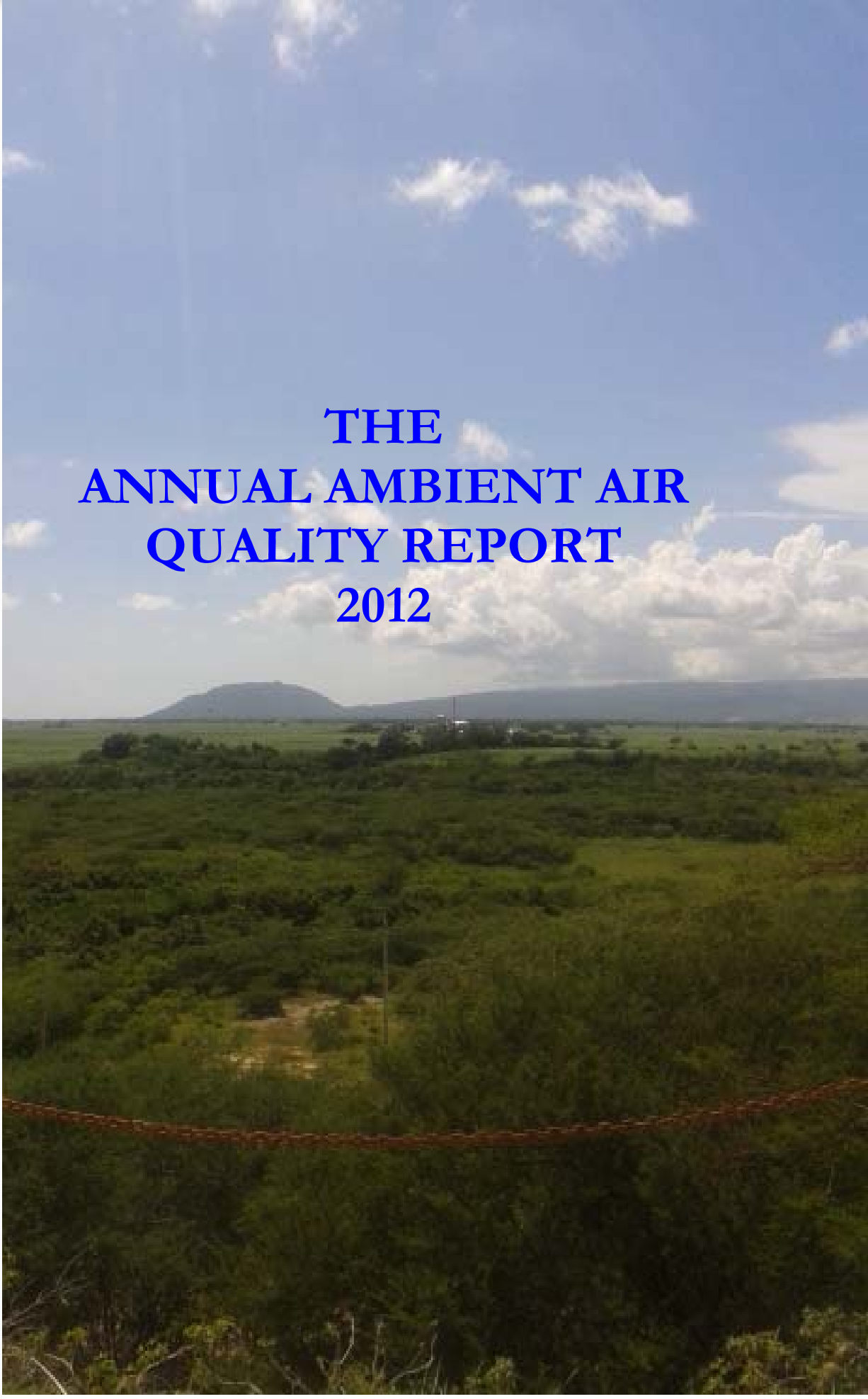
National Environment and Planning Agency

THE ANNUAL AMBIENT AIR QUALITY REPORT 2012



Managing and protecting Jamaica's air, land, wood and water

Annual Ambient Air Quality Report 2012

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Acknowledgement

This document is prepared by the technical staff of the Air Quality Management Unit in the Pollution Monitoring and Assessment Branch. The Pollution Monitoring and Assessment Branch is a part of the Environmental Management Subdivision in the Environmental Management & Conservation Division of the National Environment and Planning Agency. It is the third report coming out of this unit following the previous 2010 and 2011 editions. The Air Quality Management Unit was developed to administer the National Air Quality Management Programme. This is an air quality management programme which is funded by the Natural Resources Conservation Authority. The data and technical information provided in this report was due to the tireless effort towards data analysis and data management of unit's staff.

Special appreciation and thanks to the ***Zephyr Environmental Corporation*** *whom provided the technical review of the report leading to improvement of the final draft*

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List of Abbreviations

Alpart	Aluminum Partners of Jamaica
APDL	Air Pollutant Discharge Licence
AQMP	Air Quality Management Programme
CAMS	Cross Roads Ambient Monitoring Station
CAPs	Criteria Air Pollutants
CCCL	Caribbean Cement Company Limited
CO	Carbon Monoxide
JAM	Jamalco
JAAQS	Jamaica Ambient Air Quality Standards
JAQMP	Jamaica Air Quality Management Programme
JBGL	Jamaica Broilers Group Limited
JEP	Jamaica Energy Partners
JPSCo	Jamaica Public Service Company Limited
KSA	Kingston and St. Andrew
KMA	Kingston Metropolitan Area
LNG	Liquid Natural Gas
NEPA	National Environment and Planning Agency
NO_2	Nitrogen Dioxide
NOR	Noranda Jamaica Bauxite Partners
NRCA	Natural Resources Conservation Authority
MLW	Mud Lake West
PAPs	Priority Air Pollutants
Pet	Petrojam
PM_{10}	Particulate Matter less than 10 microns
RAMS	Rockfort Ambient Monitoring Station
SO_2	Sulphur Dioxide
TSP	Total Suspended Particulates
ULDF	Ultra Low Diesel Fuel
WIN	Windalco

Appendices

Appendix A

Appendix B

Executive Summary

This report is prepared to provide an overview of the ambient air quality in Jamaica during 2012. The purpose of the report is to provide quantitative and qualitative analysis on ambient air concentrations of:

- Total Suspended Particulate (TSP)
- Particulate Matter Less than 10 Microns (PM_{10})
- Sulphur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)
- Carbon Monoxide (CO)
- Ozone (O_3)

These pollutants are listed as criteria air pollutants in the Natural Resources Conservation Ambient Air Quality Standards Regulations 1996. The standards were set to protect the environment and public health. Hence the report on monitoring data gathered in 2012 is to provide the users of the report with an indication of the average level of these specific criteria pollutants in the atmosphere on an hourly, daily and annual basis during 2012. These averages are compared with the Jamaica Ambient Air Quality Standards (JAAQS) and a determination is made as to the monitoring sites' compliance with this standard. Compliance with the JAAQS in this report suggests that the environment and public health in these locations are not at threat from the air pollutants being monitored. Non-compliance indicates the opposite; however, the level of threat cannot be determined without the proper health and ecological assessments.

The report outlines the amount of stations now in operation across the island. The locations of these stations, the parameters monitored as well as the operator and date of commission of each station is also given. In addition, this report breaks down the monitoring responsibility shared across the island by sectors.

In the first section of the report a statistical analysis is done for the sixty two (62) monitoring sites across Jamaica. This represents an increase of four monitoring site over the previous year. The status of the ambient air is given for each site monitored during 2012 along with an analysis of the causes and trends. The hourly ambient levels, twenty four (24) hour average ambient levels and average annual levels are also analyzed quantitatively and compared with the Jamaica Ambient Air Quality Standards (JAAQS) set by the Natural Resources Conservation Authority. In addition, the communities that are impacted are identified in some cases.

The report goes on to statistically compare the annual average ambient air quality between 2012 and previous years for all the sites that have historical data available and outlines the trends. It also seeks to identify why ambient levels have increased or decreased in some areas.

The report concludes by giving a qualitative analysis of the ambient air in Jamaica specific to each type of pollutant and mentions strategies the Agency has been undertaking to maintain and improve the country's air quality

The report concludes that from the data collected in 2012, the country continues to experience low impact from Nitrogen Dioxide, Sulphur Dioxide and Carbon Monoxide as there was no breach of the JAAQS recorded. Despite both SO_2 and NO_x accounting for over 90% of the emissions produced in the country from major industry, they have not materialized as major contaminants in ambient air. It is suspected that the main reason for this maybe the dispersion of the pollutants from major sources and the limit placed on sulphur content in fuel oil by the NRCA Air Quality Regulations 2006. Ozone data was compiled in 2012 for the first time and will continue to be tracked during 2013. Although 14 exceedances of the 1 hour JAAQS was observed from the data recorded during 2012 the Agency requires more data to comprehensively inform the country on the current status of the air in relation to tropospheric (ground level) ozone.

Data quality for and recovery for gas sampling improved to average of 65% over a low of 45% in 2011. This enhanced the level of assessment that was possible by the Agency and continued technical training during 2012 and 2013 will see the continued increase in data recovery and quality.

The country has seen an overall increase in the levels of particulate matter present in ambient air during 2012. There has been an increase in the number of exceedances of both the daily JAAQS and the annual JAAQS. Breaches of the daily standards increased from 17 to 19 and annual breaches increased from 3 to 8 over the previous year. These increases are for the combined TSP and PM_{10} monitoring stations. Interventions will have to be made in those air sheds that have been identified by the current monitoring as compromised. Hayes Corn Piece Clarendon and the Rockfort Kingston are two locations that will have to be thoroughly assessed during 2013 and recommendations made for possible mitigations against the air emissions producing activities in those locations.

