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HAMLET OF BONANZA

AIR QUALITY SUMMARY REPORT

JUNE 2010 TO JUNE 2011

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Executive Summary

The Hamlet of Bonanza, Alberta is located in the northeast corner of the Peace Airshed Zone in an area of agriculture and oil and gas activity. The Peace Airshed Zone Association (PAZA) conducted an air quality survey just outside Bonanza from June 2010 to June 2011. The reasons for this air quality survey were as follows:

- Request from the Government of Alberta;
- Responding to land-owner concerns;
- To collect continuous air quality data in an area of PAZA lacking continuous data (data gap); and,
- To collect continuous air quality data in an area of PAZA that could be representative of air quality entering PAZA (background conditions).

A continuous monitoring station was used to monitor total reduced sulphur compounds (TRS), sulphur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), total oxides of nitrogen (NO_x), ozone (O_3) and meteorology during that period.

There were no exceedances of Alberta Ambient Air Quality Objectives (AAAQO) or Canada Wide Standard Triggers (CWS) measured at the monitoring station. Of NO, NO_2 and NO_x, only NO_2 has an AAAQO. The results are summarized as follows:

- The TRS measurements may be influenced by fugitive emissions from industrial activity in the area but the measurements are comparable to other areas in the province where oil and gas activity is ongoing.
- The SO_2 measurements suggest there were no significant sources of SO_2 in the area during the measurement period and were low compared to other areas in the province.
- Due to the proximity of the monitor station to the hamlet, the NO_2 measurements may have been influenced by emission sources from the community of Bonanza, Secondary Highway 719 and Township Road 801 and an adjacent seasonal campground. This was supported by comparison to the closest passive monitor to the site which showed lower monthly averaged NO_2 values during the period. However, data indicated NO_2 levels were lower than other areas of the province.
- Ozone measurements are comparable with other areas in province. A typical diurnal profile is present in the ozone measurements and relates with the diurnal patterns of NO and NO_2. This pattern shows the photo-chemical formation and destruction of ozone through complex reactions with NO_x and volatile organic compounds.
- Meteorology measurements indicate that December 2010 was the coldest and least windy month. This appears to have contributed to the highest average measurements of TRS, SO_2, and NO_2 being recorded in that month which could be attributed to stagnant, poor dispersion conditions including atmospheric inversions.

The volume of data collected indicates that this area is comparable of air quality in rural Alberta with oil and gas activity. Overall TRS measurements, although below the regulatory AAAQOs (for hydrogen sulphide and carbon disulphide), are likely influenced by local sources such as oil and gas, agricultural, municipal and natural sources. The highest 1-hour TRS measurements are most likely due to one particular non-routine event at an oil and gas facility. However, general source contributions can be inferred but not definitively determined without more information on activity in the area during the event.

The summary of the air quality monitoring data is limited to the parameters measured in this study. Air quality surrounding the Hamlet of Bonanza may be affected by other compounds associated with oil and gas or other activities some of which PAZA was not equipped to measure such as volatile organic compounds (VOCs) which are a component of oil and gas facility fugitive emissions.

The results do not necessarily support further continuous monitoring in the area. In other words, the parameters measured during the monitoring period did not exceed AAAQO or CWS. However, if PAZA chooses to conduct additional monitoring in the Bonanza area, it is recommended that PAZA consider collecting air samples for analysis of speciated VOCs and speciated TRS, and consider passive hydrogen sulphide monitoring to determine trends.

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1. INTRODUCTION

The Peace Airshed Zone Association (PAZA) is a nonprofit, multi-stakeholder organization that conducts ambient air quality monitoring in northwestern Alberta. PAZA is an unbiased, open and transparent organization, and our members collaborate to provide local solutions to local air quality concerns.

PAZA was formed in March 1999 in response to air quality concerns in the Peace region. As an independent third-party, PAZA has invested ten years into building trust among members of the public, industry, non-governmental organizations, Alberta Environment and Sustainable Resource Development (AESRD), Energy Resources Conservation Board, and Alberta Health Services.

The air quality monitoring program is a resource for the public to become informed about local air quality. Members work collaboratively to produce scientifically defensible data to allow stakeholders to make informed decisions regarding air quality in the region.

In 2003, PAZA became the fifth airshed zone in Alberta recognized by the Clean Air Strategic Alliance (CASA).

PAZA operates under the guidelines developed in the *CASA Airshed Zone Guidelines*. These guidelines include management by consensus, representation from affected stakeholders and public accessibility to data and information from monitoring activities.

Consensus is reached when there is unanimous agreement among our stakeholders, ensuring each one can live with the outcome of the decision. Stakeholders may not achieve all their goals, but the objective is to find the optimal solution that includes something for everyone. Decisions made through consensus processes are likely to be more innovative and longer lasting than those reached through traditional negotiation or top-down hierarchy.

Air Quality Management Zones are a key component in Alberta's strategy for the management of air quality within Alberta.

PAZA is funded by compulsory and voluntary membership through a funding mechanism which is based on calculated relative impacts to air quality within the PAZA boundaries. For more information about PAZA and regional air quality, please visit PAZA's web site[1]

PAZA operates a network of seven continuous monitoring stations and 46 passive monitoring stations that collectively monitor air quality across the airshed. One of these continuous stations is a portable or roving continuous monitoring station that is used to respond to various concerns. This roving station was setup on June 2010 to June 2011 in response to landowner concerns and requests from the Government of Alberta to collect continuous air quality data in an area of PAZA lacking continuous data (data gap).

[1] http://www.paza.ca/

2. SITE SETTTING

The air quality monitoring station was proposed to be located near the Hamlet of Bonanza and the final site location was based on the following considerations while accounting for AESRD's siting criteria. The PAZA siting criteria can be obtained from PAZA.

- Considerations
  - Current and future landowner(s)
  - Potential future land use change (avoid roads and right-of-ways)
  - All weather access
  - Power availability
  - Maximum security
- AESRD Air Monitoring Directive (AMD) Siting Criteria
  - Away from nearby emission sources such as roads, oil and gas wells/batteries, gas processing plants, maintenance/fuelling areas, etc.
  - Avoid low-lying areas and high areas to prevent local air flow biases
  - An open area away from buildings and tree canopies to ensure representative flows are recorded and to ensure passive samplers are suitable exposed
  - Stations cannot be located in pastures because of potential damage

Accounting for the above criteria and considerations, the monitor that was used for the air quality survey was placed on the north side of Township Road 801 just west of Highway 719 on the western edge of the Hamlet of Bonanza within SE 1-8-80-12 W6M. The geographic and projected coordinates of the site are:

- 55° 54' 46.45" N, 119° 49' 46.46" W (NAD 83)
- 55.912903° N, 119.829572° W (NAD 83)
- 323156 m E, 6200004 m N (UTM Zone 11 – NAD 83)

A regional area map is shown in Figure 2.1. The PAZA monitoring network is shown in Figure 2.2.

Photos of monitoring station and views from it are shown in Figure 2.3. There were potential airflow restrictions for winds from the eastern quadrant due to the Bonanza Fire Hall which is located 15 m east of the monitoring station. The nearest tree to the station is 20 m distance with a height of 8 m.

Figure 2.4 shows the local setting around the Hamlet of Bonanza and the monitoring station. The major industries in the area are oil and gas and agriculture. A number of oil gas facilities are noted in the area and were identified from the Environment Canada National Pollution Release Inventory for 2008. The closest oil and gas facility to the monitoring station is the Birchcliff Energy Ltd. Bonanza 7-8-80-12 W6M site located about 600 m to the northwest. The closest roads are Township Road 801 located 25 m to the south and Secondary Highway 719 located 150 m to the east. According to Alberta Transportation, the Average Annual Daily Traffic

Volume on Highway 719 in 2010[2] was 600 vehicles/day south of Bonanza, and 380 vehicles/day north of Bonanza. Traffic volumes are not available on Township Road 801. As noted previously, the monitoring station is located adjacent to the Bonanza Fire Hall and also in close proximity to the Hamlet of Bonanza.

[2] http://www.transportation.alberta.ca/Content/docType181/production/HTVH2001-2010.pdf

