 ppb versus 0.12 ppb.

Although the measured levels at the study site were higher than elsewhere in the province, they remain well below the guideline value of 2500 ppb (annual average). Note that New Brunswick has not adopted an ambient air quality standard for this contaminant. The guideline value is taken from an air quality screening tool that is used by the Texas Commission on Environmental Quality, State of Texas, USA.[10]

The Province of Ontario has adopted a standard of 17,875 ppb (24 hour average) for acetylene.[11] The maximum 24 hour average value from the study site was far lower than this standard (1.38 ppb).

3. 2, 3, 4-trimethylpentane

2, 3, 4-trimethylpentane is one of the 18 different forms of a chemical that is more commonly known as "octane".[12] It is a component of petroleum based fuels such as gasoline and jet fuel.[12]

The overall average (2 month) levels measured at the study site were only slightly higher than in Forest Hills (0.09 ppb versus 0.06 ppb). However, this difference was the result of a single reading (one reading out of the 630 collected) of 13.46 ppb at 15:00 (Atlantic Standard Time) November 12, 2015.

New Brunswick has not adopted an ambient air quality standard for this contaminant. However, the 13.46 ppb peak is much lower than the only guideline value that is available (750 ppb - hourly average), which is taken from an air quality screening tool that is used by the Texas Commission on Environmental Quality, State of Texas, USA.[10]

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[10] http://www.tceq.state.tx.us/toxicology/esl

[11] Ontario Ambient Air Quality Criteria.

[12] Concise Encyclopedia of Chemistry, Pg. 743, Translated and revised by Mary Eagleson, Walter de Gruyter & CO., Berlin, New York, 1994.

Cross referencing this peak against wind and aircraft activity data revealed no relationship with the airport or aircraft. At the time of the event (15:00, November 12, 2015) winds were originating from the south east and there were no flight arrivals or departures near that time. The most recent preceding aircraft activity was a departure, which occurred at 05:30.

4.7 Dustfall Analysis

Three dustfall samples were collected over a 72 hour period, from 14:59 on October 5 to 15:40 on October 8. During that time, aircraft were active at the airport for a total of 26 hours. The wind originated from the direction of the airport (north) 5% of the time (3.6 hours) that aircraft were present during this period.

Dust loading on the 72-hour exposure samples was characterized as "light" and dominated by mineral and organic material. Further details are provided in Appendix F.

None of the particulate types identified would implicate the airport or aircraft. In particular, the absence of any kind of soot suggests that particulates from aircraft exhaust did not reach the study location during the sampling period. The particulate types that accumulated in the area are consistent with a rural residential neighbourhood.

Similarly, the sample taken from the pre-existing black residue also contained no soot. This sample was moderately loaded with particulates, but these were dominated by mould spores. When considered together with the 72 hour sample results, this suggests that the black residue issue in the area is not associated with the airport, but is primarily mould growth, which is quite common on vinyl siding.

These results are in agreement with the continuous particulate (TSP and $PM_{2.5}$) results, which suggest that particulate levels at this location are low.

4.8 Additional Context - Airport Impacts

The results discussed above are consistent with the findings of other studies that have investigated the air quality of communities near airports and source characterizations studies for aircraft and airports. Although airport-related air quality impacts are an area of active research, existing studies suggest that airports contribute relatively small amounts of key air pollutants.[1]

Of particular note, fine particulate matter has been identified as the primary health-related pollutant from airports.[1] As noted in Sections 4.2 and 4.3, fine particulate levels at the study location were quite low. This is not unexpected, as the literature tends to focus on very large urban airports, whereas the Bathurst Regional Airport is very small by comparison.

[1] See previous.