2.0 Current Ambient Monitoring Network Status

Table2-1: Jamaica's Ambient Monitoring Network

Unit	Parish, Location	Air shed	Parameters sampled	Operator	Status	Instruments and frequency of monitoring	Commission
1	KIN, Crossroads	Kingston and St. Andrew, Portmore	TSP, PM10	NEPA	ON	HI-VOL- every six days	2006
2	KIN, Harbour View		TSP,	NEPA	ON	MINI-VOL-every six days	2006
3	KIN, Hope Road		TSP, PM10	NEPA	ON	MINI-VOL-every six days	2006
4	KIN, Harbour View		PM10	CCCL	ON	HI-VOL- every six days	2011
5	KIN, Washington, Gardens		PM10	NEPA	ON	MINI-VOL-every six days	2012
6	Portmore,		PM10	NEPA	ON	MINI-VOL-every six days	2012
7	KIN, Collage Commons		PM10	CCCL	ON	HI_VOL HI-VOL- every six days	2008
8	KIN, Rock Fort		PM10	CCCL	ON	HI_VOL HI-VOL- every six days	2008
9	KIN, Maritime Institute		PM10	CCCL	ON	HI_VOL HI-VOL- every six days	2008
10	KIN, Marcus Garvey Dr		SO2, NO2	JEP	ON	Continuous Analyzers- Chemiluminesene, fluorescence , BAM	2009
11	KIN, Garmex		SO2, NO2	JEP	ON	Continuous Analyzers- Chemiluminesene, fluorescence,BAM	2009
12	KIN, Garmex		SO2, NO2, PM10	JPSCO	ON	Continuous Analyzers- Chemiluminesene, fluorescence,BAM	2009
13	KIN, Petrojam		SO2, NO2, PM10	PET	ON	Continuous Analyzers- Chemiluminesene, fluorescence, BAM1020	2009
14	KIN, Bournemount Dr.		SO2, NO2, PM10	JPPC	ON	Continuous Analyzers- Chemiluminesene, fluorescence, BAM	2010
15	St. CAT, Terminal	Old Harbour Bay Area, St. Catherine	SO2, NO2, PM10	JPSCO	OFF	Continuous Analyzers- Chemiluminesene, fluorescence, BAM1020	2011
16	*St. CAT, Port Esquivel		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
17	*St. CAT, Port Esquivel		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
18	St. CAT, Bunting Prop.		PM10	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
19	St. CAT, Free Town		PM10	JBGL	ON	BAM1020- every six days	2011
20	St. CAT, Longville Park		SO2, NO2, PM10	JEP	ON	Continuous Analyzers- Chemiluminesene, fluorescence	2009
21	St. CAT, Lauder wood		SO2, NO2, , O3	JPSCO	ON	Continuous Analyzers- Chemiluminesene, fluorescence	2008

22	St. CAT, Longville Park		SO2, NO2, PM10	JEP	ON	Continuous Analyzers- Chemiluminesene, fluorescence , BAM1020	2011
23	St. CAT, Spring Village		SO2, PM10	JBGL	ON	Continuous Analyzers- fluorescence , BAM1020	2011
24	St. CAT, Orangefield	Northern St. Catherine	SO2,NO2,TSP	WIN	ON	HI_VOL HI-VOL- every six days, Continuous Analyzers- Chemiluminesene, fluorescence	post 2007
25	*St. CAT, Mud stacking		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
26	St. CAT, Hayfield Close		SO2,NO2,TSP	WIN	ON	HI_VOL HI-VOL- every six days Continuous Analyzers- Chemiluminesene, fluorescence ,	post 2007
27	St. CAT. Amity Hall		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
28	St. CAT, Brighton St.		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
29	St. CAT, Clapham		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
30	St. CAT, Faith's Pen		PM10	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
31	St. CAT, Hayfield Club		PM10	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
32	CLA, New Bowens	Vere plains, Clarendon	SO2, NO2, CO, PM10	JAM	ON	Continuous Analyzers- Chemiluminesene, fluorescence, EBAM	post 2007
33	CLA, Hayes Corn piece		SO2, NO2 CO, PM10	JAM	ON	Continuous Analyzers- Chemiluminesene, fluorescence, EBAM	post 2007
34	CLA, Kemps Hill		SO2, NO2	JAM	ON	Continuous Analyzers- Chemiluminesene, fluorescence	post 2007
35	*CLA, Rocky Point		TSP	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
36	MAN, Ballynure	South Eastern Manchester	PM10	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
37	MAN, Broadleaf		PM10	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
38	MAN, Windsor		PM10	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
39	MAN, Asia		PM10	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
40	MAN, Mile Gully	Northern Central Manchester	PM10	JAM	ON	HI_VOL HI-VOL- every six days	post 2007
41	MAN, Kendal		TSP SO2, NO2, CO	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
42	MAN, Kendal 2		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
43	MAN, Mud lake South		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
44	MAN, Mud lake East		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
45	*MAN, Mud lake West		TSP	WIN	ON	HI_VOL HI-VOL- every six days	post 2007
46	St. Elz, Lower Warminster	Southern St. Elizabeth	TSP	Alpart	ON	HI_VOL HI-VOL- every six days	2010
47	St. Elz, Brinkley		PM10	Alpart	ON	HI_VOL HI-VOL- every six days	post 2007
48	St. Elz, Steven Run		TSP	Alpart	ON	HI_VOL HI-VOL- every six days	2010

49	St. Elz, Myersville		TSP	Alpart	ON	HI_VOL HI-VOL- every six days	post 2007
50	St. Elz, Gazeland		TSP	Alpart	ON	HI_VOL HI-VOL- every six days	2010
51	St. Elz,Sports club		TSP	Alpart	ON	HI_VOL HI-VOL- every six days	post 2007
52	St. Jam, Bogue	Montego Bay	SO2, NO2	JPSCO	ON	Continuous Analyzers- Chemiluminesene, fluorescence	2009
53	St. ANN, Farm Town	North Eastern St. Ann	TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
54	St. ANN, Old Folly		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
55	St. ANN, Bengal		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
56	St. ANN, Queens Road		PM10	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
57	St. ANN, Clinic		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
58	St. ANN, Rousseau		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
59	St. ANN, Farm Town		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
60	St. ANN, Calderwood	South Central St. Ann	TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
61	St. ANN, Clydesdale		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007
62	St. ANN, Greens Hill		TSP	NOR	ON	HI_VOL HI-VOL- every six days	post 2007

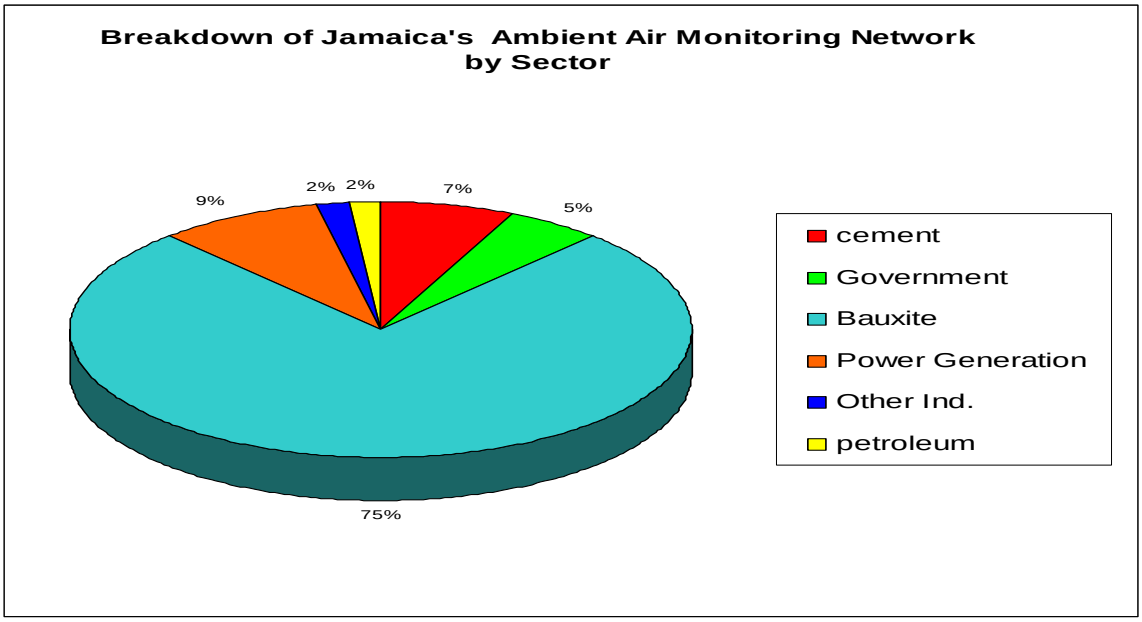
* Represent stations that are located within a facility's boundary of operation and are not technically defined as Ambient Monitoring Stations. Data from these stations are still reported to the Agency because they provide useful information. These stations are included in this report only for information and analysis and are not to be considered by the reader as ambient stations.

16 of 62 sites have analyzers for SO_2 and NO_x represents 26% of the network
3 of the 62 sites have CO analyzers representing 5% of the network
2 of the 62 sites have O_3 analyzers representing 3 % of the network
28 of the 62 sites have PM_{10} samplers representing 42% of the network
31 of the 62 sites have TSP samplers representing 50% of the network
57 of the 62 sites have PM (TSP&PM10) sampler's representing 92% of the network

Figure2-0 Map of Jamaica showing Ambient Monitoring Network

Jamaica currently has sixty two (62) monitoring stations spread across the island. Forty eight (48) of these stations are located outside of the Kingston and St. Andrew region. The Bauxite companies own and operate 44 of these stations which represent 91% of the ambient monitoring done in the parishes outside of the country's capital Kingston. Figure 2-1 shows the breakdown of the ambient monitoring network by sector in the country.