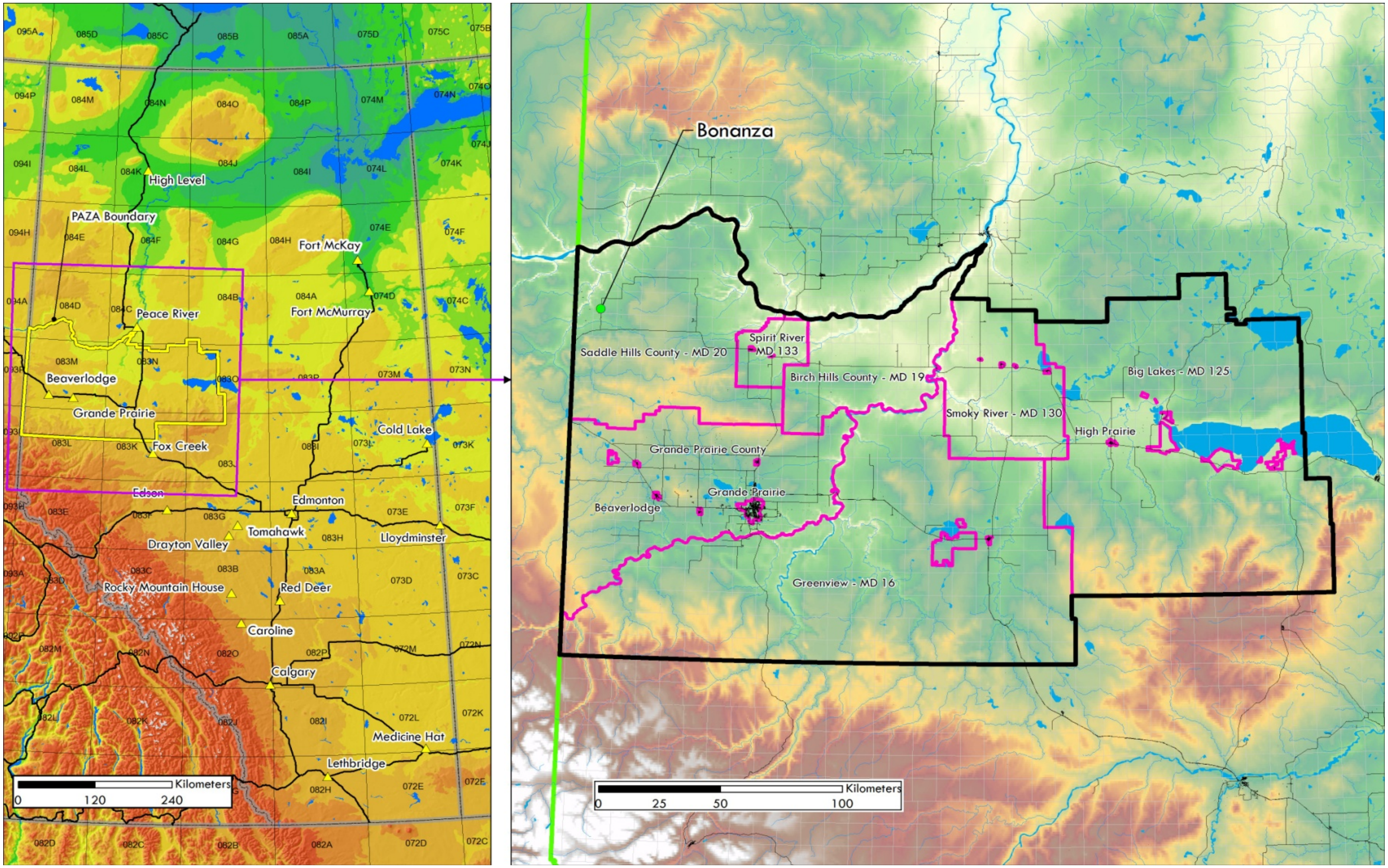


Figure 2.1 Regional Area Map showing location of Bonanza and PAZA

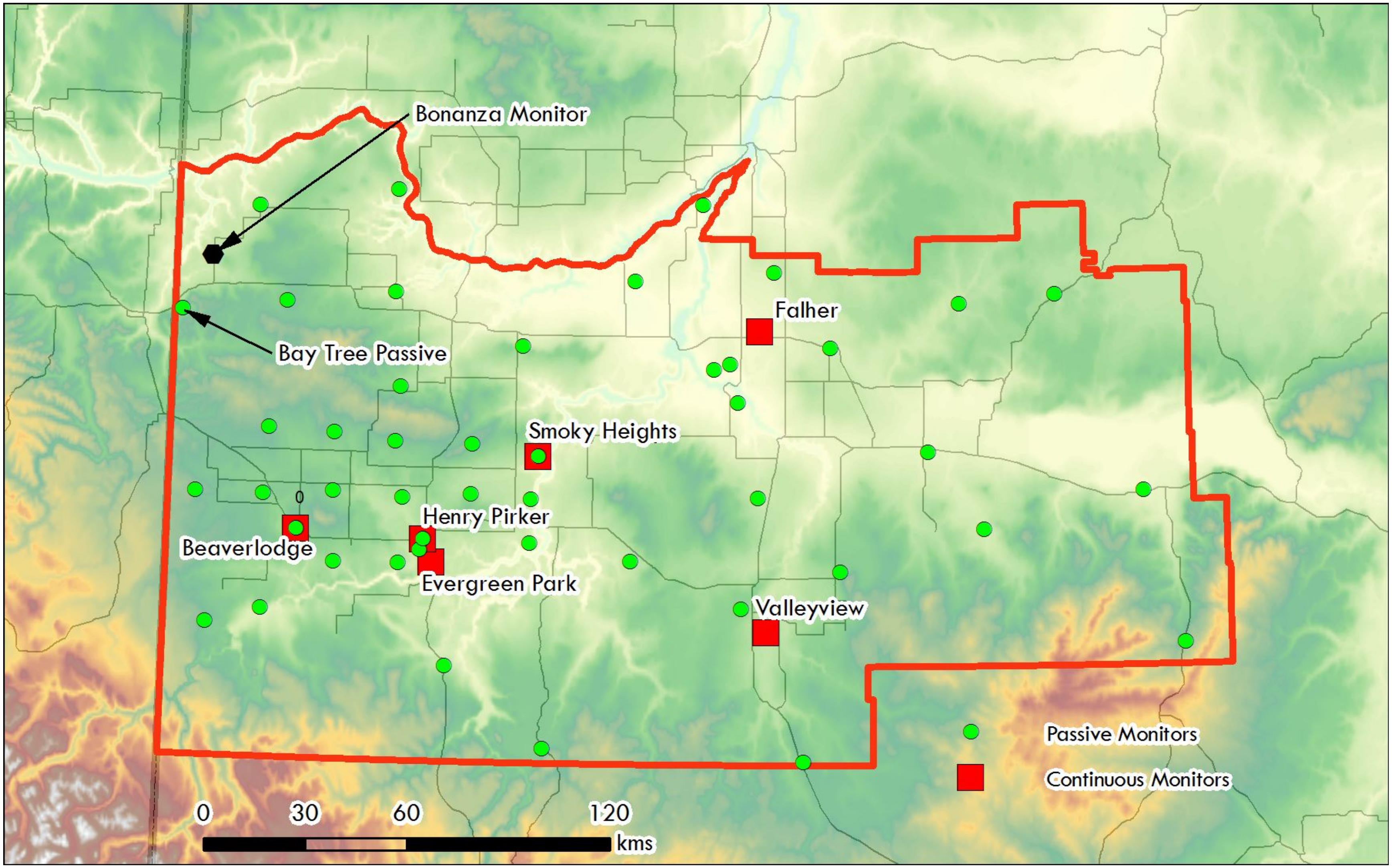


Figure 2.2 PAZA Monitoring Network

Looking North

Looking South

Looking East

Looking West

Monitoring Trailer

Analyzers

Figure 2.3 Views from and of Bonanza Monitoring Station

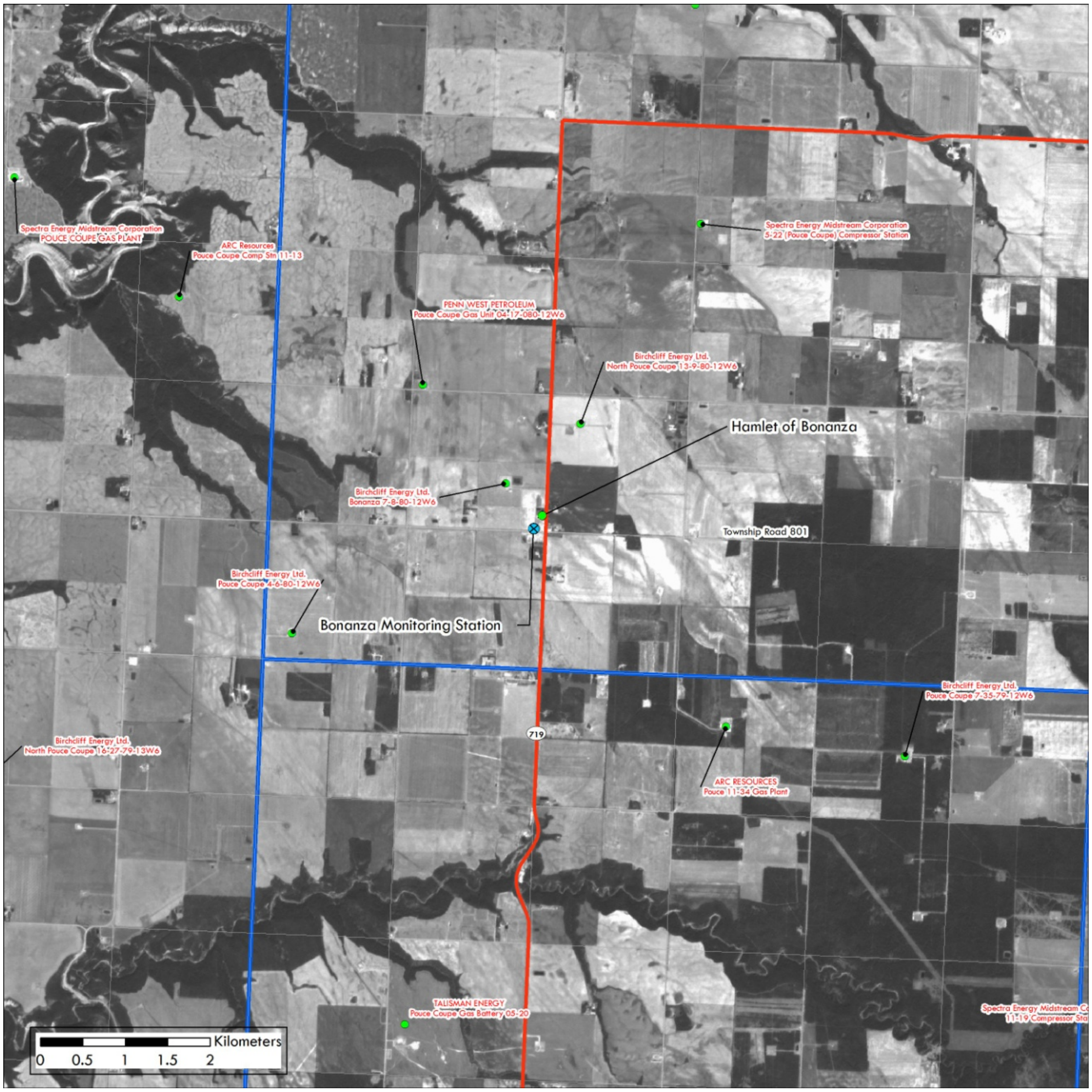


Figure 2.4 Local setting around Bonanza Monitor

3. AIR MONITORING (PARAMETERS, EQUIPMENT, ETC)

The monitoring station equipment is described in Table 3.1. The continuous monitoring station sampled for TRS, SO_2, NO_x (including NO and NO_2), O_3, and meteorology (wind speed, wind direction, and ambient temperature). Sampling occurred every second and 1-hour averages were calculated from the 1 second samples. The data acquisition system used was the Focus DACS-AP1000. The monitoring station operated from June 18, 2010 0700 to June 30, 2011 24:00 (9054 hours). The continuous monitoring equipment was operated according to the AESRD AMD[3] including daily instruments checks, monthly multipoint calibrations, and annual audits conducted by AESRD. The annual rover monitoring station audit was completed May 13, 2010 by AESRD while located in Kinuso.

The Contractor's Standard Operating Procedures (SOPs) contain information on completeness, lower detection limits, ranges, accuracy, detection and calibration methods, and zero and span deviations. SOPs for each of the parameters measured are listed in Table 3.1. For more information on SOPs please contact PAZA.

Continuous monitoring equipment uptime and downtime during the Bonanza air quality monitoring survey is presented in Table 3.2.

Table 3.1 Monitoring Station Equipment Description

Parameter	Instrument Make and Model	Units of Measure	Sampling Height (m)	Standard Operating Procedures Document
TRS	TEI/43C with converter	Parts per billion (ppb)	4	FAQP-1.002
SO_2	TECO/43C	ppb	4	FAQP-1.001
NO_x	TECO/42i	ppb	4	FAQP-1.003
O_3	TECO/49c	ppb	4	FAQP-1.004
Wind Speed	Met One 010C	km/hr	10	FAQP-2.001
Wind Direction	Met One 020C	Degrees direction from	10	FAQP-2.001
Temperature	Met One 062	°C	4	FAQP-2.006

[3] http://environment.alberta.ca/0996.html

Table 3.2 Monitoring Equipment Uptime

Measurement	TRS	SO_2	NO_x	O_3	Temperature	Wind Speed	Wind Direction
Valid Reading	95.01%	95.00%	94.05%	92.60%	99.79%	98.80%	98.80%
Not in Service	0.06%	0.00%	0.00%	1.08%	0.00%	0.00%	0.00%
Daily Automated Zero/Span Sequence	4.31%	4.29%	4.26%	4.20%	0.00%	0.00%	0.00%
Calibration	0.49%	0.57%	1.06%	0.66%	0.00%	0.00%	0.00%
Not Valid[a]	0.00%	0.00%	0.23%	1.25%	0.08%	1.07%	1.07%
Maintenance	0.06%	0.06%	0.31%	0.12%	0.04%	0.04%	0.04%
Span (Used for Manual Span)	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
Power Failure	0.08%	0.08%	0.08%	0.07%	0.08%	0.08%	0.08%

a) Not Valid is defined as data collected when the instrument is operating outside normal conditions

4. ALBERTA AMBIENT AIR QUALITY OBJECTIVES

The AAAQOs for the pollutants that were measured are shown in Table 4.1. There are currently no AAAQOs for TRS. However, hydrogen sulphide (H_2S) and carbon disulphide (CS_2) are classified as reduced sulphur compounds and have AAAQOs. Of the NO_x compounds measured, only NO_2 has AAAQOs. Although, there is currently a 1-hour AAAQO for O_3, compliance or achievement is usually determined by the Canada-Wide Standards for O_3 which is an 8-hour average of 65 ppb based on the 4th highest daily 8-hr measurement annually, averaged over 3 consecutive years. Since the Bonanza monitoring station only measured O_3 for one year, direct comparison to the CWS cannot be made. Also included in the CWS for O_3 are provisions for "Keeping Clean Areas Clean and Continuous Improvement" that apply at ambient concentrations below the numeric CWS, as well as provisions on monitoring and reporting of progress and activities.

Table 4.1 Alberta Ambient Air Quality Objectives.

Pollutant	Averaging Period				
	1-hr (ppb)	8-hr (ppb)	24-hr (ppb)	30 day (ppb)	Annual (ppb)
TRS	10 (H_2S) 10 (CS_2)	-	3 (H_2S)		
SO_2	172	-	48	11	8
NO_2	159	-	-	-	24
O_3	82	65 (CWS)[1] 58 (CWS)[1]	-	-	-

Note: 1 CWS Exceedance Trigger is 65 ppb, CWS Planning Trigger is 58 ppb, both based on the 4th highest 8-hour daily measurement annually, averaged over 3 years

5. MONITORING RESULTS

This report provides an overall summary of the monitoring data; the detailed one-hour monitoring data results are available on the PAZA website, monthly and annual reports and at the CASA Data Warehouse[4].

In the sections that follow, several summary statistics are used in the discussion of monitoring results including the average, maximum, minimum, and percentile concentrations. An nth percentile concentration indicates that n percent of data are less than that concentration, and (100 – n) percent of data are greater than that concentration. . For example, a dataset with a 90th percentile concentration of 50 ppb indicates that 90 % of the data will be less than 50 ppb and 10 % percent of the data will be greater than 50 ppb.

Frequency distributions and data distributions by wind direction known as wind, pollution or data roses depending on the data being analyzed are presented to help identify potential sources of pollutants.

Comparison with other areas of the province was undertaken using ambient measurements from the following locations for the same time period as the Bonanza monitoring except where noted. The locations of these stations are shown in Figure 2.1 and Figure 2.2.

- Beaverlodge (PAZA)
  - Small urban
- Evergreen Park (PAZA) (TRS only)
  - Small urban
- Henry Pirker (PAZA) (TRS only)
  - Small urban
- Caroline
  - Rural
- Calgary NW
  - Urban
- Cold Lake South
  - Small urban
- Fort McKay (June 18 2010 to April 30 2011)
  - Rural – near oil sands
- Tomahawk (June 18 2010 to May 31 2011)
  - Rural

Also included is a comparison of monthly averages from the closest PAZA passive monitoring station for SO_2, NO_2, and O_3. The closest passive station to the Bonanza monitoring location is the Bay Tree passive monitoring station which is 18 km south-southwest. The closest current

[4] http://www.casadata.org/Reports/SelectCategory.asp

passive monitor that measures TRS or H_2S is located 150 km west and was not included in the comparison as it was not operating at the time of the Bonanza monitor.

5.1 Meteorology

The following figures illustrate the meteorological conditions recorded at the Bonanza monitoring station during the period June 18 2010 07:00 to June 30 2011 24:00. Figure 5.1 shows that the most frequent winds are from the southwestern quadrant. As well, the highest wind speeds most frequently occur from the southwestern quadrant. Figure 5.2 shows the monthly temperature and wind speed distributions. These figures show that the coldest and most calm weather occurred in the month of December.