4.9 Implications for Human Health

The New Brunswick Department of Health has reviewed the data collected and has provided the following statement with respect to the potential for human health impacts:

> "Results for air contaminant concentrations obtained from air quality monitoring at the study site between July and November 2015 were compared to accepted air quality thresholds. The standards are set as concentrations below which effects are unlikely, even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based upon the scientific and medical evidence regarding the effects of individual pollutants.
>
> From the data obtained, results meet the threshold values and in most cases are greatly below the set values to protect human health.
>
> In conclusion, taking account of results obtained at the study site and control sites compared to accepted thresholds for pollutants, evidence from other studies on contribution of airports to ambient air pollution compared to other sources, the size of the airport and the number of flights per day, the health risks associated with the air quality at the study site are considered extremely small."[13]

4.10 Data Limitations

The data collected represents conditions at the time of sampling and does not capture all possible variations in ambient air conditions that may be possible at this location.

This study 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 data interruptions for several parameters at various points throughout the study period.

The study analyzed air quality at a single fixed location. This location may have been impacted by air pollutants from multiple sources during this period. As such, the results provide a quantitative assessment of overall air quality at that location. However, this type of study does not provide a complete basis for "source apportionment" (i.e., identifying specific emission sources and their individual impacts).

A power failure interrupted data collection for all parameters from September 11 through September 15, 2015.

The AMA Instruments Gas Chromatograph suffered a malfunction resulting in data collection being disrupted in November (see Section 3.3 for details).

Other significant gaps in data availability are noted, where applicable, in Section 4.

[13] Dr. M. Paquet, Medical Officer of Health, North Region, New Brunswick Department of Health. Personal communication. January 11, 2016.

5.0 Glossary of Abbreviations

CO	Carbon monoxide
DELG	New Brunswick Department of Environment and Local Government
ICAO	International Civil Aviation Organization
km/h	Kilometers per hour
LDL	Lower detection limit
NO_2	Nitrogen dioxide
O_3	Ozone (ground level ozone)
$PM_{2.5}$	Fine particulate (particulates with a diameter < 2.5 microns)
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
SO_2	Sulphur dioxide
TRS	Total reduced sulphur
TSP	Total suspended particulate
$\mu g/m^3$	Micrograms per cubic meter
USA	United States of America
VOC	Volatile organic compound

Appendix A: Common Air Contaminants - Summary of Sources and Effects

Table A1: Overview of Common Air Contaminants

Air Contaminant	Sources	Effects
Sulphur Dioxide (SO_2)	A colourless gas with a sharp odour, like that of a struck match. It is produced by the burning of sulphur-bearing fuels such as oil and coal.	High concentrations can damage plants, and corrode metals. It can irritate the eyes, throat, and lungs. It is a major contributor to acid rain, which impacts sensitive lakes and rivers.
Nitrogen Dioxide (NO_2)	A reddish-brown gas with a sharp odour. It is generated through combustion, especially motor vehicle exhaust and fossil fuel burning electrical power generation.	Similar to SO_2, high concentrations can harm plants, corrode metals, and cause irritation to the eyes, throat, and lungs. It also contributes to acid rain. NO_2 also reacts with other pollutants to cause the formation of ground level ozone.
Carbon Monoxide (CO)	An invisible and odourless gas. It is created when there is incomplete (inefficient) combustion of fuels. Motor vehicles are a significant source.	It interferes with the blood's ability to carry oxygen to vital organs and tissues. Exposure to very high concentrations can be fatal.
Total Reduced Sulphur (TRS)	A group of gases with a characteristic "rotten egg" odour. It is produced by natural decomposition (e.g., in marshes and tidal flats), and certain industrial processes (e.g., kraft pulp mills, and oil refineries).	Causes nuisance odours. At very high concentrations it can cause respiratory irritation and related health concerns. It also contributes to acid rain.
Ground Level Ozone (O_3)	An invisible and odourless gas. Ozone is formed through chemical reactions between a variety of "ozone precursor" pollutants, which are released by industrial facilities and motor vehicles. Most of New Brunswick's ozone is carried here by air masses originating in the United States and central Canada.	Irritates the lungs and makes breathing difficult. Also damages plants, weakens rubber, and attacks metals and painted surfaces.
Total Suspended Particulate (TSP)	Airborne dust particles. It is generated by natural sources (e.g. wind-blown dust and forest fires), and through fuel burning (especially fossil fuels and wood).	May irritate the throat and upper airways. It will fall out over time and may result in dust accumulations on vegetation and other surfaces.
Fine Particulate Matter, 2.5 microns in diameter or less ($PM_{2.5}$)	Tiny (invisible) airborne specks of solid or liquid material (e.g., dust & soot).	Causes and aggravates a variety of human cardiovascular ailments (*e.g.*, asthma, lung disease, and bronchitis). It also contributes to haze.
Volatile Organic Compounds (VOCs)	A group of carbon-containing chemicals. They are produced by evaporation of solvents (e.g., fuels, and paint thinner), by a variety of industrial processes (*e.g.*, petroleum refining), and through fuel combustion. Some VOCs are generated naturally by plants and animals.	Many act as "ozone precursors", and contribute to smog. Some VOCs are toxic and can impact human health. Others are of interest in climate research.