Figure 2-1: Chart Showing Breakdown of Jamaica's Ambient Monitoring Network by Sectors



2.1 Pollutants Monitored

Jamaica focuses directly on the ambient concentrations of Criteria Air Pollutants (CAP)[1]. These pollutants all have ambient air quality standards. Standards are reflected by time base averaging periods. Table 2 below is the current Jamaica Ambient Air Quality Standards (JAAQS).

Table 2-2: Ambient Air Quality Standards for Jamaica

Pollutant	Averaging Time	Standard (maximum concentration in ug/m³)
TSP	Annual 24h	60 150
PM_{10}	Annual 24h	50 150
Lead	Calendar Quarter	2
Sulphur Dioxide	Annual 24h 1h	80 primary, 60 secondary 365 primary, 280 secondary 700
Photochemical Oxidants (Ozone)	1h	235

99

[1] Criteria Air Pollutants are listed as Sulphur Dioxide (SO_2), Nitrogen Dioxides (NO_2), lead (Pb), Carbon Monoxide, Ozone, Total Suspended Particulate (TSP) and Particulate Matter less than 10 microns (PM_{10})

Carbon Monoxide	8h 1h	10,000 40,000
Nitrogen Dioxide	Annual 1h	100 400

Standards also have been set for a wide range of Priority Air Pollutants (POPs). A list of these POPs can be obtained from the Natural Resources Conservation Authority (Air Quality) Regulations, 2006. Although standards have been in place for these pollutants since 2006, the levels of most of these pollutants are yet to be quantified in the countries ambient air. Currently monitoring is only being undertaken for the CAPs with the exception of Lead. The CAPs being measured currently have been the main focus of monitoring because:

- These pollutants are the main emissions produced from the air pollution discharge sources existing in the Jamaica.
- The country's main energy source is oil which produces significant quantities of these pollutants
- Equipment and technology is more affordable and available to monitor these types of pollutants
- Air Dispersion models done for all the major industries in the country show these pollutants as having the greatest impact on the environment and the public

Table 2-1 shows the percentage of monitors currently equipped to monitor each type of pollutant. Figure 2-0 shows the location of these sites across the island.

2.2 Description of pollutants monitored in the current air monitoring network

PM_{10} or inhalable particulate matter is a composition of solid particles and semisolid particles released into the atmosphere with an aerodynamic diameter less than 10 micrometers. These particles have been proven to be small enough to enter a human's respiratory track and cause health impacts.

TSP or Total Suspended Particulates, these are particulate and aerosols that are in the range below 100 micrometer. TSP, while containing inhalable portions usually consist of larger particles and is mostly associated with nuisance. Large deposits on vegetation may lead to plant life being affected negatively.

Sulphur Dioxide (SO_2) this is a sulphur compound that is released mainly from the burning of fossil fuel. The release of this compound has been known to cause acid rain in some countries. Current scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms. These effects are particularly important for asthmatics at elevated ventilation rates (e.g., while exercising or playing.).

Nitrogen Dioxide (NO_2) this is a nitrogen compound that is release from combustion of fuel at high temperature. It is a suffocating, brownish gas, nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone (or smog). Current scientific evidence links short-term NO_2 exposures, ranging from

30 minutes to 24 hours, with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma.

Ozone (O_3) is tropospheric or ground level ozone is not released from a source but is formed from chemical reactions with compounds such as Nitrogen Oxides and Volatile Organic Compounds in the presence of sunlight. Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

Carbon Monoxide (CO) is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.

3.0 Ambient Air Quality Tracking and Analysis for 2012

3.1 Introduction

This section provides an analysis of the daily and annual trends recorded from the monitors which recorded data during 2012. Some of the monitor did not meet the required target of 75% data recovery during 2012; however, data which was validated from these stations is still used to make an analysis of the status of air quality in those locations. All graphs and statistical data are provided in Appendix B of the report. The data are discussed and related as best as possible to long term and short term impact of each pollutant on health and the environment. The data are discussed from an air shed stand point. These air sheds at present have no official boundaries but the similarities in sources that affect a certain area, its terrain; general wind pattern and network location is used to discuss the impacts and trends in this section. Not all locations are discussed in detail; the locations during 2012 that were significantly impacted based on the data and pollution incidents during the year are highlighted and discussed in detail.

3.2 Sulphur Dioxide data analysis 2012

Hourly trends for daily concentrations of Sulphur Dioxide (SO_2) recorded at the thirteen SO_2 monitoring stations that operated during 2012 did not show any exceedance of the 700ug/m^3 ambient standard. No exceedance of the 24 hour average ambient standard was recorded either. All data related to SO_2 trends and averages in presented graphically in Appendix A. The maximum daily average recorded from all monitoring stations was 194ug/m^3, recorded at the Rockfort Air Monitoring station located in the Bournemouth Community off Windward Road in Kingston. This site also recorded the highest annual average of 36.50ug/m^3. This community is heavily impacted by emission generated from two power plants which burn Heavy Fuel oil, as well as activity from ships in the Harbour and traffic. Overall the Kingston and St. Andrew SO_2 monitoring stations recorded the highest cumulative average of 24.30ug/m^3 from the 3 sites that operated during 2012. Figure 3-1 below shows that during 2012 the Kingston and St. Andrew Air shed received over 15000 MT of SO_x from the major industries in the country. There are seven such plants located in the city, along with numerous other minor sources of sulphur dioxide. Three of these facilities directly impact the Bournemouth community. It should be noted that only one ambient air monitoring station in the Kingston and St. Andrew area achieved the desired 75% data recovery. The other sites failed to achieve the target and hence the annual averages reflected in this report from these sites do not reflect the true average in 2012. However historical data from these ambient monitoring stations that did not achieve 75% data recovery indicate that that averages are in range with those recorded when 75% data was recovered. This comparison was done over the last five years hence not much is expected to have changed with respect to activities that might impact the monitoring station and meteorology.

Figure 3-1 Graph showing total SO_x emitted during 2012 in specific air sheds from major and significant sources

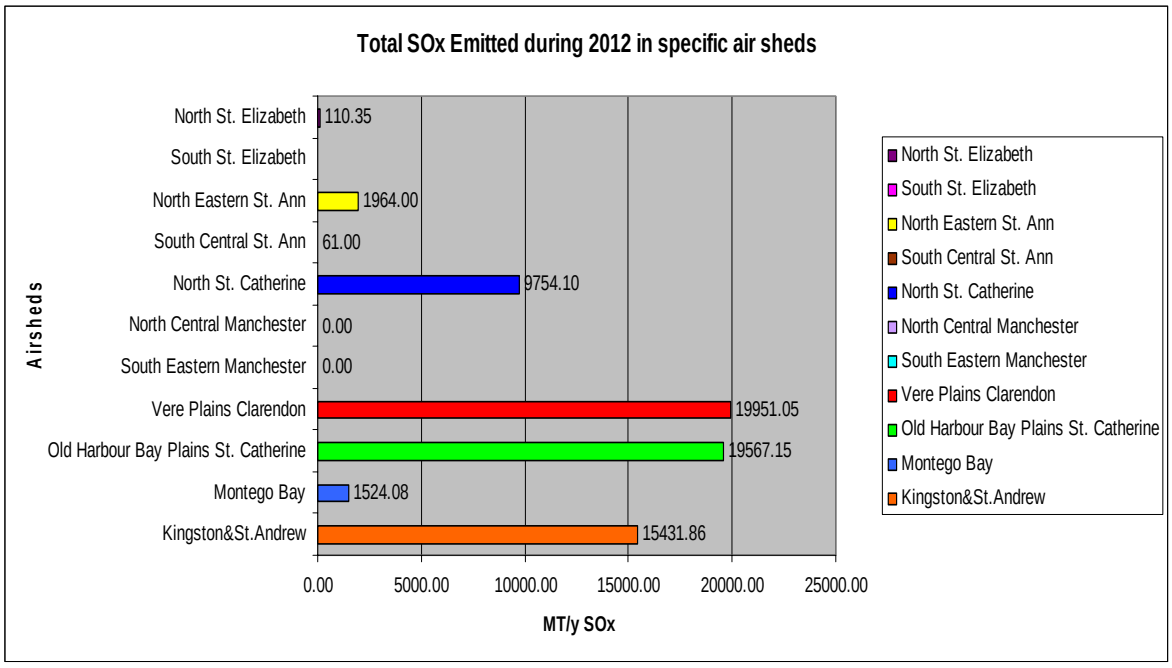
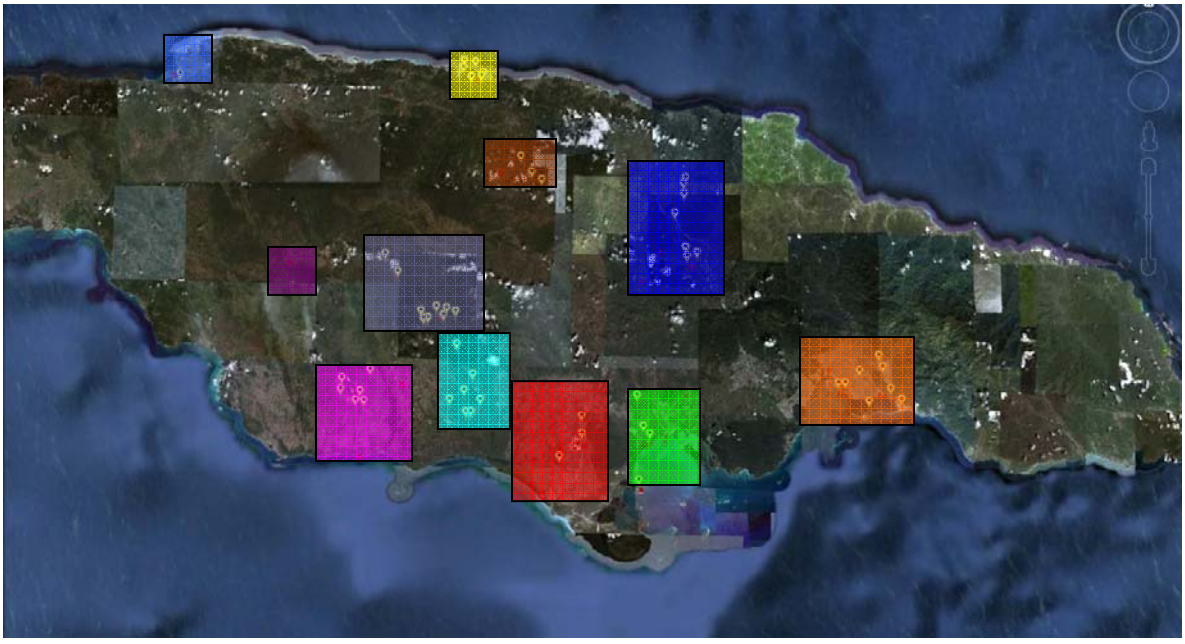