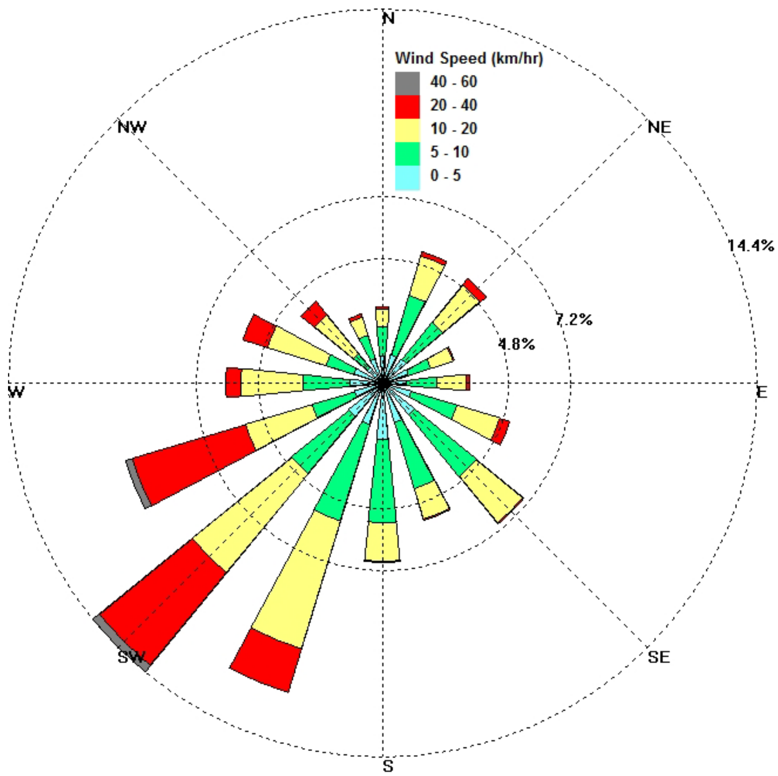
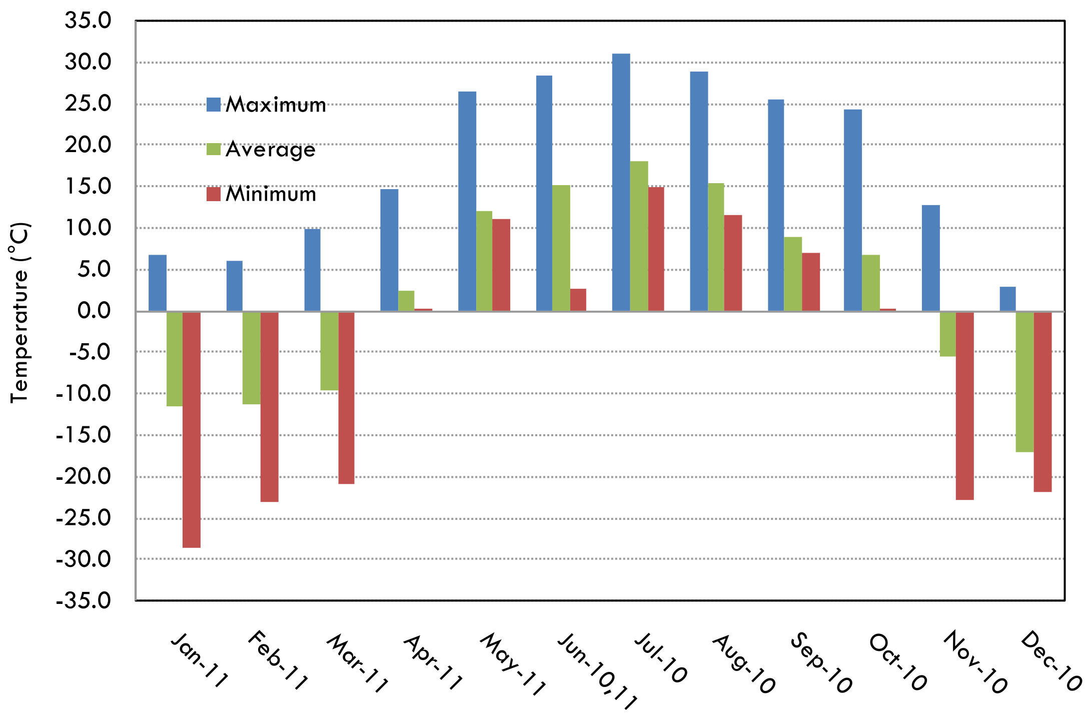


Figure 5.1 Wind Frequency Distribution at Bonanza Monitoring Station



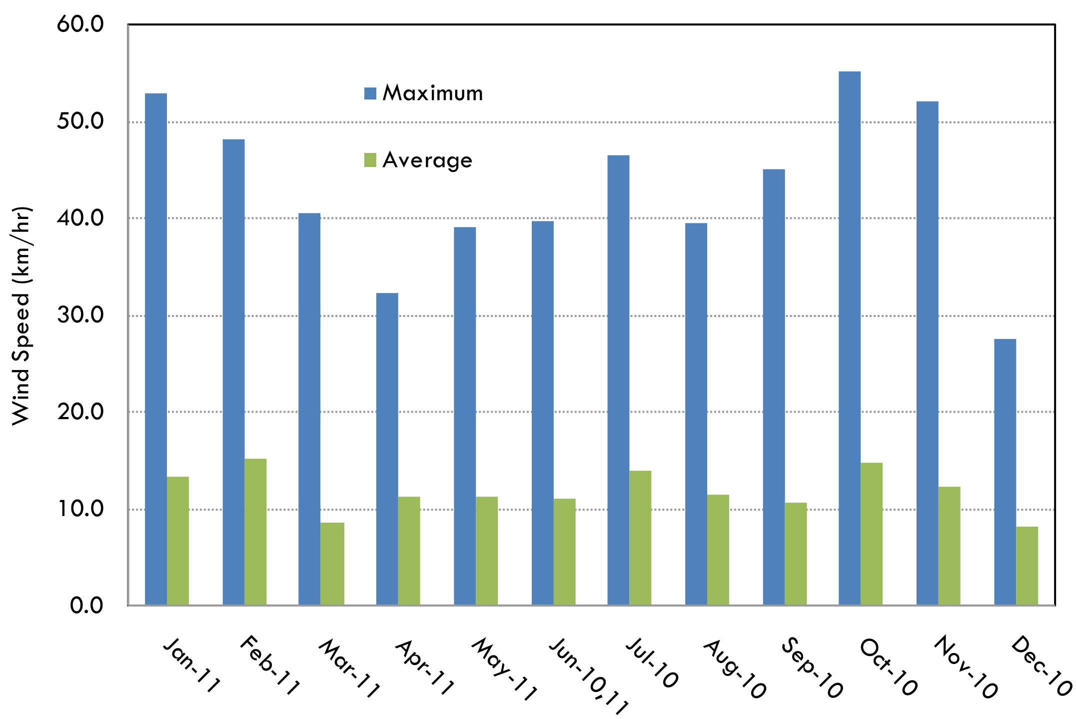


Figure 5.2 Monthly Temperature and Wind Speed Distribution Measured at Bonanza Monitoring Station

5.2 Total Reduced Sulphur Compounds

Reduced sulphur compounds are a complex family of substances. They are defined by the presence of sulphur in a reduced state and are generally characterized by strong odours at relatively low concentrations. Total reduced sulphur compounds (TRS) includes hydrogen sulphide (H_2S), carbon disulphide (CS_2), mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide (SO_2) is not a reduced sulphur compound.

As noted earlier in Table 4.1, currently there are no AAAQO for TRS. However, there are AAAQOs for H_2S and CS_2 which are based on odour thresholds. H_2S is known to have highly toxic properties, and can cause negative health effects at low concentrations.[5]

Natural sources of reduced sulphur compounds in air include volcanoes and sulphur springs, oceans and estuaries, and exposed faces of sulphur-containing oil and coal deposits. The primary anthropogenic sources include oil and gas processing facilities, Kraft pulp mills, chemical manufacturing plants, and livestock operations. TRS can be produced when manure undergoes anaerobic (absence of oxygen) fermentation.

In the area around Bonanza, the main sources of TRS emissions would be sour oil and gas activity, agricultural practices, landfill, and sewage lagoons. As well, swamps and sloughs can be natural sources of TRS.

A summary of TRS measurements are shown in Table 5.1 and the time series of measurements are shown in Figure 5.3. The measurements indicate although the AAAQO for H_2S and CS_2 were not exceeded during the monitoring period, the maximum concentrations were high enough to suggest that nuisance odours could have been detected by certain individuals. However, Figure 5.4 shows that concentrations above 1 ppb were not frequently recorded. Figure 5.5 shows that the maximum recorded TRS concentrations occurred for winds from the west and west-southwest, but the average TRS concentrations do not show a distinctive trend for any particular wind direction.

Figure 5.6 presents the maximum and average measured TRS concentrations as a function of month and hour of day. The figures show a slight bias toward higher concentrations in the colder months and at sunrise but the bias is not considered significant.

Figure 5.7 provides a comparison of TRS measurements from other monitoring stations in the province for the same time period (except where noted at the beginning of Section 5). TRS is not a commonly measured suite of pollutants and would usually measured in areas where TRS compounds are present and considered important from an air quality perspective. The figure shows that the measurements at Bonanza are comparable to other areas in Alberta and PAZA where TRS are measured.

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[5] http://environment.gov.ab.ca/info/library/6664.pdf

The five highest TRS measurements occurred on January 10 and 11, 2011 during very cold, low wind speed conditions which are indicative of poor atmospheric dispersion for low level or ground based sources . The highest measurement of 7.72 ppb was measured when the monitoring station was directly downwind from a nearby oil and gas facility. At that time of year, it unlikely that agricultural or natural sources would contribute to these high measurements; however, the main cause of these high concentrations cannot be definitely determined without further investigation outside the scope of this report.

Overall the main contributor to TRS concentrations cannot be positively determined from the measured data ; however, due to the oil and gas presence in the area and the fact that highest average measured values are occurring during colder months, it is possible that oil and gas activity in general could be the main contributor. However, the colder months would have the most frequent poor dispersion conditions particularly for low level or ground based emissions which could lead to higher measurements and may not be representative of increased emissions during those months.. Further, more thorough analysis of the measured data coupled with detailed information about industrial, agricultural and municipal activity in the area may yield more definitive conclusions on source contributions.

Table 5.1 Summary of TRS Measurements (ppb) at Bonanza Monitoring Station

1-hour AAAQO	10 (H_2S and CS_2)
Maximum 1-hour Measurement	7.72
99.9th Percentile Measurement	1.91
99th Percentile Measurement	0.98
90th Percentile Measurement	0.67
Median Measurement	0.47
Average Measurement	0.48
24-hour AAAQO	3 (H_2S)
Maximum 24-hour Average Measurement	1.75

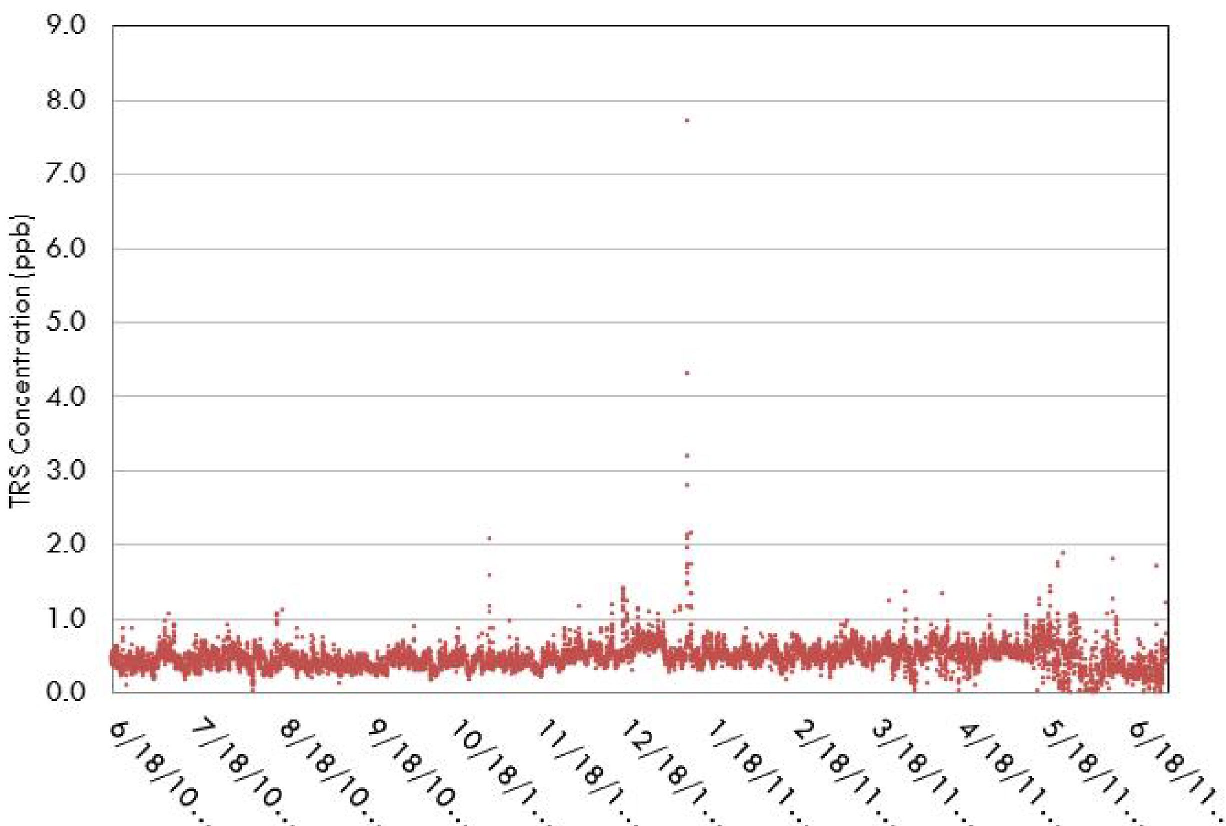


Figure 5.3 Time Series of the Bonanza TRS Measurements (non-zero values)