Modified from: New Brunswick Department of Environment and Local Government Air Quality Monitoring Results, 2011, and New Brunswick Department of Environment and Local Government Air Quality Monitoring Results, 2012 &2 013.

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 43C, 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)
Total Suspended Particulate (TSP)	Met-One Instruments Inc. Continuous Particle Monitor, model BAM-1020, outfitted with a TSP head.	4.8 µg/m^3 (hourly) 1.0 µg/m^3 (daily)	± 0.2 µg/m^3
Fine Particulate ($PM_{2.5}$)	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

Appendix C: Data Plots

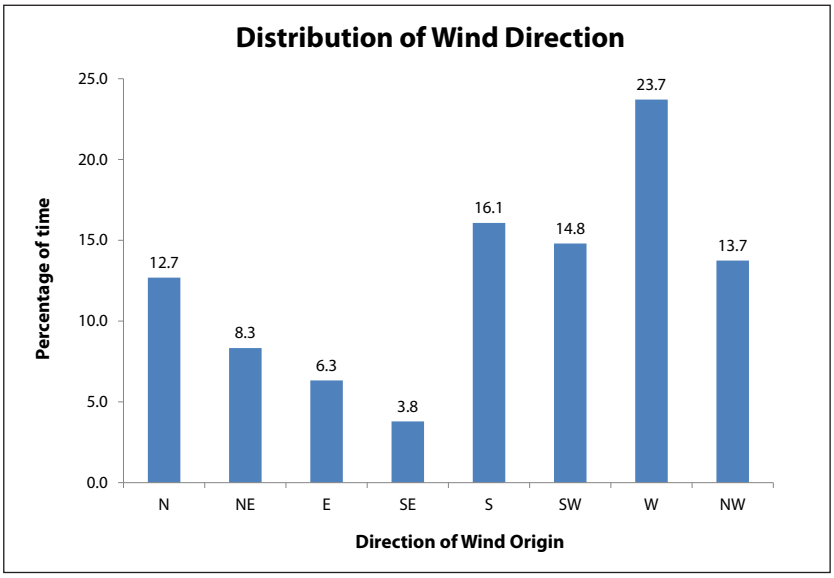

Figure C1. Direction of Wind Origin