Figure 3-2 Map showing specific air sheds with monitoring network



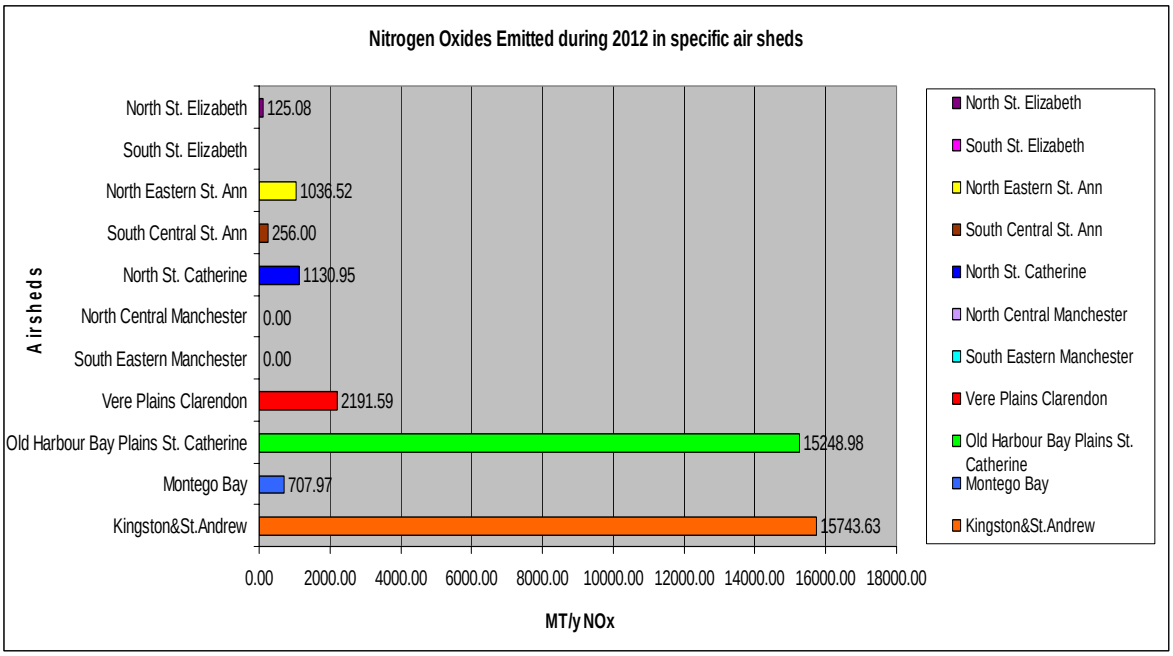
Data from ambient monitoring in the next two greatest receiving air sheds of Sulphur Dioxide the Vere Plains and Old Harbour Bay indicated a maximum annual average 22 and 24ug/m^3 respectively. The overall average for both areas was of 12ug/m^3 and 13ug/m^3 respectively. The maximum daily value of 81ug/m^3 was recorded in the Hayes Corn piece community located to the south of the Jamalco Alumina Refinery which burns Heavy Fuel Oil in their 5 industrial boilers and three rotary Kilns producing in excess of 18000MT/y of

SO_x. Although the amount of SO_x generated in this air shed appears to be more than the Kingston air shed, there are few minor sources or traffic emissions that create a Sulphur Dioxide impact on both air sheds. It may also be argued that both these air sheds allow greater movement of air because of the set back of the mountain terrain from the coast and the distance between these complex terrains. Kingston and St. Andrew on the other hand is surrounded by the mountains to the North and Eastern sides and the sea on the South. The wind is predominantly from the south east which moves in land towards the mountains. All the sources are located along the coast and so the predominant wind direction takes the fallout of Sulphur Dioxide and other emitted pollutants inland to the communities in the city

3.3 Nitrogen Dioxide data analysis 2012

The country recorded no exceedance of the Nitrogen Dioxide JAAQS during 2012 for either the hourly average concentration or annual average concentrations of 400ug/m^3 and 100ug/m^3 respectively. Trends in Nitrogen Dioxide emissions were reasonably steady.

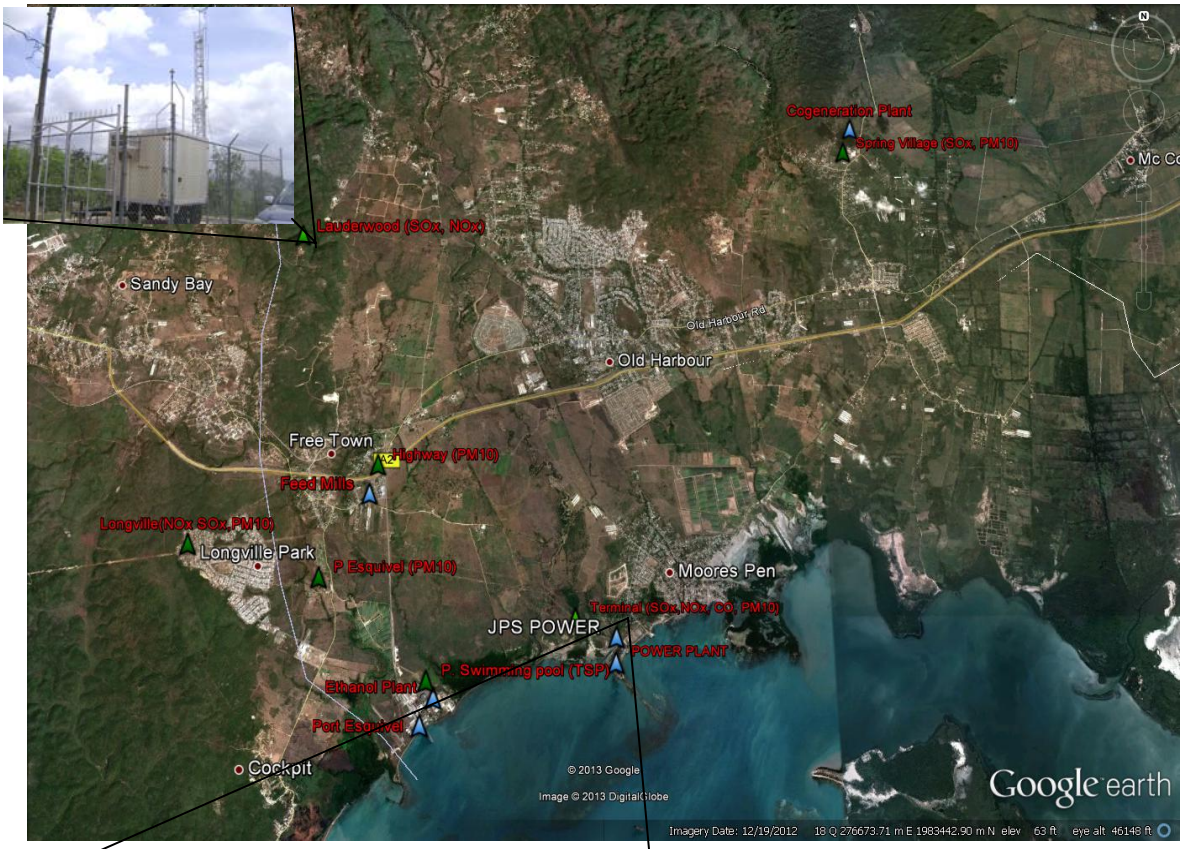
Figure 3-3 Graph showing total NO_x emitted during 2012 in specific air sheds from major and significant sources



The KMA and the Old Harbour Bay air shed received the majority of the emissions due to the location of the majority of the islands' power production plants in these two areas. The data gathered in 2012 on emissions released from the major industry shows that Kingston and St. Andrew and Old Harbour Bay receive over 90% of the total Nitrogen Dioxide released. This is a result of the presence of major power production plants which burn heavy fuel oil. This fact would remain the same if emission data from the transport sector were included as these two air sheds are heavily trafficked areas as well. Ambient air monitoring stations located in these two air sheds recorded the highest annual averages for the year 2012. Longville station located in the Old Harbour Bay air shed recorded the highest annual

average of 29ug/m^3. This station is located in the Longville community down wind approximately 6Km North West of two major power plants. The data from this location as well as the Lauder wood site indicate that Nitrogen Dioxide is not a threat to health or environment in the Old Harbour Bay Air shed.