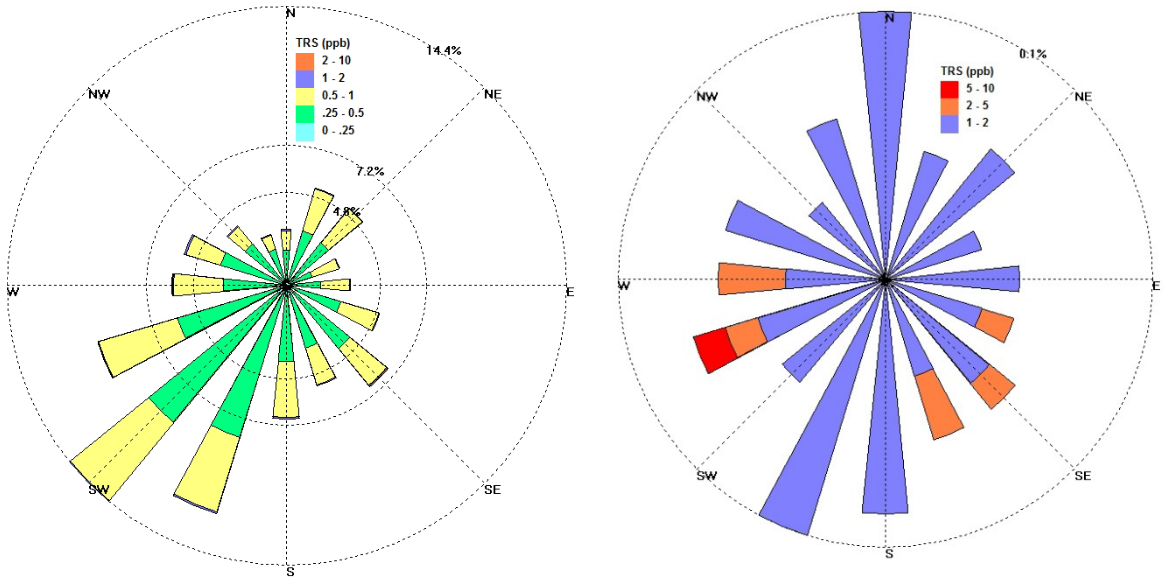


Figure 5.4 Frequency Distribution of TRS Measurements by Wind Direction

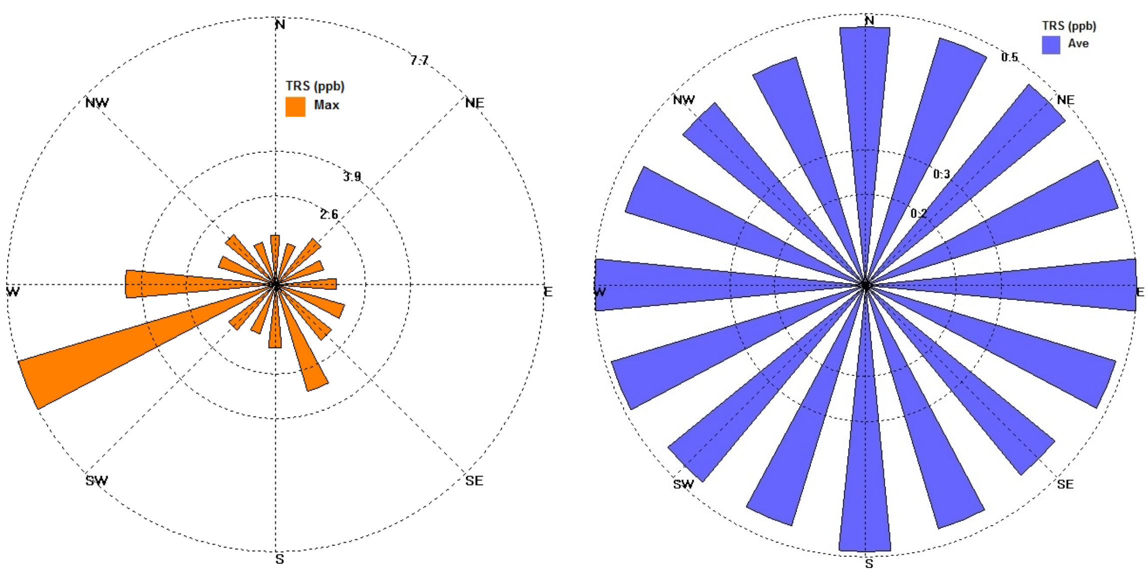
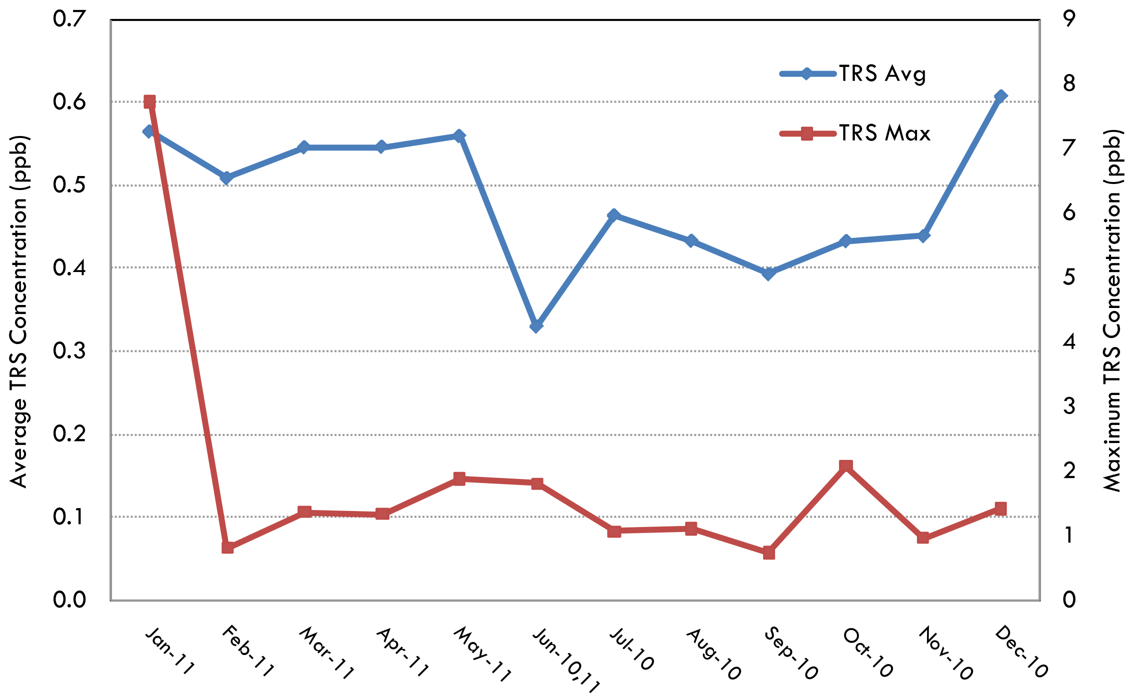


Figure 5.5 Maximum and Average TRS measurements by Wind Direction



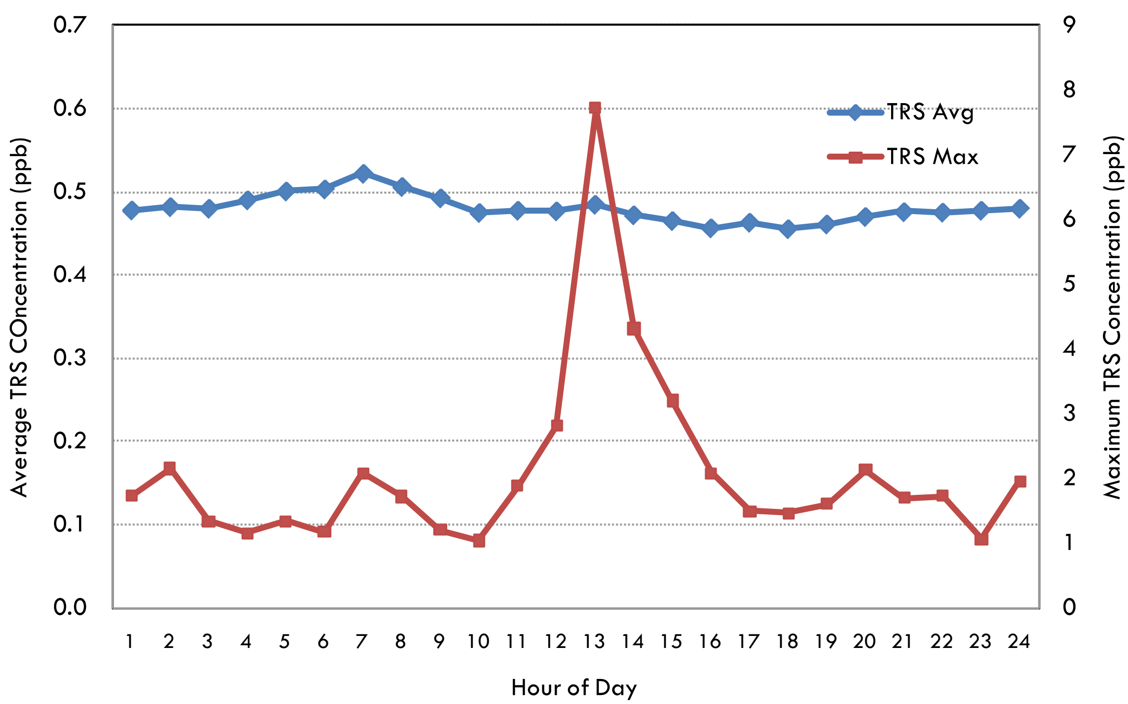


Figure 5.6 Maximum and Average TRS Measurements by Month and Hour of Day

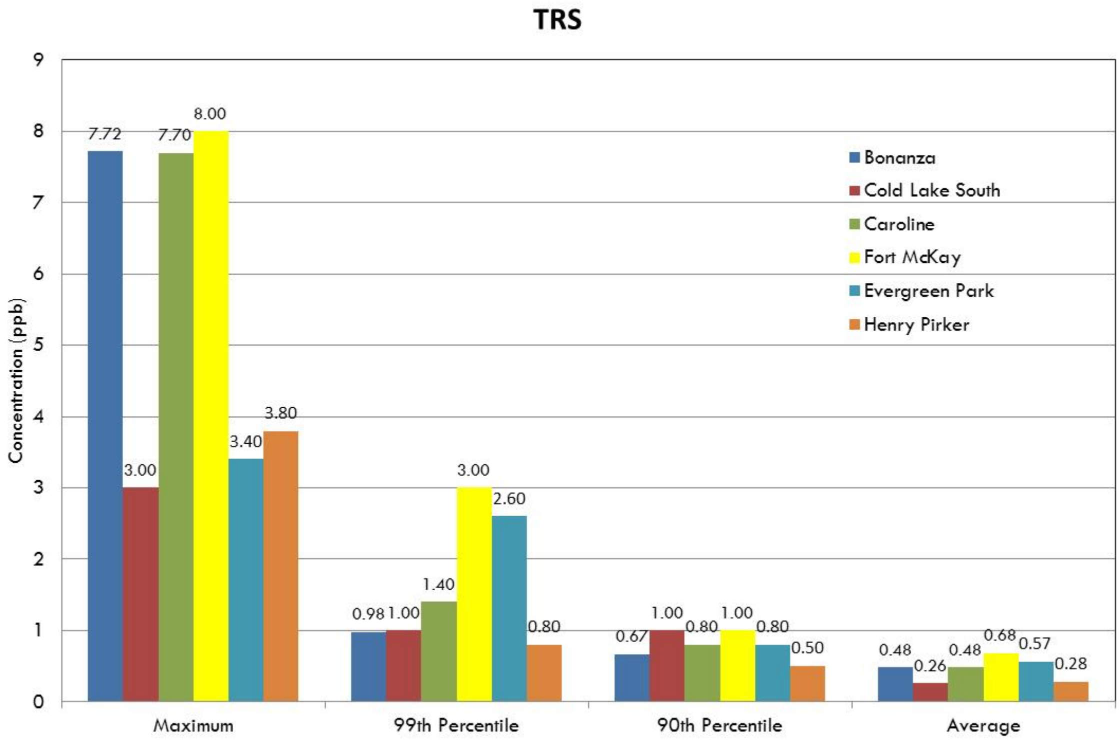


Figure 5.7 Comparison of TRS Measurements from other Continuous Monitoring Stations

5.3 Sulphur Dioxide

Sulphur dioxide is a colourless, non-flammable gas with a sharp, pungent odour. Natural sources include volcanoes, decaying organic matter and solar action on seawater. The most significant anthropogenic emission sources of sulphur dioxide are from combustion of sulphur-containing fossil fuels, smelting sulphide ores, and petroleum refining. Other less significant sources include chemical and allied products manufacturing, metal processing, other industrial processes, and vehicle emissions.

Once sulphur dioxide is released into the atmosphere, it may be converted to other compounds and/or removed from the atmosphere by various mechanisms. Processes such as oxidation, wet deposition, dry deposition, absorption by vegetation and by soil, dissolution into water and other processes contribute to the removal of sulphur dioxide from the atmosphere. Exposure to high enough concentrations of SO_2 can affect human and environmental health.[6]

[6] http://environment.gov.ab.ca/info/library/8304.pdf

A summary of SO_2 measurements are shown in Table 5.2 and the time series of measurements are shown in Figure 5.8. The measurements were well below the SO_2 AAAQO in all instances. Figure 5.9 shows that most concentrations were less than 1 ppb. Figure 5.9 and Figure 5.10 indicate that the maximum measured SO_2 concentrations occur for winds from the western sector. Highest average SO_2 concentrations show a slight trend to the northwestern and southeastern quadrants.

Figure 5.11 presents the maximum and average measured SO_2 concentrations as a function of month and hour of day. The figures show the average concentrations have a slight bias toward higher concentrations in the colder months and in the late mornings. The figure shows that the average monthly concentrations are consistent with the measurements from the closest passive monitor.

Figure 5.12 provides a comparison of SO_2 measurements from other monitoring stations in the province for the same time period (except where noted previously). The figure shows that the measurements at Bonanza were slightly lower when compared to other areas where SO_2 is measured.

The data indicates that SO_2 levels around Bonanza are generally low inferring that there are no significant sources of SO_2 in the area. The bias of higher concentrations toward certain wind direction may be a sign of long range transport from sour gas processing plants or other industrial sources. Further, more thorough analysis of the measured data coupled with detailed information about activity in the area may yield more definitive conclusions in regard to the main emission contributors.