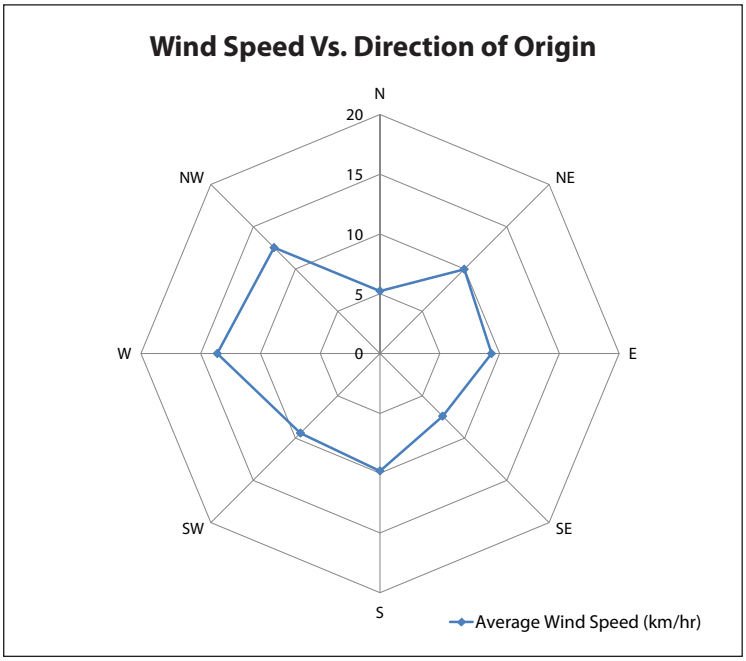

Figure C2. Wind Speed Distribution

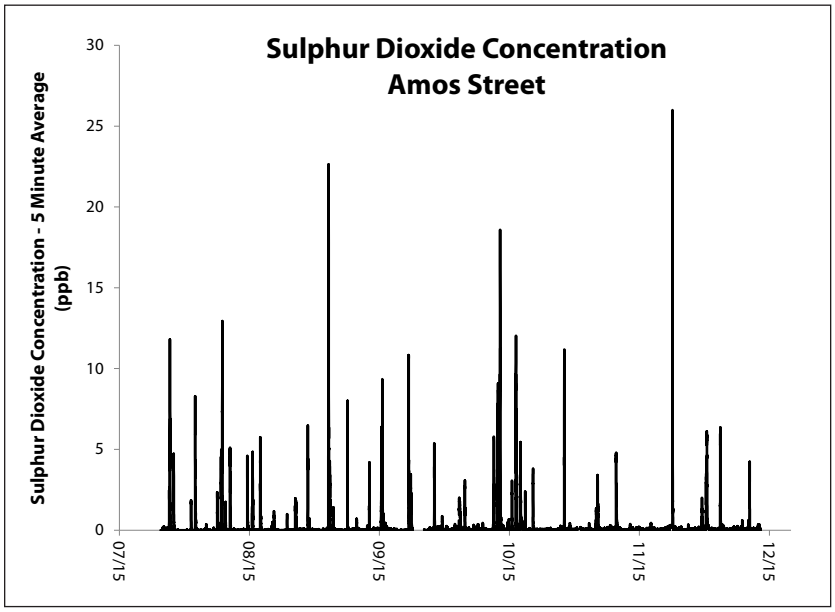

Figure C3. Sulphur Dioxide - Five Minute Average

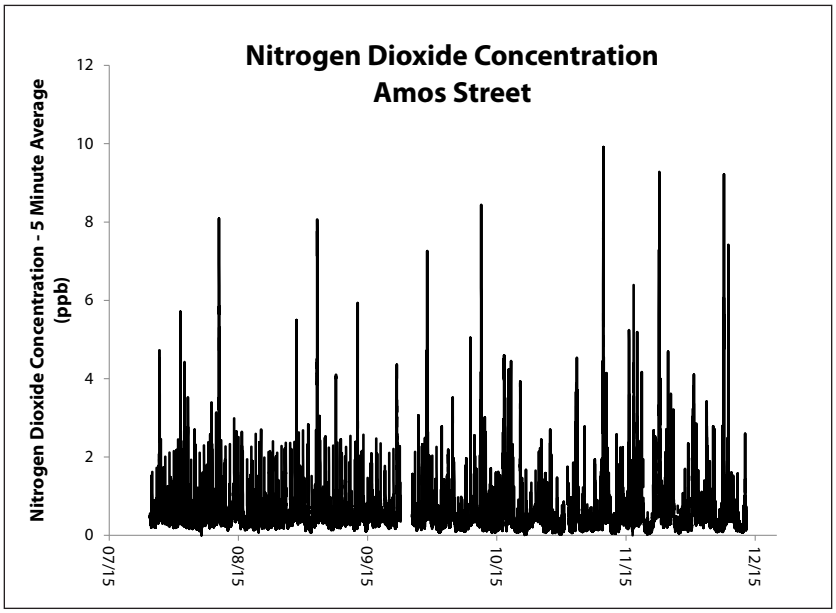

Figure C4. Nitrogen Dioxide - Five Minute Average

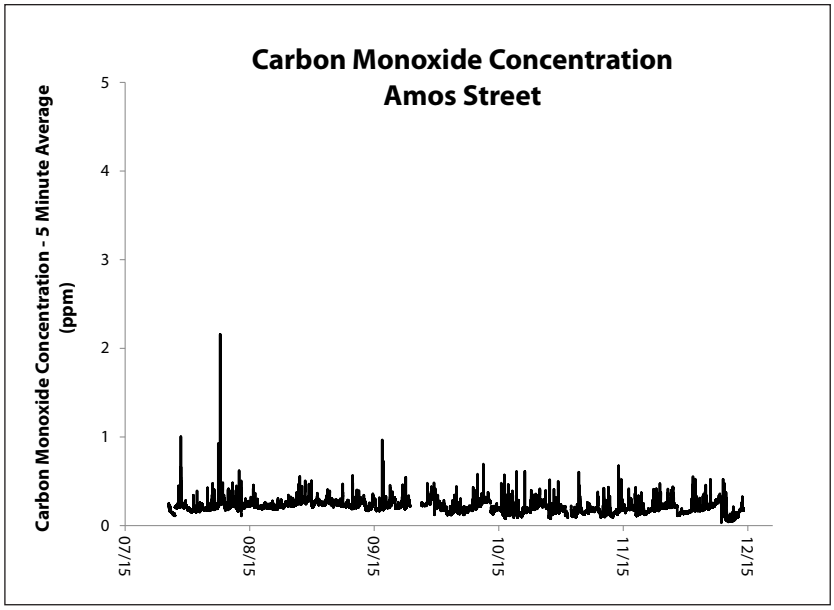

Figure C5. Carbon Monoxide - Five Minute Average

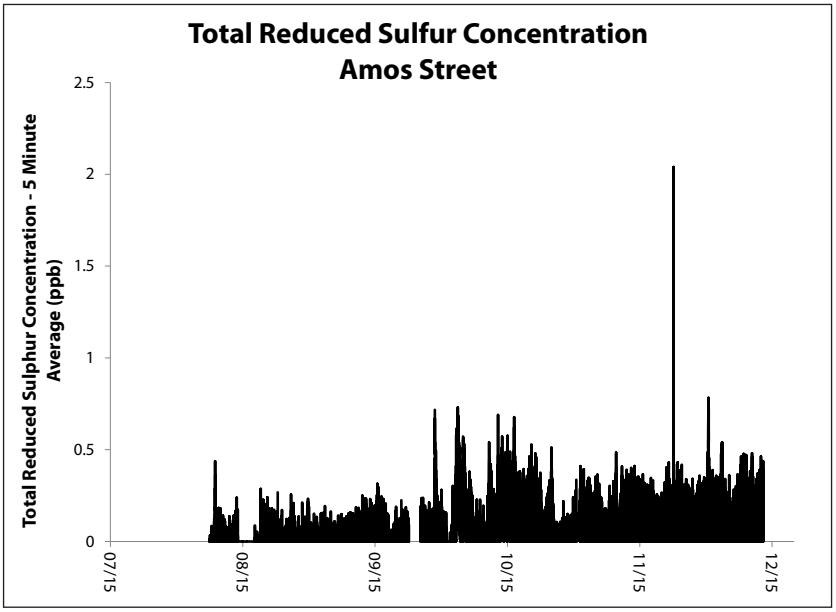

Figure C6. Total Reduced Sulphur - Five Minute Average

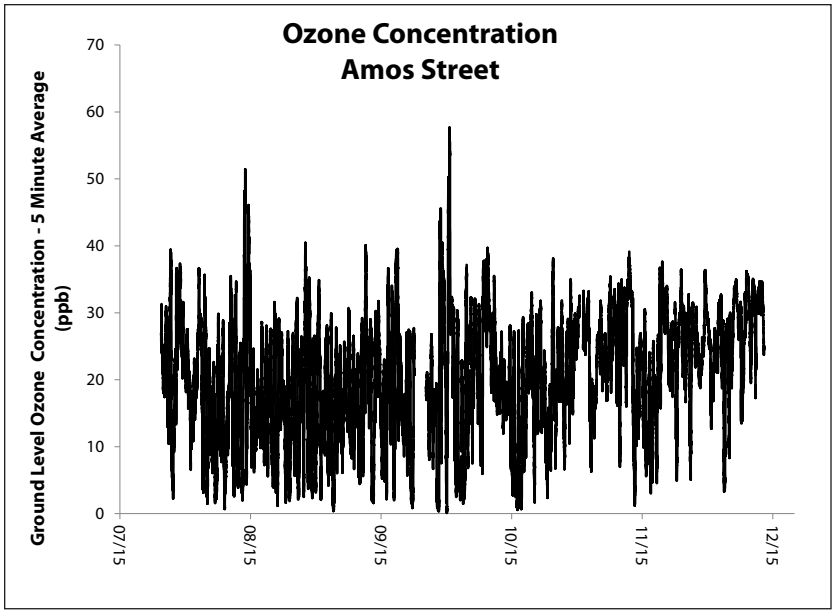

Figure C7. Ground Level Ozone - Five Minute Average

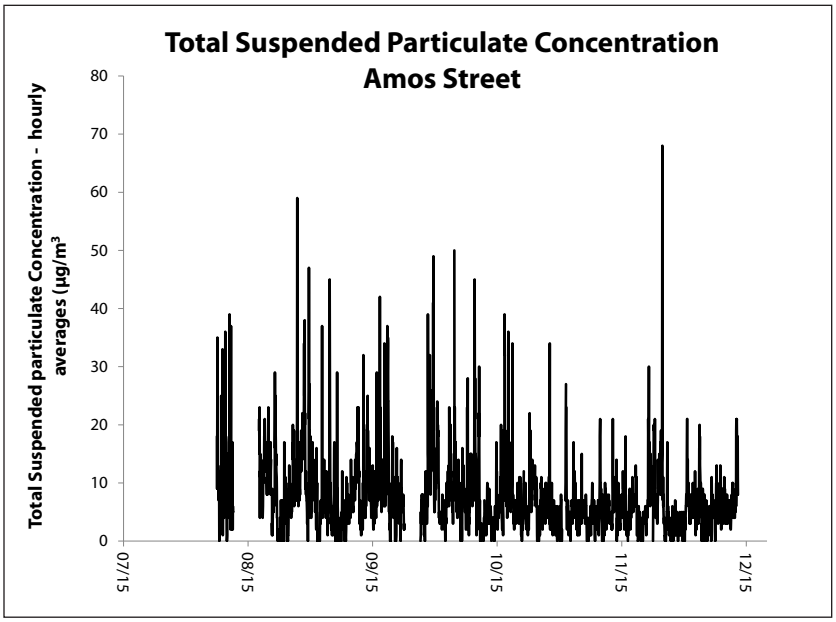

Figure C8. Total Suspended Particulate - Hourly Average

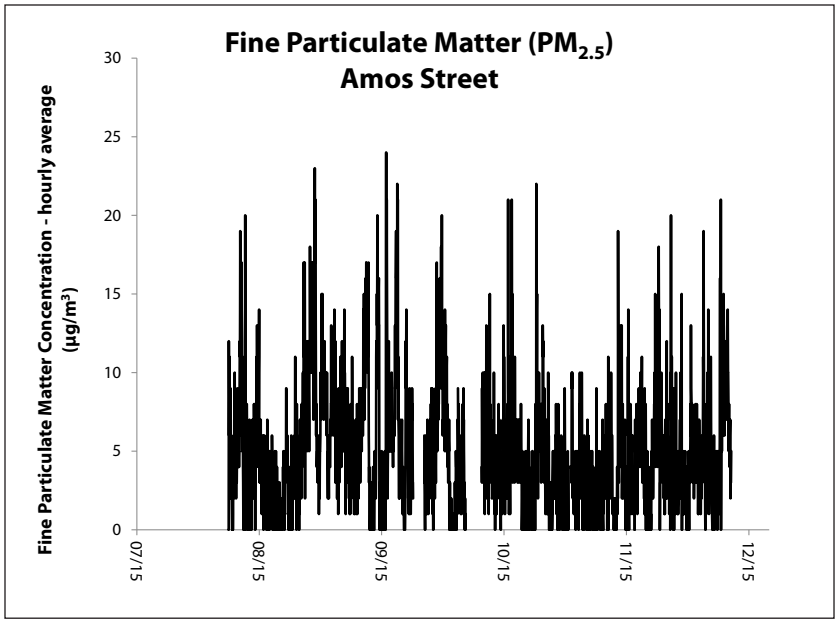