Figure 3-4 Map showing Old Harbour Bay



Picture of Two Power Plant's Emissions blowing towards Old Harbour Bay communities on a typical day

MAP LEGEND

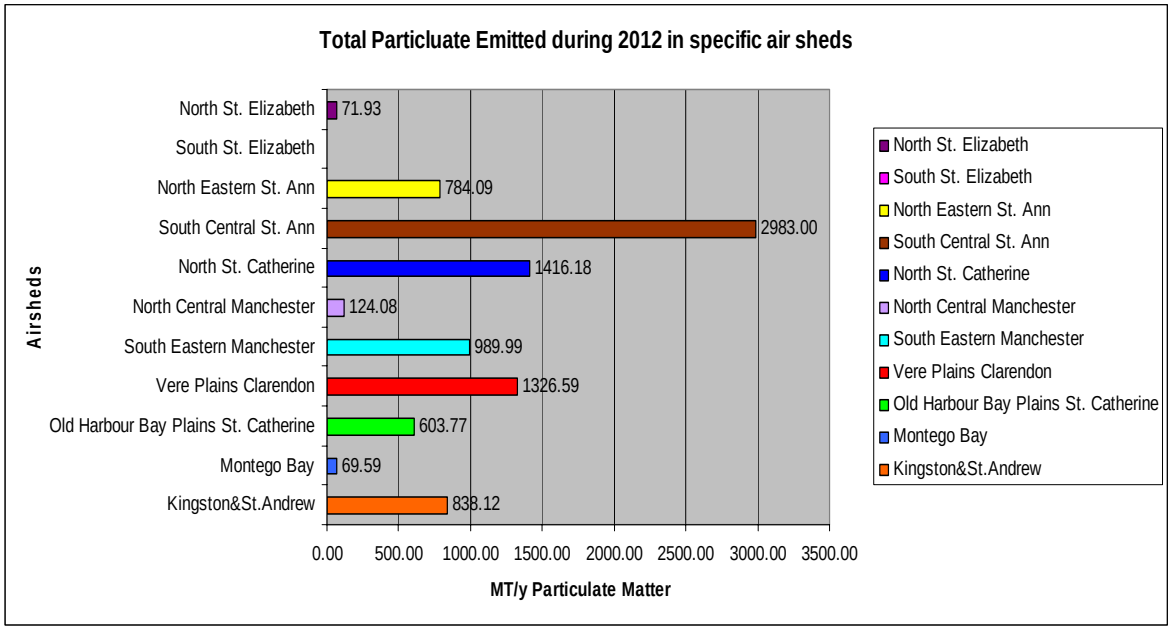
Air monitoring sites

Air Pollution Sources

3.4 Particulate Matter less than 10 micrometers (PM_{10}) data analysis 2012

PM_{10} or inhalable particulate matter is a composition of solid particles and semisolid particles released into the atmosphere with an aerodynamic diameter less than 10 micrometers. These particles have been proven to be small enough to enter a human's respiratory track and cause health impacts. In 1996 Jamaica gazzetted ambient air quality standards and PM_{10} was given a daily average standard of a 150ug/m^3 and an annual standard of 50ug/m^3. Since 2006 the National Environment and Planning Agency has been tracking the levels of this pollutant in the atmosphere. Since 2009 some of the major private industry which emits this form of pollutant have received air pollutant discharge licenses and are required to monitor in ambient air for this pollutant. Most of these monitors have been strategically placed to measure the impacts of this pollutant on public health, the environment, the community and the measure compliance with the ambient air quality standards. Below in Figure 3 it shows the level of Particulate Matter emitted during 2011 in the sections of the island that the major sources exist. The ambient data showed that despite South central St. Ann recording the highest release of Particulate Matter, the highest concentrations in ambient air of fine particulate (PM_{10}) was not recorded in this area. One main reason for this may be that South Central St. Ann is impacted specifically from bauxite Mining and Hauling activities, which release heavy particulates (TSP) and not so much fine particulate matter in great quantities. Heavy particulate is mostly associated with nuisance complaints which are received usually from the communities in these areas that are impacted by the activity. This will be elaborated on in the Total Suspended Solid (TSP) discussion section

Figure 3-5: Graph showing releases of Particulate matter by air shed in Jamaica 2012

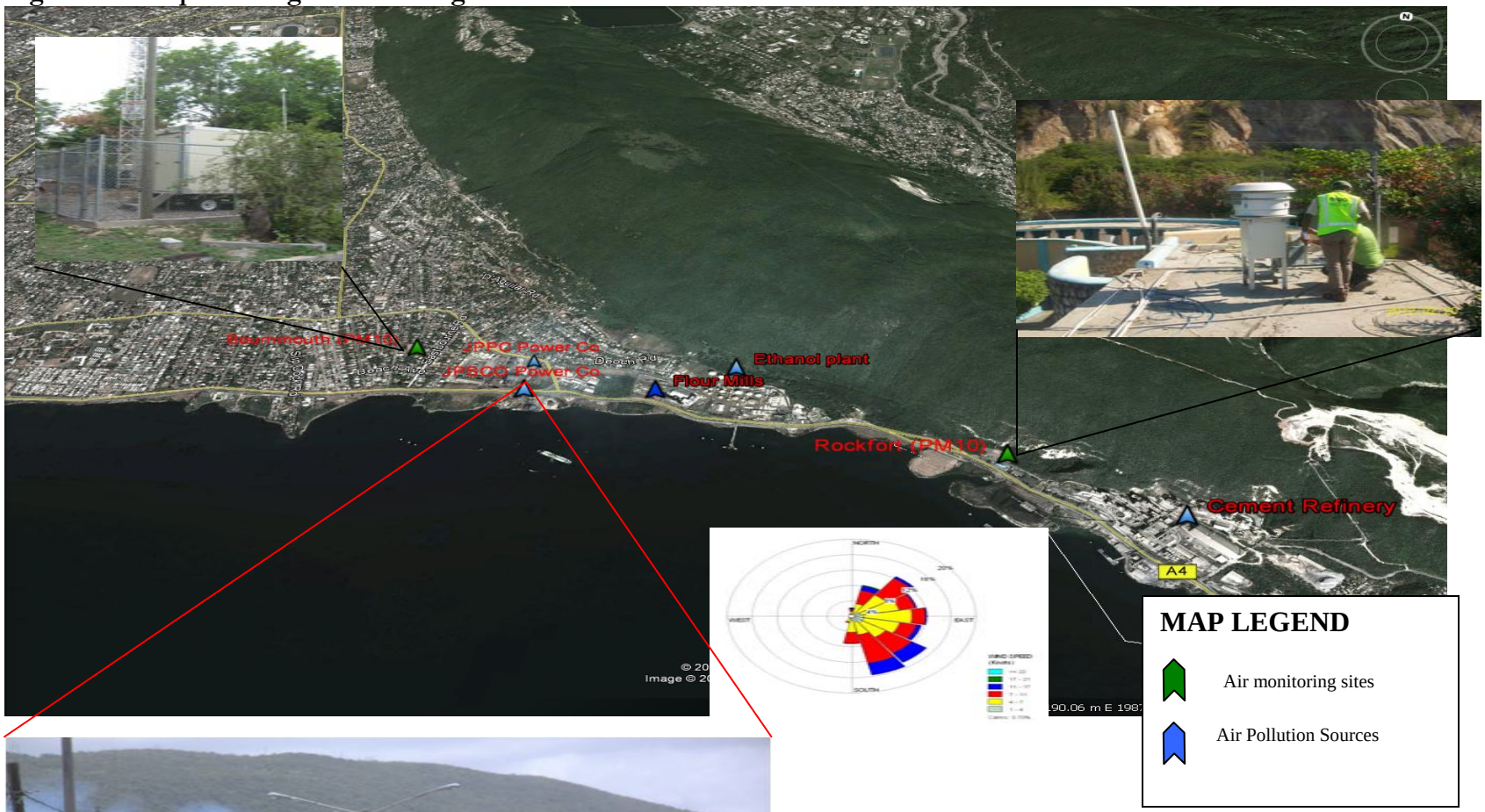


The analysis of the ambient data has revealed that PM_{10} average 24 hour concentrations exceeded the Jamaica Ambient Air Quality Standards (JAAQS) on seven occasions during the period January 1 2012 to December 31 2012. Six of the seven exceedances occurred in the Kingston and St. Andrew zone. These occurred at five of the six locations monitored in

this zone. Only one site exceeded twice, the Rock Fort Mineral Spa. This location is heavily impacted by the Cement Factory located immediately to the east of the site. The location also recorded the year's highest 24 hour average of 348ug/m^3. A second monitoring station (Bournemouth, Rockfort) located approximately 2 Km east of Rockfort Mineral Spa site also recorded a 24 hour breach during the year. Despite both 24 hour trends following similar patterns which suggest that PM_{10} impacts are from similar sources, the exceedance detected at the Bournemouth site was unrelated as data from the Rockfort Spa did not indicate a spike on this day. The Bournemouth community practices a lot of open burning and its community roads near the site were being repair with marl. It is suspected that the combination of both practices along with the continued impact of the surrounding industry on that day contributed to the exceedance. The Rock Fort area is heavily impacted by particulate matter from four major facilities, as well as traffic, a bus station depot, ships in the Harbour, domestic practices, pour road surfaces and other minor sources. The data during 2012 from the two PM_{10} station located in this area suggest that it is heavily impacted by this type of pollutant. Both monitoring locations also exceeded the annual average concentrations for PM_{10} which suggest that the community maybe experiencing long term impact from PM_{10} inhalation. Two major power producing facilities which burn bunker C Oil and One 2000ton/day Cement plant is located in the area.

The community of Bournemouth and other communities along Windward Road and in the Rockfort area maybe exposed on a daily basis to PM_{10} concentrations that exceed the national standard as the predominant wind direction is to the North West placing these communities down wind of the major PM_{10} emitting sources.