Table 5.2 Summary of SO_2 Measurements (ppb) at Bonanza Monitoring Station

1-hour AAAQO	172
Annual AAAQO	20
Maximum 1-hour Measurement	9.1
99.9th Percentile Measurement	6.3
99th Percentile Measurement	2.6
90th Percentile Measurement	0.8
Median Measurement	0.26
Average Measurement	0.4
24-hour AAAQO	48
Maximum 24-hour Average Measurement	3.7

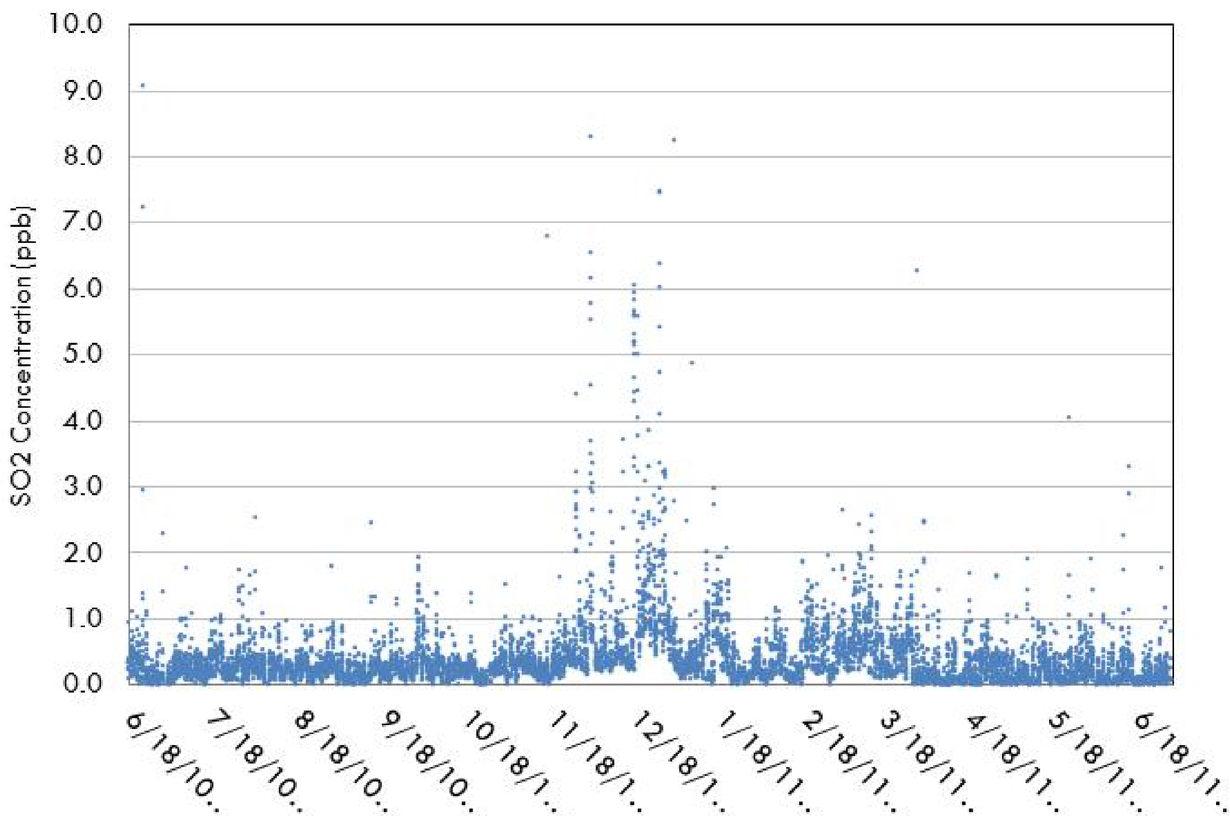


Figure 5.8 Time Series of the Bonanza SO_2 Measurements (non-zero values)

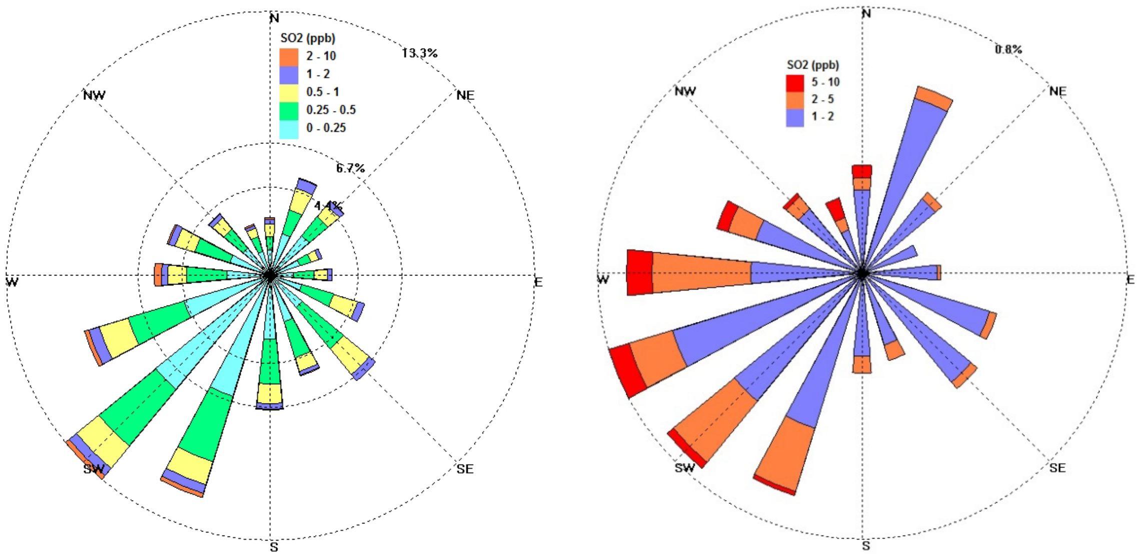


Figure 5.9 Frequency Distribution of SO_2 Measurements by Wind Direction

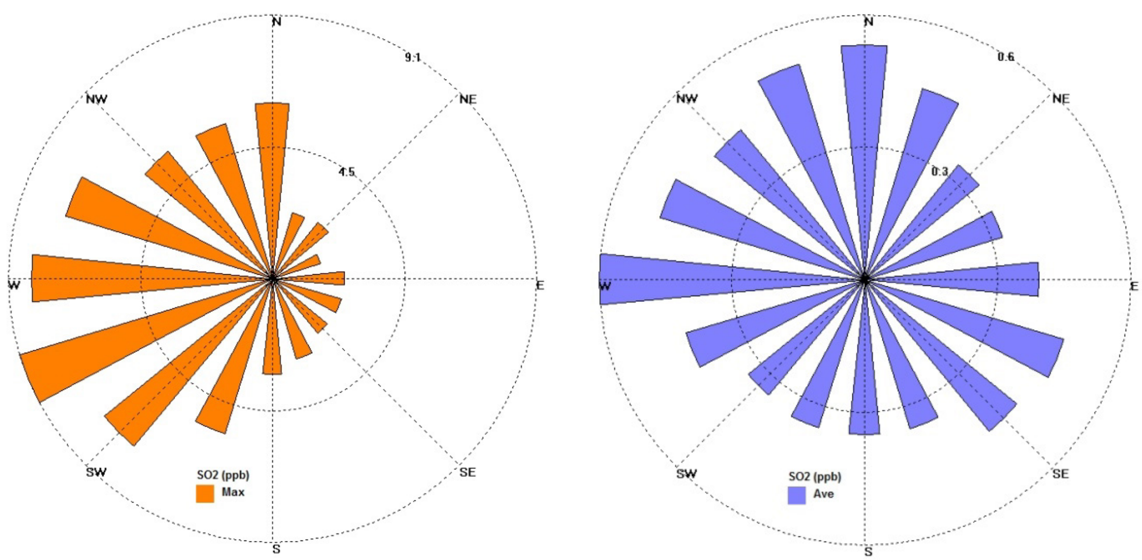
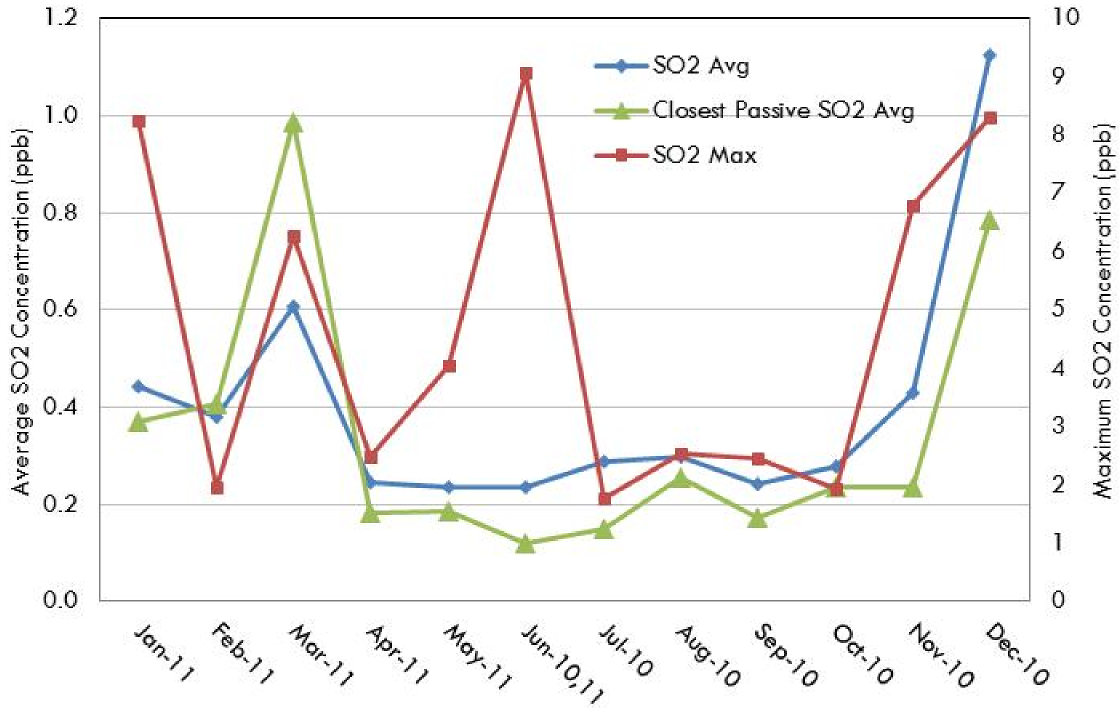


Figure 5.10 Maximum and Average SO_2 measurements by Wind Direction



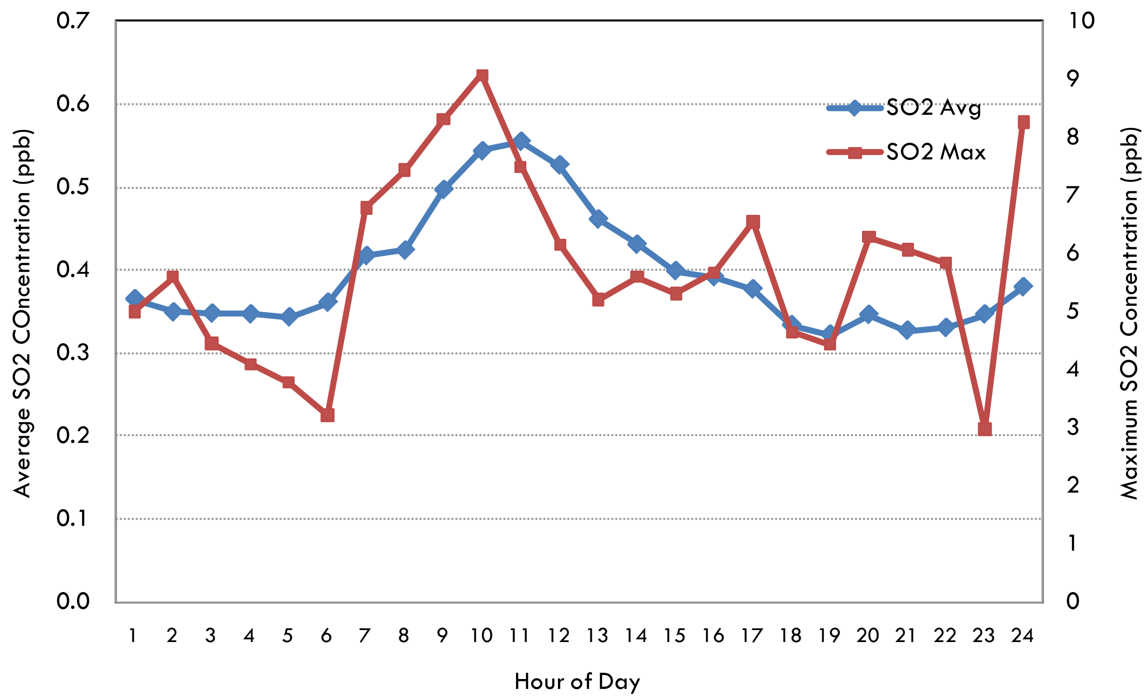


Figure 5.11 Maximum and Average SO_2 Measurements by Month and Hour of Day

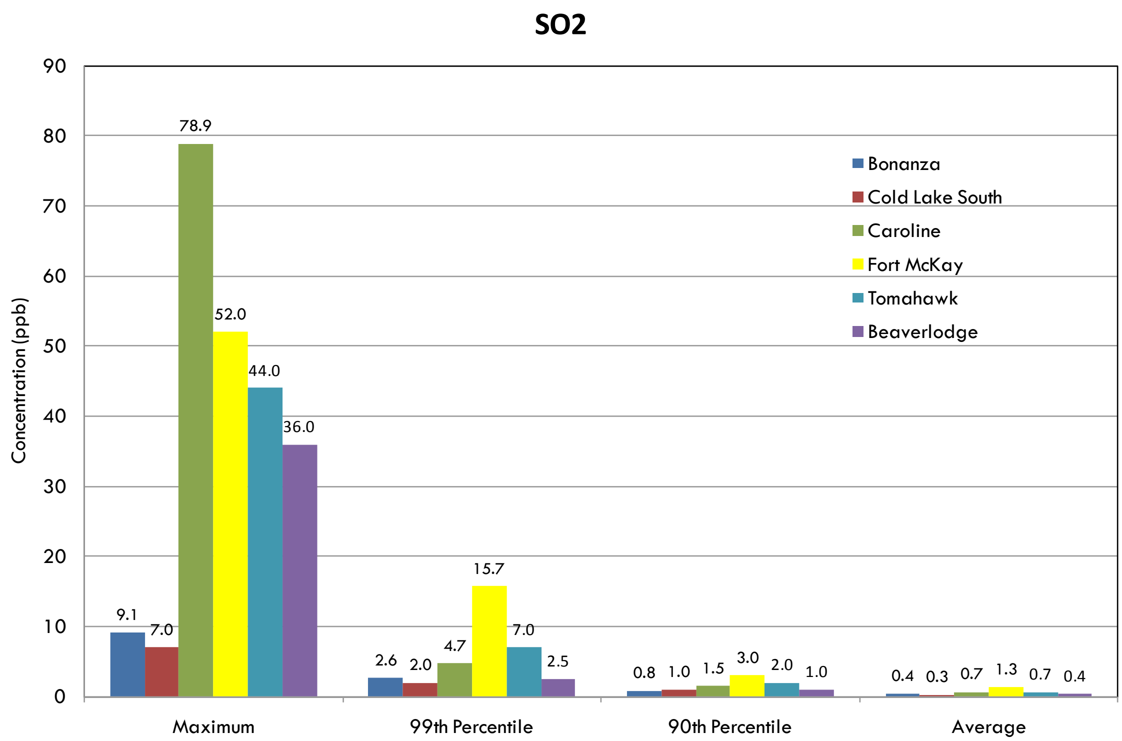


Figure 5.12 Comparison of SO_2 Measurements from other Continuous Monitoring Stations