Figure C9. Fine Particulate Matter - Hourly Average

Appendix D: Volatile Organic Compound Data Summary

Table D1: Volatile Organic Compound Results

Parameter	Maximum 15 Minute Average Concentration (ppb)	Maximum Daily Average Concentration (ppb)	Average Concentration for the Study Period (ppb)
2,2-Dimethylbutane	0.27	0.03	0.01
3-Methylpentane	0.59	0.07	0.02
1-Hexene	0.13	0.02	0.01
n-Hexane	0.52	0.07	0.03
Benzene	0.76	0.17	0.10
Cyclohexane	0.24	0.10	0.04
2-Methylhexane	0.17	0.02	<0.01
2,3-Dimethylpentane	0.05	<0.01	<0.01
3-Methylhexane	0.18	0.02	<0.01
2,2,4-Trimethylpentane	0.14	0.02	<0.01
n-Heptane	0.02	0.02	<0.01
Methylcyclohexane	0.13	0.01	<0.01
2,3,4-Trimethylpentane	13.46	1.12	0.09
Toluene	1.35	0.12	<0.01
2-Methylheptane	0.08	<0.01	<0.01
3-Methylheptane	0.06	0.01	<0.01
n-Octane	0.09	0.02	<0.01
Ethylbenzene	0.25	0.04	0.01
m,p-Xylene	1.18	0.14	0.01
Styrene	0.10	0.02	<0.01
o-Xylene	0.25	0.03	0.01
n-Nonane	0.26	0.01	<0.01
i-Propylbenzene	0.15	0.06	0.01
n-Propylbenzene	0.53	0.16	0.02
m-Ethyltoluene	0.59	0.21	0.05
p-Ethyltoluene	0.40	0.10	<0.01
1,3,5-Trimethylbenzene	0.15	0.05	0.02
o-Ethyltoluene	0.13	0.01	<0.01
1,2,4-Trimethylbenzene	0.24	0.02	<0.01
n-Decane	0.56	0.01	<0.01
1,2,3-Trimethylbenzene	0.84	0.20	0.04
m-Diethylbenzene	0.15	<0.01	<0.01

Table D1: Volatile Organic Compound Results (Continued)

Parameter	Maximum 15 Minute Average Concentration (ppb)	Maximum Daily Average Concentration (ppb)	Average Concentration for the Study Period (ppb)
p-Diethylbenzene	0.12	<0.01	<0.01
n-Undecane	0.92	0.05	0.01
Ethane	3.70	2.05	1.47
Ethene	2.35	0.77	0.36
Propane	1.87	1.13	0.55
Propene	0.72	0.22	0.08
i-Butane	0.71	0.27	0.17
Acetylene	3.62	2.92	1.20
trans-2-Butene	0.11	0.03	0.01
cis-2-Butene	0.32	0.13	0.01
i-Pentane	1.29	0.16	0.07
trans-2-Pentene	0.16	0.03	0.01
cis-2-Pentene	<0.01	<0.01	<0.01
Methylcyclopentane	67.66	10.15	2.69
2,3-Dimethylbutane	0.18	0.06	0.01
2-Methylpentane	0.19	0.04	0.01
Isoprene	0.33	0.08	0.03
2,4-Dimethylpentane	0.10	0.01	<0.01

Appendix E: Site Comparisons - Other Volatile Organic Compounds

Table E1: Other Volatile Organic Compound Levels Compared to Other Sites in New Brunswick