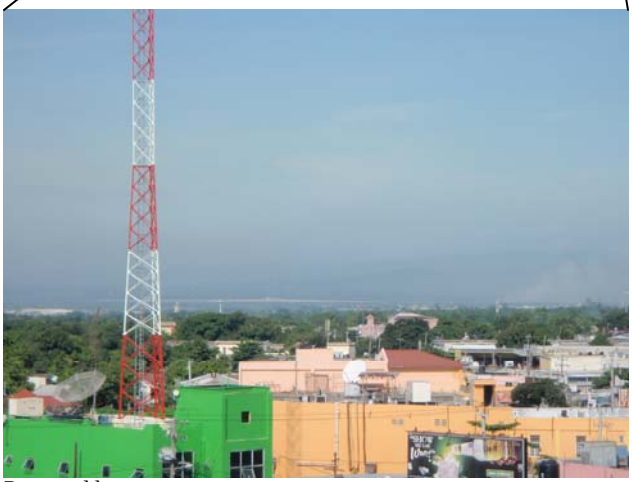
Figure 3-6: Map showing Eastern Kingston



Picture of Two Power Plant's Emissions blowing towards Rockfort communities on a typical day in the background is Flour Mills and Cement Refinery

Two other locations in the Kingston, St. Andrew and Portmore area which recorded a daily exceedance of the 24 hour standard were Washington Gardens and Portmore (Waterford Community). These two sites did not achieve 75% data recovery for 2012 but from the data gathered the annual average was above the 50ug/m^3 JAAQS. These two locations were established because of a major fire on February 2012 at the solid waste disposal site located in Riverton City, Kingston. Outside of this period their have been three other fires from the disposal site that all correspond with spikes in the data collected at these locations. The communities of Washington Gardens, along Spanish town road and eastern Portmore are impacted significantly by the activities at the disposal site; illicit burning in the Riverton City community, high traffic corridors and Cane Field burning. All of these activities release uncontrolled PM_{10} which is not captured from the emissions estimates in Figure 3-5. These areas are highly populated and the PM_{10} data gathered to date suggest that this pollutant may cause a serious long term health impact if these activities are allowed to go unabated.

Figure3-7: Map showing north western Kingston and St. Andrew and northern Portmore



Picture of Haze created over this section of the city by Burning at the solid waste disposal site on February 2013

MAP LEGEND

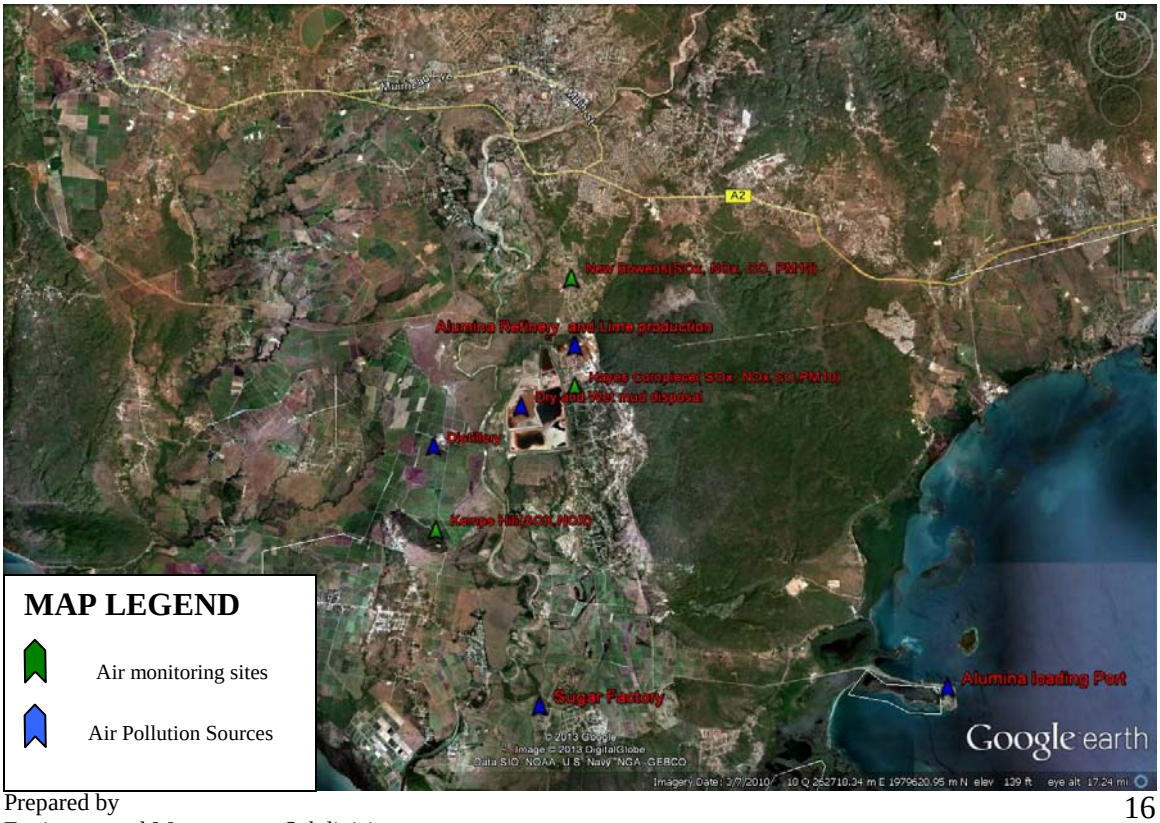
Air monitoring sites

Air Pollution Sources

Only two other monitoring stations recorded a 24 hour exceedance during the year. These stations are located in Kendal, in the Central and North Manchester air shed and in Spring Village in the Old Harbour Bay, St. Catherine air shed. The Kendal site is impacted by a 300Ha bauxite Refinery dry mud disposal area as well as numerous deteriorating mining haul roads while the Spring Village site is impacted by a cogeneration facility. It is suspected that the Spring Village single exceedance occurred as a result of bush fires which occur regular in the dry periods in that area.

The Kendal North Manchester monitoring location and the Hayes Corn Piece monitoring site located on the Vere Plains in Clarendon are the only locations outside of Kingston, St. Andrew and Portmore which averaged above the annual JAAQS of 50ug/m^3 in 2012. One of these monitoring locations is on the Vere Plains in Clarendon. This station which records PM_{10} continuously using Beta Attenuation technology is located in a community less than 1Km south from the boundary of a 1.3 million MT/y alumina refinery and a supporting lime production plant. To the west of the community is the refinery's mud storage facility which stores both wet and dry mud. The community is heavily impacted by the operations of the facility and the annual average concentration of 51ug/m^3 measured by an EBAM located at a school yard in the community in 2012 indicates that PM_{10} levels have exceeded the annual JAAQS and the community may be at a high level of exposure risk to long term impacts from this type of air pollutant.

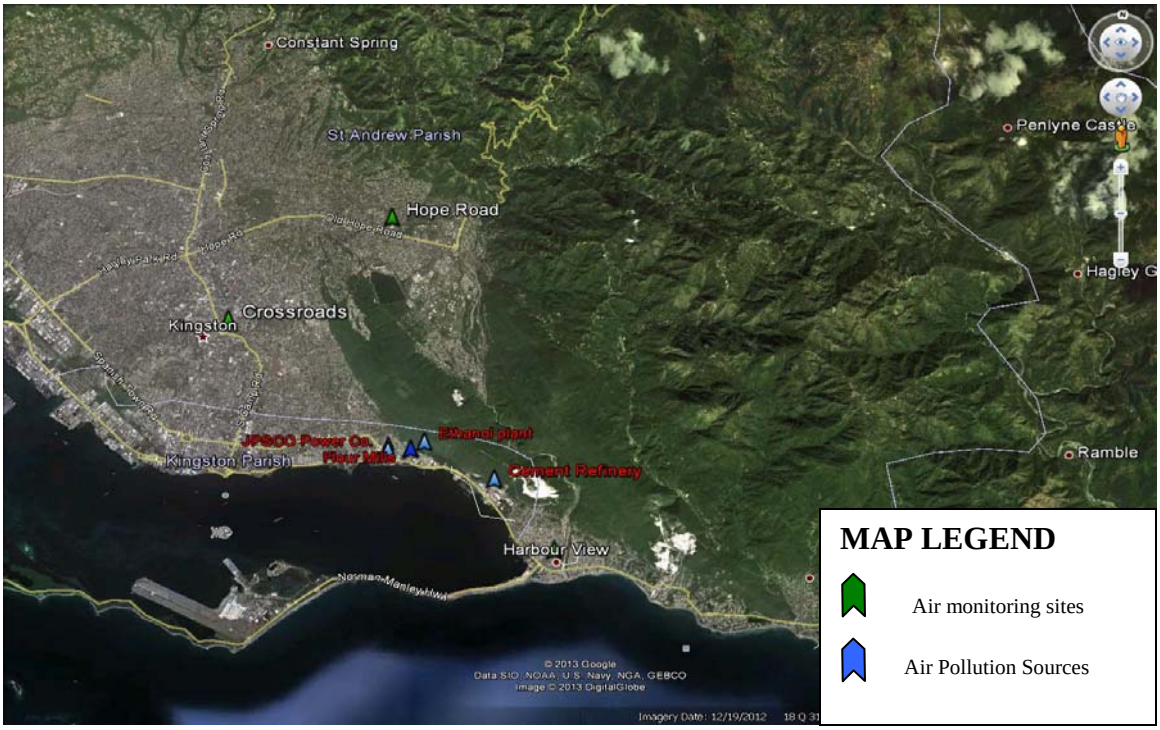
Figure 3-8 Map showing Vere Plains Clarendon



3.5 Total Suspended Particulate (TSP) data analysis 2012

TSP is particulate matter with aerodynamic diameter less than 100 micrometers. During 2012 thirty locations spread across five parishes were monitored for this pollutant. This type of particulate is not necessarily of great impact on health because it is not know known to be inhalable or respirable. However when TSP is sampled it may contain smaller particles such as PM_{10} and $PM_{2.5}$ which forms the composite and these may cause impact on health. TSP is monitored in Jamaica in two general areas Kingston and St. Andrew and the bauxite mining areas. During 2012 the country experienced twelve recorded exceedance of the 24 hour JQAAS. These all occurred within the Kingston and St. Andrew air shed and the northern St. Catherine air shed. The five exceedances in the Kingston Metropolitan Area (KMA) occurred at all three locations monitored. Within the exception of one day all the exceedances occurred at different times during the year suggesting that they were localized events leading to the exceedances. The one exception in March 2012 showed an exceedance at both the Harbour View and Old Hope Road monitoring sites. The Agency was not able to identify if both were related as the sites are not impacted by similar sources and are separated by complex terrain.