5.4 Nitrogen Oxides

Nitrogen dioxide (NO_2) and nitric oxide (NO) are known collectively as oxides of nitrogen (NO_x). NO_x occurs naturally in the environment as a result of forest fires, atmospheric lightning discharges and biogenic oxidation of nitrogen containing compounds present in soil. Anthropogenic NO_x emissions are mainly the result of combustion processes, such as the combustion of fuel for vehicles or the combustion of coal, oil and natural gas for industrial processes. Emissions of NO_x from combustion processes are initially about 90 to 95% NO and about 5 to 10% NO_2. NO is oxidized to NO_2 in the atmosphere, and through further complex atmospheric chemical reactions can lead to the formation of ozone (see next section), nitric acid and nitrate-containing particles.

Of the NO_x species, an AAAQO exists for NO_2 only. Therefore, a summary of the NO_x measurements is restricted to NO_2. NO_2 is a reddish-orange-brown gas with an irritating, acrid, characteristic pungent odour. It is corrosive, highly oxidizing and non-combustible. At high enough concentrations, NO_2 can have respiratory effects on humans on which the 1-hour

AAAQO is based. On a long term basis, NO_2 can have detrimental effects on vegetation which is reflected in the annual AAAQO.[7]

A summary of NO_2 measurements are shown in Table 5.3 and the time series of measurements are shown in Figure 5.13. The measurements were below the NO_2 AAAQO in all instances. Figure 5.14 shows that most concentrations were less than 10 ppb. Figure 5.14 and Figure 5.15 indicate that the most frequent high concentrations are occurring for winds from the south sector. Figure 5.15 shows that the highest average concentrations are occurring for winds from the eastern sector. These results are consistent with the fact that the Hamlet of Bonanza, Secondary Highway 719 and Township Road 801 are the main sources of NO_x emissions and are located to the south and east of the monitoring station.

There were two measured values above 60 ppb and both occurred during winds from the west-northwest. These values could be due to exposure to prolonged vehicle exhaust and do not appear to be representative of the rest of the data.

Figure 5.16 presents the maximum and average measured NO_2 concentrations as a function of month and hour of day. The figures show the average concentrations have a slight bias toward higher concentrations in the colder and least windy months of December and March in which dispersion of ground based sources (vehicles and home heating which are the main emission sources) would be poor. There is distinct diurnal pattern of average NO_2 values showing a peak in the morning “rush-hour” likely from vehicle and community emissions, followed by a decline due to decreased emissions and complex atmospheric processes in sunlight (discussed in the ozone section), followed by an increase in the afternoon “rush-hour” as the sun goes down, and a steady average during the night.

The figure shows that the average monthly concentrations are greater than the measurements from the closest passive monitor. This is likely due to the proximity of the Bonanza monitor to Highway 719 and Township Road 801.

Figure 5.17 provides a comparison of NO_2 measurements from other monitoring stations in the province for the same time period (except where noted at the beginning of Section 5). The figure shows that other than the peak measurements, NO_2 levels at Bonanza were slightly lower when compared to other areas in the province.

The ambient NO_2 data measured in Bonanza appears to adequately reflect the general rural setting with a close proximity to a secondary highway. Further, more thorough analysis of the measured data coupled with detailed information about activity in the area may yield more definitive conclusions.

[7] http://environment.gov.ab.ca/info/library/8303.pdf

Table 5.3 Summary of NO_2 Measurements (ppb) at Bonanza Monitoring Station

1-hour AAAQO	159
Annual AAAQO	24
Maximum 1-hour Measurement	63.0
99.9th Percentile Measurement	22.2
99th Percentile Measurement	15.1
90th Percentile Measurement	7.0
Median Measurement	2.0
Average Measurement	3.1

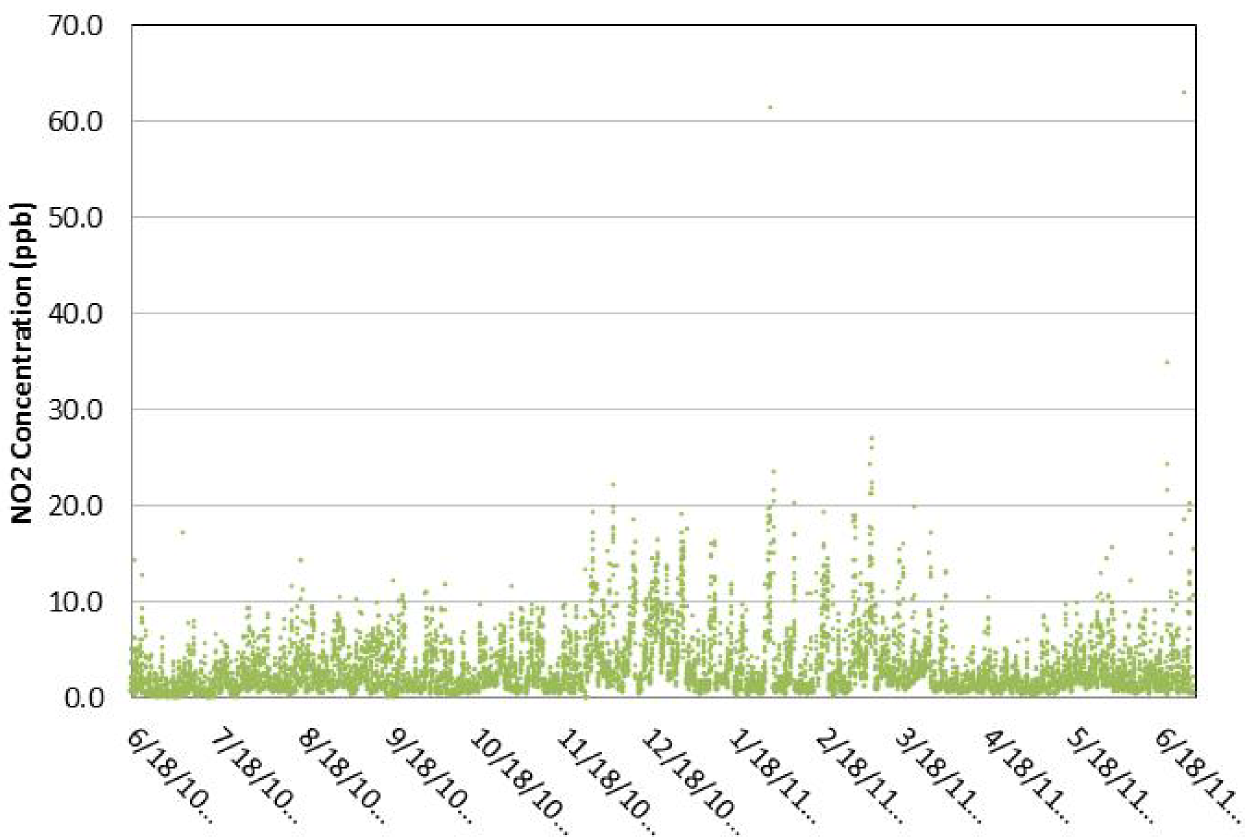


Figure 5.13 Time Series of the Bonanza NO_2 Measurements (non-zero values)