Parameter	Amos Street Two-Month Average (ppb)	Forest Hills Two-Month Average - 2013 (ppb)	Point Lepreau Two-Month Average - 2013 (ppb)
1,2,3-Trimethylbenzene	0.04	0.24	0.01
1,2,4-Trimethylbenzene	<0.01	0.22	0.01
1,3,5-Trimethylbenzene	0.02	1.16	<0.01
1-Hexene	0.01	0.38	NA
2,2,4-Trimethylpentane	<0.01	1.35	0.03
2,2-Dimethylbutane	0.01	0.55	0.01
2,3,4-Trimethylpentane	0.09	0.06	0.01
2,3-Dimethylbutane	0.02	0.09	0.01
2,3-Dimethylpentane	<0.01	0.45	0.01
2,4-Dimethylpentane	<0.01	0.05	0.01
2-Methylheptane	<0.01	0.06	0.02
2-Methylhexane	<0.01	0.12	0.02
2-Methylpentane	0.01	0.26	0.05
3-Methylheptane	<0.01	0.05	0.01
3-Methylhexane	<0.01	0.21	0.03
3-Methylpentane	0.02	0.21	0.03
Acetylene	1.20	0.12	0.20
cis-2-Butene	0.02	0.09	<0.01
cis-2-Pentene	<0.01	0.06	<0.01
Cyclohexane	0.04	0.20	0.02
Ethane	1.47	1.14	1.90
Ethene	0.36	0.28	0.21
i-Propylbenzene	0.17	1.10	<0.01
Isobutane	0.07	1.58	0.20
Isopentane	0.01	0.11	0.18
Isoprene	0.03	0.04	0.05
m-Diethylbenzene	<0.01	0.18	<0.01
Methylcyclohexane	<0.01	0.11	0.03
Methylcyclopentane	2.69	0.12	0.02
m-Ethyltoluene	0.05	0.09	0.01
n-Decane	<0.01	0.08	0.02
n-Heptane	<0.01	0.20	0.04
n-Hexane	0.03	0.21	0.05
n-Nonane	<0.01	0.08	0.02
n-Octane	<0.01	0.18	0.02
n-Propylbenzene	0.02	0.02	0.01
n-Undecane	0.01	0.05	0.02
o-Ethyltoluene	<0.01	0.04	0.01

Table E1: Other Volatile Organic Compound Levels Compared to Other Sites in New Brunswick (continued)

Parameter	Amos Street Two-Month Average (ppb)	Forest Hills Two-Month Average - 2013 (ppb)	Point Lepreau Two-Month Average - 2013 (ppb)
o-Xylene	0.01	0.07	0.02
p-Diethylbenzene	<0.01	0.03	0.01
p-Ethyltoluene	<0.01	0.04	0.00
Propane	0.55	1.66	1.03
Propylene	0.08	0.98	0.05
trans-2-Butene	0.01	0.07	0.01
trans-2-Pentene	0.01	0.17	<0.01

Appendix F: Dust Analysis

Table F1: Dustfall Analysis Sample Results

Sample	Dust Loading	Particle Types Present	Characteristics
#1: Plate glass (72-hour exposure)	Very Light	• Cotton fibers • Paper fibers • Biological particles (skin scales, mould spores, and starch grains) • Minerals • Paint • Metal • Glass	Primarily mineral and organic material. There were no soot or combustion related particles.
#2: Aluminum sheeting (72-hour exposure)	Light	• Cotton fibers • Paper fibers • Biological particles (skin scales and mould spores) • Minerals • Paint • Metal	Primarily metallic (aluminum) and mineral materials. There were no soot or combustion related particles.
#3: Painted metal (72-hour exposure)	Light	• Cotton fibers • Paper fibers • Biological particles (e.g., skin scales, mould spores, and starch grains) • Minerals • Paint • Metal	Primarily mineral and organic material. There were no soot or combustion related particles.
#4: Residue-laden soffit vent	Moderate	• Biological particles (e.g. mould spores and skin scales). • Minerals • Paint • Metal	Primarily mould spores and mineral material, with smaller amounts of metallic particles. There were no soot or combustion related particles.