Figure 3-9 Map showing TSP network eastern Kingston

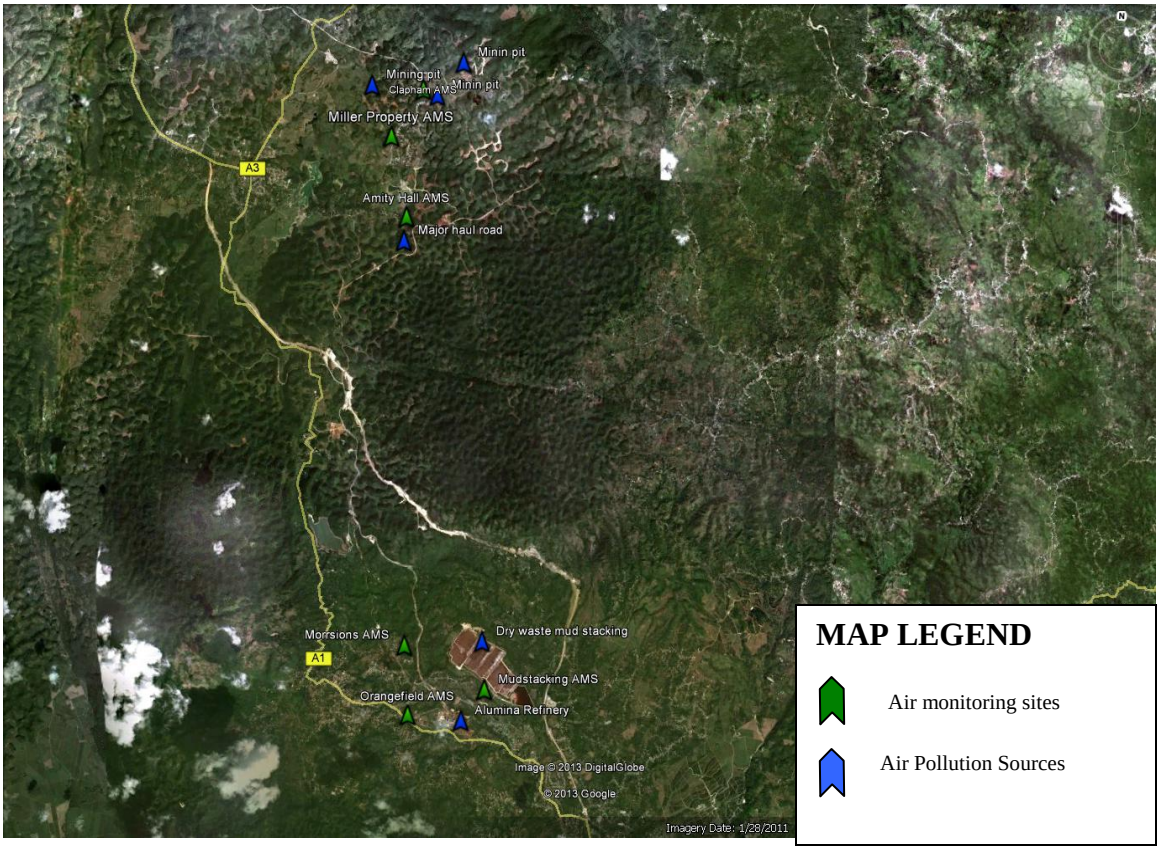


A possible source of TSP that both locations are downwind from would be a wild fire along the hill sides surrounding the city and there were no records of such an incident during this particular day in March. The location in Crossroads is heavily trafficked and has an open unpaved lot used for parking in close proximity to it. It is also located downwind of most of the major sources of air emissions along the rim of the Kingston Harbour. All these factors combined has released 2 more exceedance of the 24 hour JAAQS from the zero exceedances

recorded in 2011 and an exceedance in the annual average concentration which is and has been above the JAAQS of 60ug/m^3 for the past two years. The annual average recorded at this location is 79ug/m^3 which is second highest recorded in the country.

The other seven remaining breaches of the 24 hour JAAQS took place in the Bauxite mining communities in Northern St. Catherine. These monitoring locations are heavily impacted by dust emissions from mining, trucking, unpaved haul roads and dry mud storage areas. Five of the seven exceedances occurred at the mud stacking location. This site has been recording approximately five exceedances of the 24 hour JAAQS each year and has averaged above the annual JAAQS for the past three years. This location continues to be heavily impacted by the mud stacking activities at the major bauxite mining and refining company in the area. The monitor is located close to roads that are used by heavy trucks to access the haul roads to transport material. These road surfaces are not in good condition so dusting is a regular occurrence. The two other locations that exceeded the 24 hour JAAQS on one occasion each are located approximately 120-150 meters from the major haul road. These two locations did not record an exceedance of the annual JAAQS but averaged higher relative to 2010.

Figure 3-10 map showing network in northern St. Catherine



None of the remaining locations recorded any breaches of the 24 hour or annual JAAQS. A few nuisance complaints were received from the north eastern St. Ann air shed, the South St. Central St. Ann area and the South St. Elizabeth area. These were all related to dusting from bauxite waste mud storage or mining activities. Only one reported incident resulted in minor medical treatment. The data generally indicates that the areas being monitored are above the estimated background of 20ug/m^3 provided in 2006. All 30 locations recorded annual average concentrations above 25ug/m_3. This statistic is comparable with 2011 and 2012 showed thirteen (13) 24 hour JAAQS exceedances, six (6) more than was recorded in 2011.