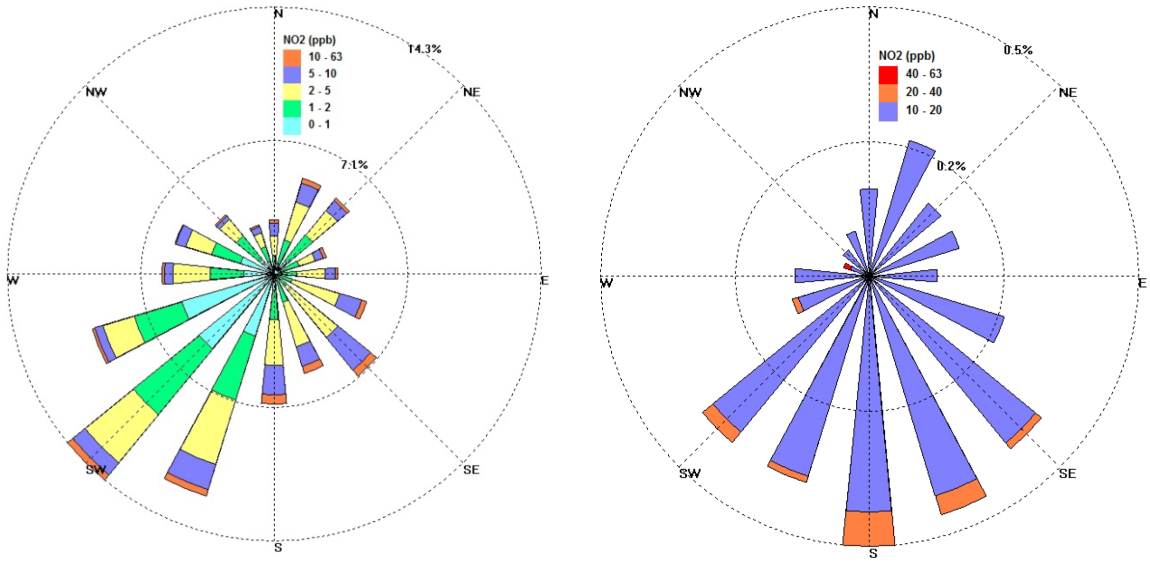


Figure 5.14 Frequency Distribution of NO_2 Measurements by Wind Direction

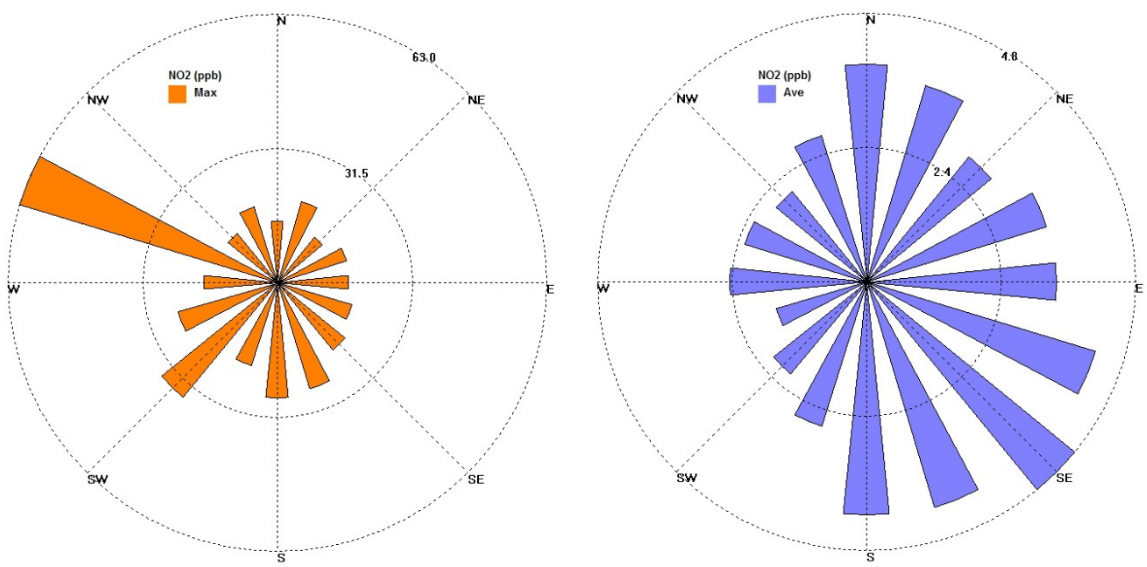


Figure 5.15 Maximum and Average NO_2 measurements by Wind Direction

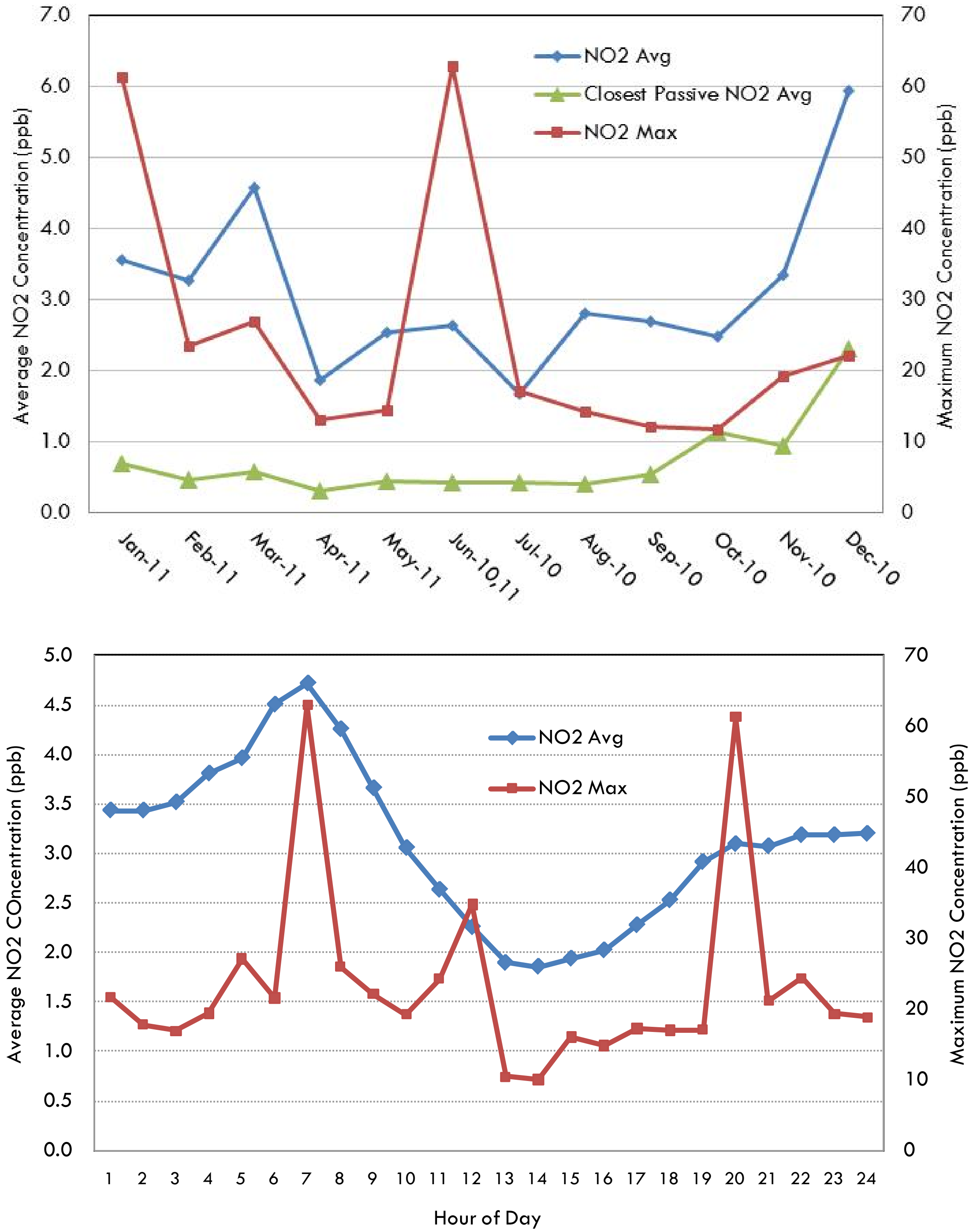


Figure 5.16 Maximum and Average NO_2 Measurements by Month and Hour of Day

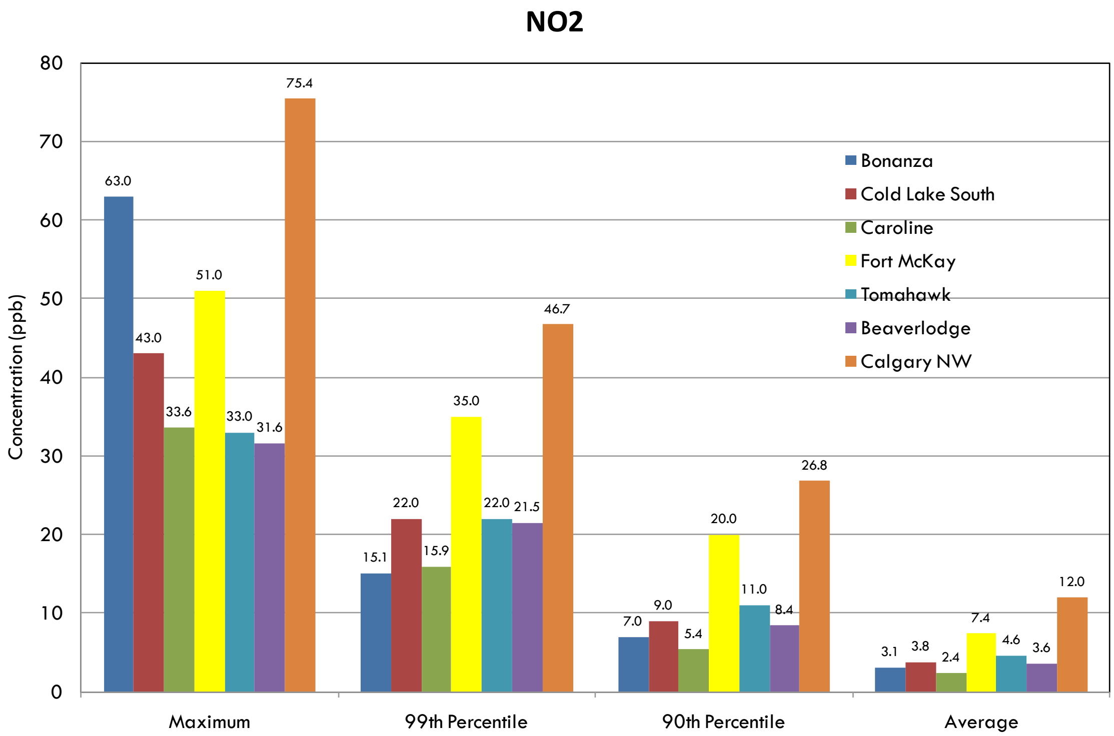


Figure 5.17 Comparison of NO_2 Measurements from other Continuous Monitoring Stations

5.5 Ozone

Ozone is a chemical whose effect on the environment is either beneficial or detrimental depending on where it occurs. Stratospheric ozone protects us from the sun's ultraviolet light, but can be toxic in the troposphere (atmospheric layer encompassing ground level). Ozone is a highly reactive, colourless gas. It has a sharp, clean odour that can often be detected around running electric motors, after lightning storms, and around new mown hay.

Ozone is not emitted by anthropogenic or natural processes. It is normally present in the troposphere as a result of naturally occurring photochemical and meteorological processes. Ground level ozone is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOCs) and NO_x in the presence of heat and sunlight. Combustion exhausts emit both VOCs and NO_x and in rural areas, trees and other vegetation naturally emit VOCs that can contribute to ozone formation. Changing weather patterns contribute to yearly differences in ozone concentrations from city to city. Ozone and the precursor substances that cause ozone also can be transported into an area from pollution sources hundreds of miles upwind.

Extensive scientific studies indicate that there can be significant health and environmental effects associated with ozone. Potential short-term effects include pulmonary function reductions, increased airway sensitivities, and airway inflammation on which the 1-hour AAAQO for ozone is based. [8]

A summary of O_3 measurements are shown in Table 5.4 and the time series of measurements are shown in Figure 5.18. The measurements were below the 1-hour AAAQO in all instances and although, the CWS are not directly comparable, the 4th highest 8-hr daily averages is less than the planning trigger of 58 ppb.

Figure 5.19 presents the frequency distribution of O_3 measurements by wind direction. Figure 5.20 presents the maximum and average O_3 measurements by wind direction. Although there is no apparent bias of maximum and average values by wind direction, the most frequent O_3 concentrations above 59 ppb are occurring during winds from the eastern sector.

Figure 5.21 presents the maximum and average measured O_3 concentrations as a function of month and hour of day. The figures show a definite pattern of the highest average and maximum values in the spring and lowest in the fall. Also seen, is a typical diurnal pattern of O_3 where O_3 is decomposed to O_2 through a reaction with NO in the early morning and then created during the day in complex reactions with VOCs and NO_2 in the presence of sunlight. The figure shows that the average monthly concentrations are consistent with the measurements from the closest passive monitor.

Figure 5.22 provides a comparison of O_3 measurements from other monitoring stations in the province for the same time period (except where noted at the beginning of Section 5). The figure shows that other O_3 levels at Bonanza were comparable to other areas in the province.

Figure 5.23 presents the diurnal relationships between NO, NO_2, and O_3 at the Bonanza monitoring station for the entire period, and for the months of December, April and August. The figures show the complex relationship between these pollutants that lead to O_3 formation. Although the formation of O_3 can be seen in all four figures, it is most pronounced in August which has the highest temperatures and sunlight.

The ambient O_3 data measured in Bonanza appears to adequately reflect the general rural setting. Although the data is showing ozone formation and destruction due to NO_x and VOC emissions from the community and local roads is occurring, the levels are below the AAAQO and CWS triggers.

[8] http://environment.gov.ab.ca/info/library/7808.pdf

Table 5.4 Summary of O_3 Measurements (ppb) at Bonanza Monitoring Station

1-hour AAAQO	82
Maximum 1-hour Measurement	64.5
99.9th Percentile Measurement	60.6
99th Percentile Measurement	54.0
90th Percentile Measurement	43.6
Median Measurement	28.6
Average Measurement	28.5
8-hour CWS Exceedance Trigger	65
8-hour CWS Planning Trigger	58
4th Highest Daily 8-hour Measurement	57.8

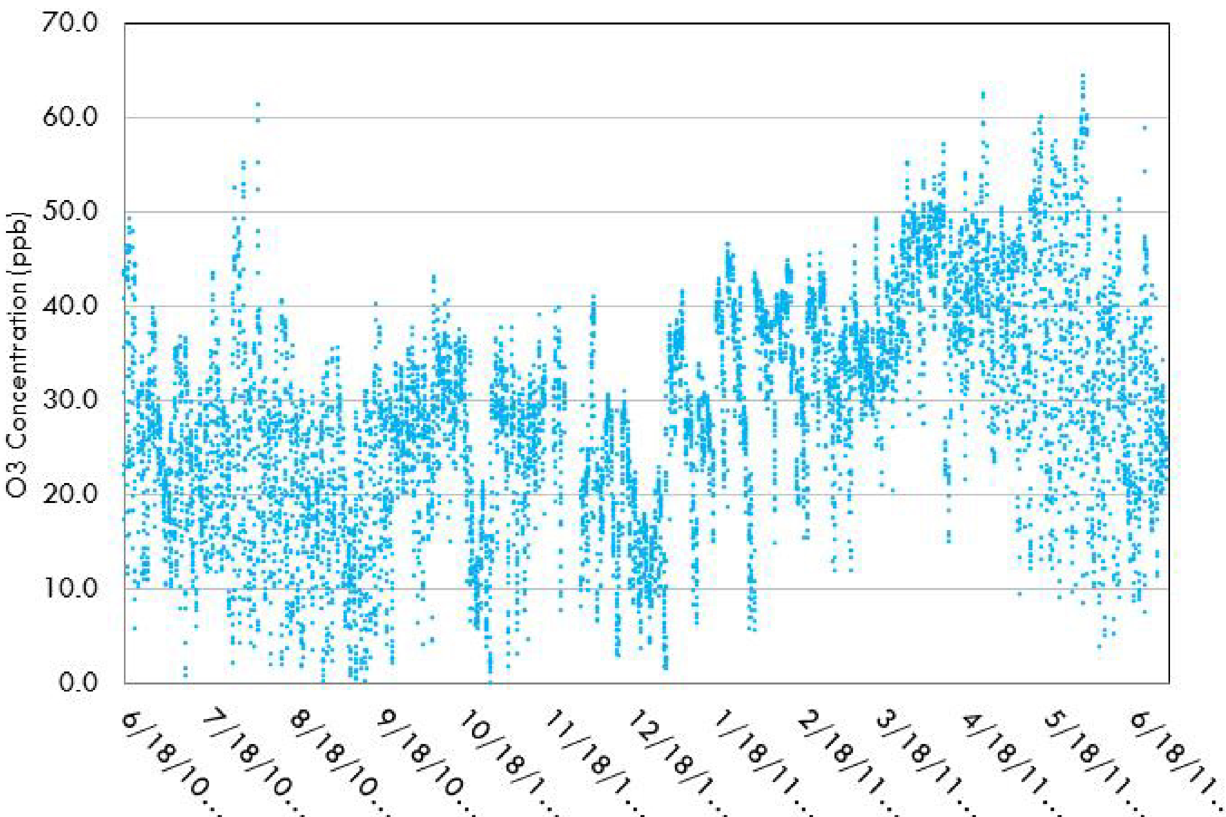


Figure 5.18 Time Series of the Bonanza O_3 Measurements (non-zero values)

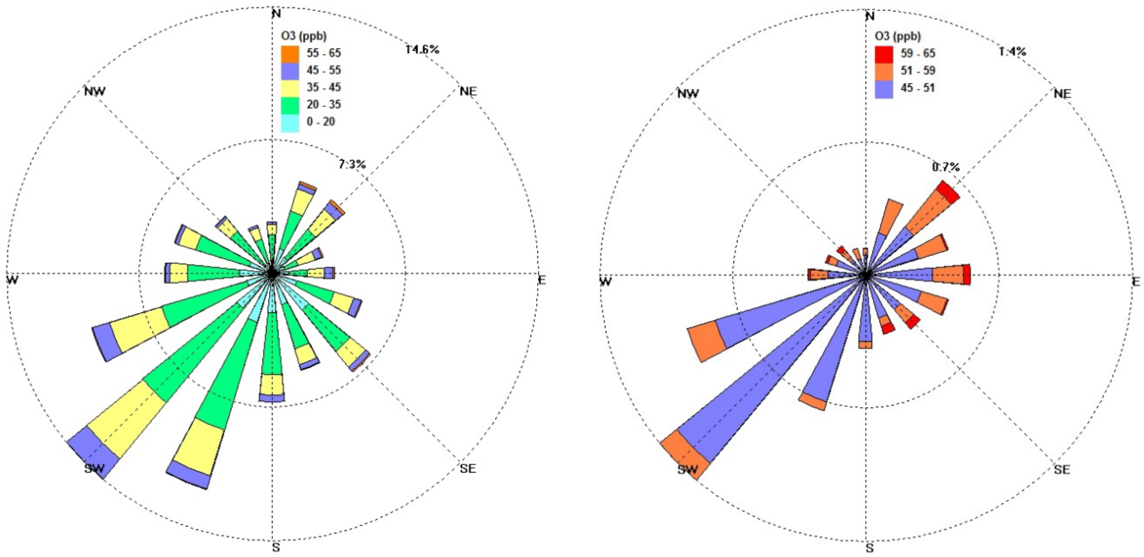


Figure 5.19 Frequency Distribution of O_3 Measurements by Wind Direction

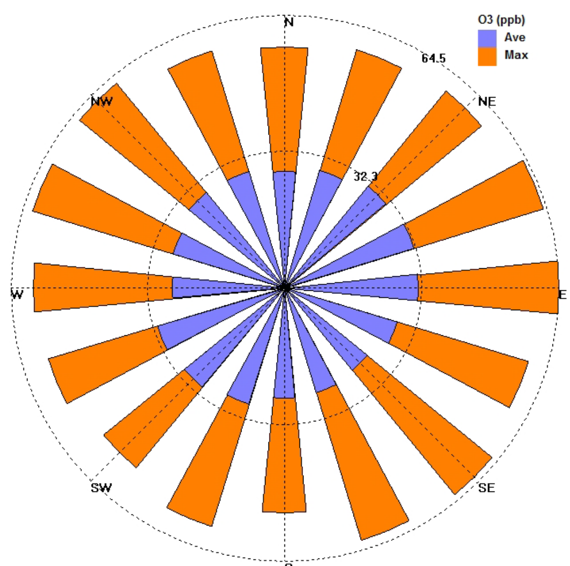


Figure 5.20 Maximum and Average O_3 Measurements by Wind Direction

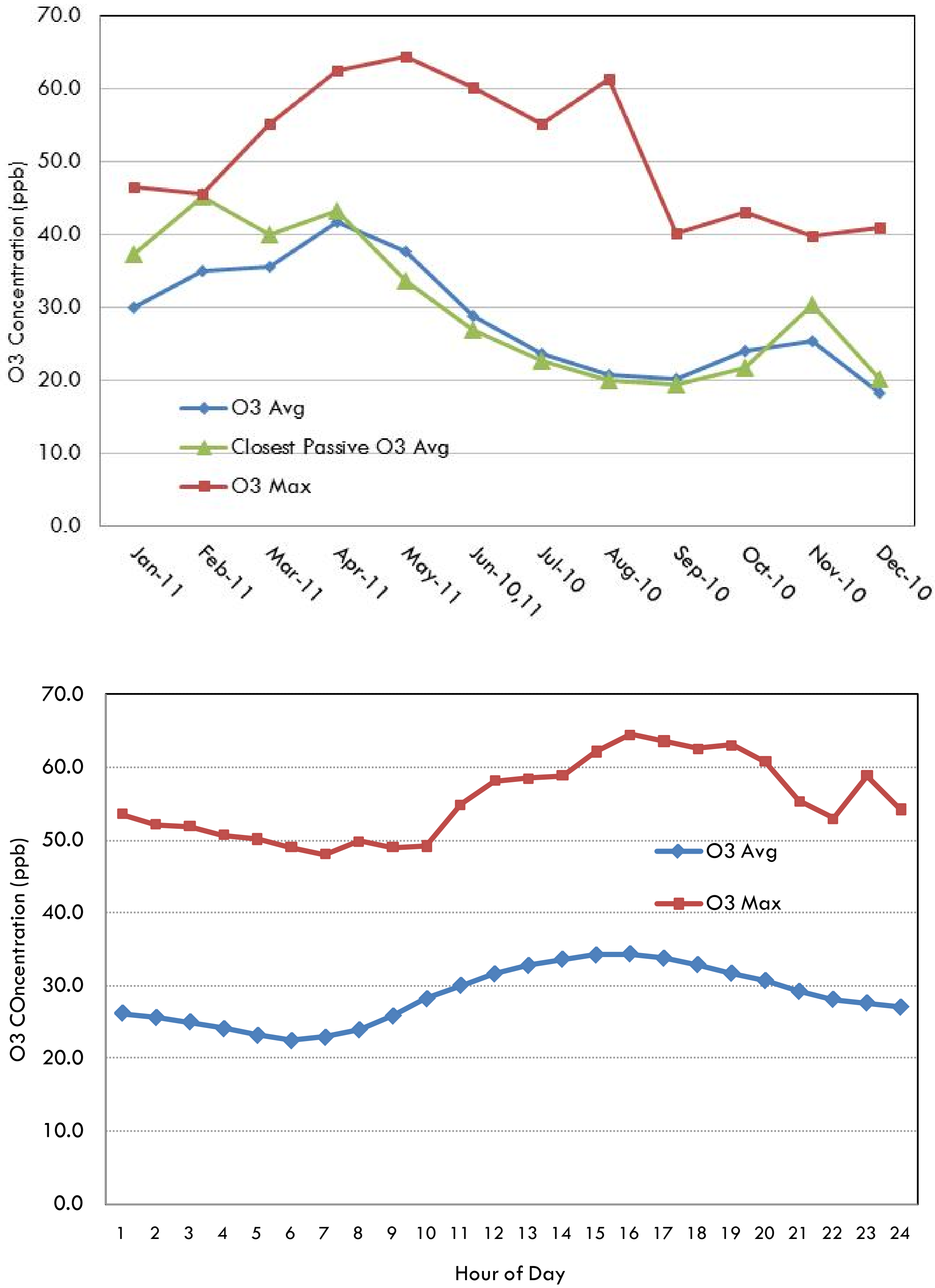


Figure 5.21 Maximum and Average O_3 Measurements by Month and Hour of Day

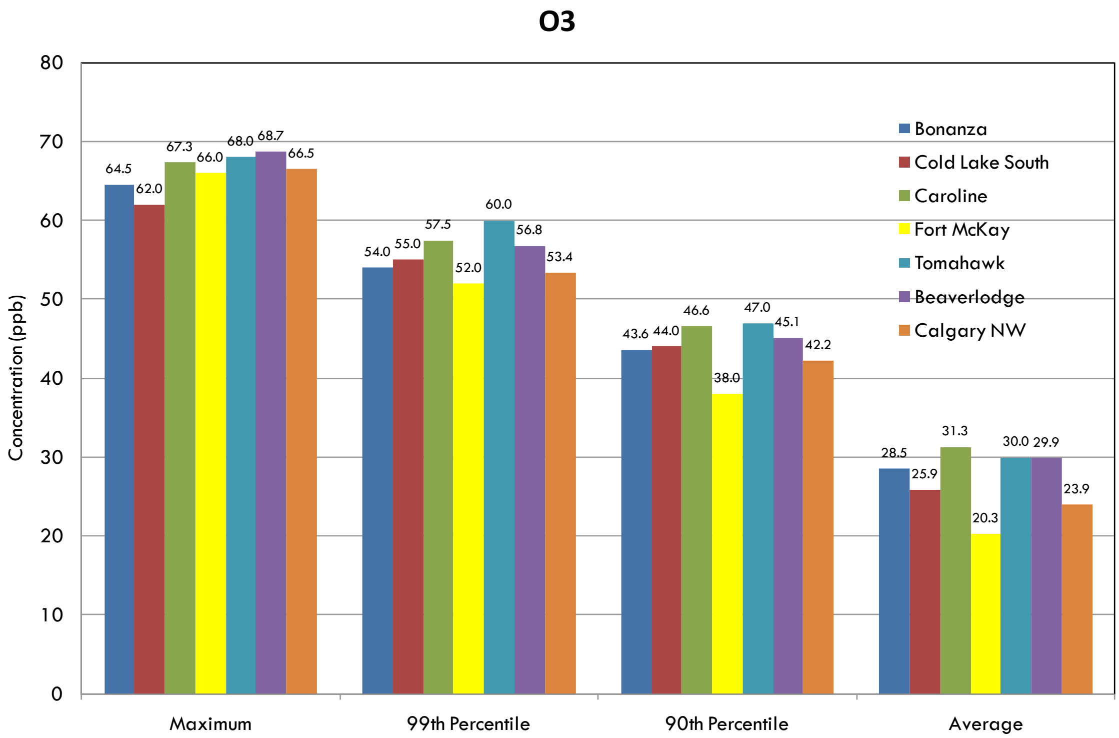


Figure 5.22 Comparison of O_3 Measurements from other Continuous Monitoring Stations

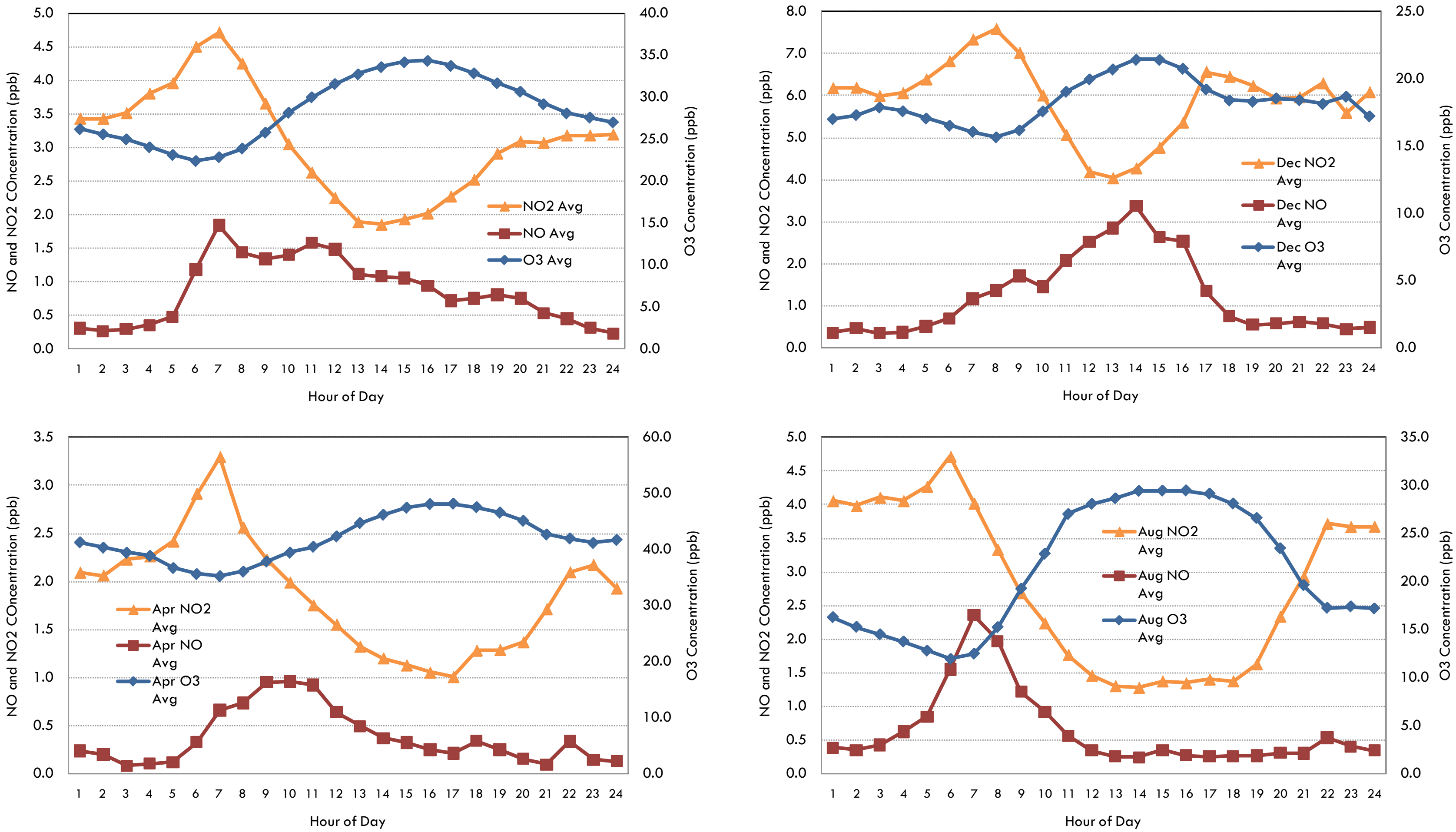


Figure 5.23 Diurnal Relationship between Measured O_3, NO, and NO_2 concentrations for entire period and selected months.

6. SUMMARY AND RECOMMENDATIONS

The monitoring data that PAZA collected through the Bonanza monitoring project suggests that the air quality is relatively good. Measured concentrations of TRS, SO_2, NO_2, and O_3 were below the applicable or representative AAAQOs and CWS Triggers. Diurnal profiles of O_3 and NO_2 measurements appear to show photo-chemical O_3 formation and destruction.

Although TRS concentrations were below the representative AAAQO for two components of TRS (H_2S and CS_2), infrequent measurements that could be perceived as nuisance odours by sensitive individuals were recorded. It is possible that the highest TRS measurements were influenced by fugitive emissions from nearby sour oil and gas facilities but overall TRS averages could be also be influenced by other TRS emission sources in the area. Further detailed analysis that considered actual operations and facility information could provide more definitive conclusions on source contributions.

The summary of the air quality monitoring data is limited to the parameters measured in this study. Air quality surrounding the Hamlet of Bonanza may be affected by other compounds associated with oil and gas or other activities some of which PAZA was not equipped to measure such as volatile organic compounds (VOCs) which are a component of oil and gas facility fugitive emissions.

Although the monitoring results do not necessarily support further continuous monitoring in the area, if PAZA chooses to conduct additional monitoring in the Bonanza area, it is recommended to consider collecting air samples for analysis of speciated VOCs and TRS, and consider passive hydrogen sulphide monitoring to determine trends.