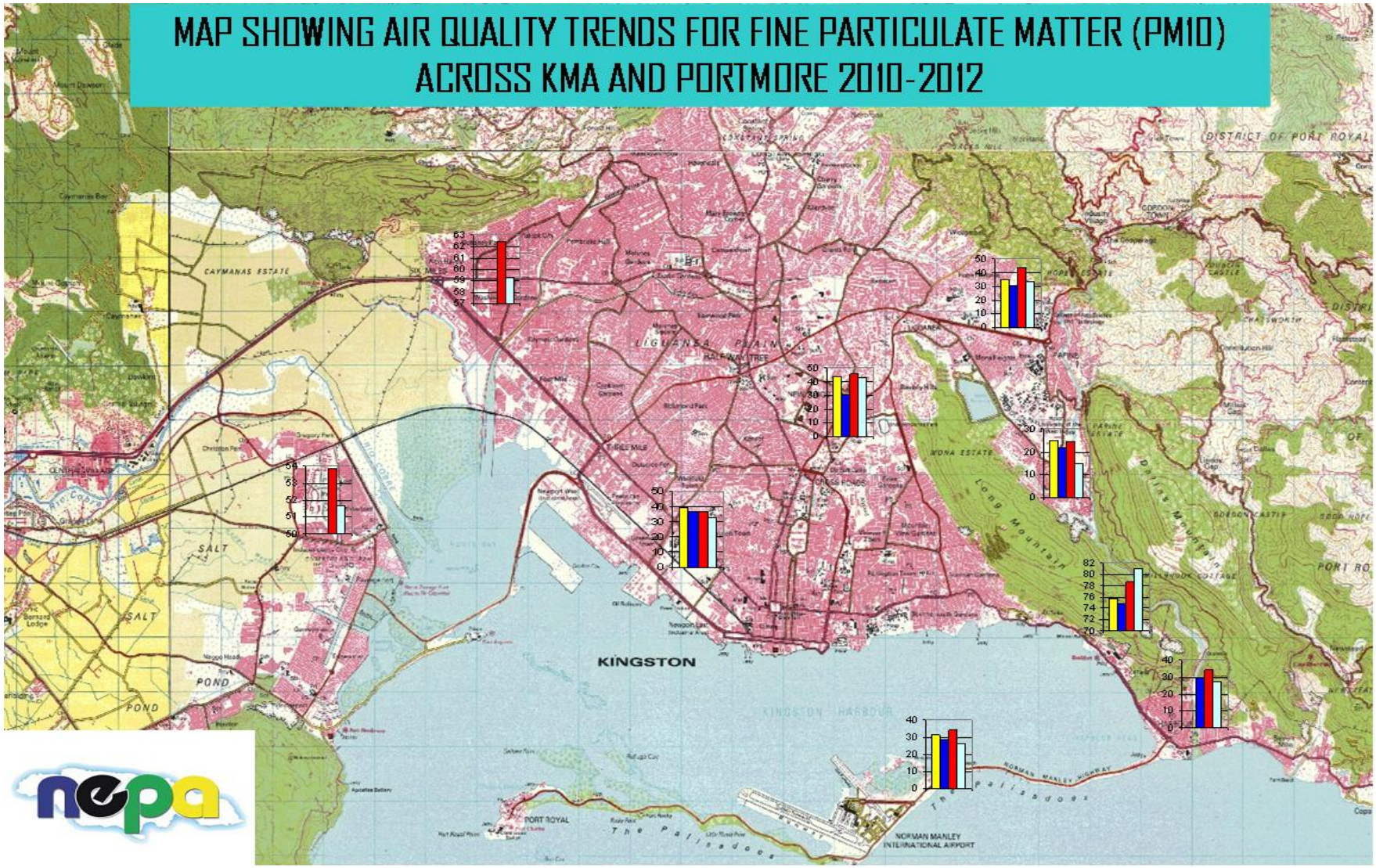
3.6 Ozone data analysis 2012

Ozone (O_3) exists in two forms stratospheric ozone which is the most familiar ozone forms the ozone layer which aid in protecting the earth from the sun's rays. Tropospheric or ground level ozone is formed when Nitrogen Oxides and Volatile Organic Compounds react in heat provided by sunlight. This ozone is dangerous to health and it aids in the formation of smog. O_3 was monitored during 2012 at two locations in the Old Harbour Bay air shed St. Catherine and Kingston and St. Andrew. The Old Harbour Bay ambient monitoring station has been in existence since 2009. The Kingston and St. Andrew location was commissioned in 2012. Both locations are privately owned and operated. The data gathered indicates that there were 14 exceedances of the 1 hour JAAQS recorded at the Kingston and St. Andrew AMS during 2012. No exceedance was recorded at the Old Harbour Bay AMS. The exceedances all occurred during June, July and August. The July and August exceedances occurred on consecutive days. This period is the summer season for the country and temperatures during the day time are in low to high 90 F. This location is also heavily impacted by release of NO_x and VOC from fuel burning activities by two major power plants. These factors may have contributed to the 1 hour JAAQS exceedance; however, Ozone is a pollutant that can be formed from biogenic sources and also originate from pollutants released from very distant sources, hence the contribution to its formation from these local sources could be minimal. The Old Harbour Bay site recorded no exceedance of the 24 hour JAAQS. The annual average for each location was approximately 12ug/m^3 for Old Harbour Bay and 27ug/m^3 for Kingston and St. Andrew. Jamaica has no national standard for annual ozone and annual standards are not a feature of most jurisdictions.

3.7 Carbon Monoxide data analysis 2012

At present and during 2012 only two locations monitored for Carbon Monoxide. The two sites are located on the Vere Plains in Clarendon. Carbon Monoxide is a gas that is produced from the incomplete combustion of fuel. The locations monitored indicated no breach of the JAAQS for 1 hour and 8 hour average concentrations during the year. This is similar to the results of monitoring the previous two years.

4.0 Ambient Air Quality Annual Trends Analysis for 2009-2012



4.1 Sulphur Dioxide annual trends 2010-2012

In the Kingston and St. Andrew region there was an increase in the average annual ambient concentration over 2011 at both Sulphur Dioxide SO_2 monitoring sites that have recorded data since 2009 (see appendices B). The two stations located at Garmex facility along Marcus Garvey Drive (Garmex) and Greenwich Farm beach (Petro) are both continuous ambient monitoring stations that use Thermo Scientific instruments to record SO_2 concentrations continuously. The method of analysis utilized by the instruments is Florescence. The instruments method of analysis is a NRCA recognized method of monitoring for SO_2 in ambient air. Both air inlets are within the 10 meter requirement for the data gathered to be used to determine impacts on both health and environment. Both stations are also within the fallout impact zones of major SO_2 producing industry and so also serve to monitor compliance. Both stations are operated by private industry and are audited and the data is validated by NEPA. The graphical data indicating annual trends is displayed in Appendix B. The data shows a 12% and 26% increase in the ambient concentrations. These increases may be due to a number of minor activities as well as the increased output from the major sources in the air shed. This will be confirmed after the 2012 emissions data is compiled. The 2012 concentrations are still below the NAAQS for annual averages hence communities close to these monitoring stations and down wind of these sites should not be experiencing any chronic health impacts from the exposure to SO_2. The ecosystems in these locations should also experience little long term impact from this air pollutant. After five years of data the analysis will be made to determine establishing background levels for this pollutant in this air shed. The trends are very similar for all the locations that have historical data for SO_2. No recorded breaches were observed and all sites with the exception of Kendal showed a slight increase in annual average concentration for SO_2.

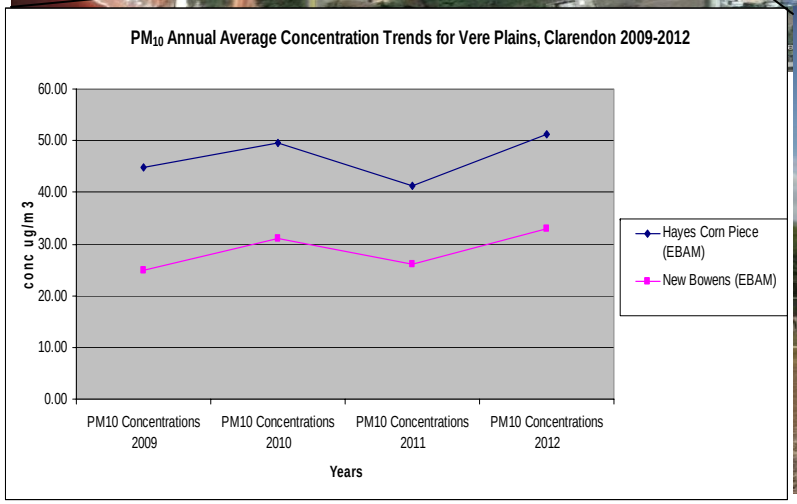
4.2 Nitrogen Dioxide trends 2010-2012

The KMA experienced a slight increase in the annual average NO_2 at both locations monitored during 2012 (see appendices B). The value increased by maximum 10% over 2011. The average**s** are well below the JAAQS of 100ug/m^3. The trend in the KMA has indicated that NOx levels continue to rise each year at the Garmex monitoring station. In Montego Bay at the Bogue site NOx levels have remain consistent for the past two years. For the rest of the country the trend is similar with slight increases in the concentration of NO_2 over the past three years. The Kendal monitoring station which is no longer being impacted by the Alumina Refinery has remained consistent. All sites recorded averages over the past three years below the JAAQS. From the data gathered over the past three years at the locations monitored across the country it is not expected that the country's population or natural environment is threatened by the presence of NO_2 in ambient air. Although at the locations where NO_2 producing activities continue a slight increase is observed in the annual average concentration, concentrations still remain well below the JAAQS which is set to protect the environment and human health from acute health impacts associated with exposure to Nitrogen Dioxide.

4.3 Particulate Matter trends 2009-2012

Fine particulates PM_{10} continue to be a major concern for the Kingston and St. Andrew air shed. All locations monitored during the last three years have shown steady increase (see appendices B). This fact highlights the level of pollutant loading that continues to increase in this air shed from the various activities and sources located in the area. The air shed excluding Portmore has a population of over 500,000 residents who are exposed on a daily basis to unsafe levels of PM_{10}. The trends were similar at the locations monitored in the six other sections of the country highlighted in this report The Hayes Corn Piece monitoring station which averaged in the high to low 40s since 2009 exceeded the $50ug/m^3$ JAAQS mark in 2012. This site is of great concern to the Agency as it is not only located at a school in the community but it is located in close proximity to an alumina refinery. The data gathered at this location for the last four years indicates that the persons who are exposed to this level of continuous pollution faces serious threat of long term impact from PM_{10}

Figure 4-1Hayes Corn Piece PM10 monitoring site using EBAM technology to record data continuously



5.0 Data Quality

Quality assurance and quality control has been a main focus of the Agency during 2012. Over 50% of the networks monitoring stations were audited by the Agency during the year as part of the QA/QC. Data received from the sites undergo all four stages of data validation to ensure data quality is kept at optimum. All data received from both gases and particulates undergo similar data validation exercises. Data recovery increased from an average of 61% in 2011 to 73% in 2012. This is mainly because of quality assurance and quality control procedures being one of the main focuses. Both Particulate data sets (TSP and PM_{10}) surpassed the 75% recovery mark which is the bench mark for the Agency to provide true annual average concentrations as each location. Data and gases showed an improvement to 66% up from 40%.

Quality Control and Quality Assurance is a requirement under the Natural Resources Conservation Authority (Air Quality) Regulations 2006. This document outlines reference methods in Schedule 15, Regulation 35. These methods are all Title 40, Code of Federal Regulations Part 50 Appendices A-G methods. Each method has its individual allowable confidence limit. This confident limit is maintained by practicing the appropriate QA/QC

The following documents are utilized to ensure adequate QA:

- QA Handbook for Air Pollution Measurement Systems: "Volume I: A Field Guide to Environmental Quality Assurance," EPA-600/R-94/038a, April 1994
- QA Handbook for Air Pollution Measurement Systems: "Volume II: Ambient Air Quality Monitoring Program" EPA-454/B-13-003, May 2013

Procedures outlined in these handbooks are used to ensure the all field and laboratory procedures undergo the necessary quality assurance to ensure accuracy and precision of results

All equipment used is consistent with the Schedule 14 Regulation 35 of the NRCA Air Quality Regulations 2006. This section of regulations outlines the minimum specifications for ambient air monitoring equipment used in the network to monitor for criteria pollutants

6.0 Summary

From the data collected in 2012, the country continues to experience low impact from Nitrogen Dioxide, Sulphur Dioxide and Carbon Monoxide as there was no breach of the JAAQS recorded. Despite both SO_2 and NO_2 accounting for over 90% of the emissions produced in the country from major industry, both have not materialized as major contaminants in ambient air. It is suspected that the main reason for this is the dispersion from the major sources due to the relatively tall stacks and the limit placed on sulphur content in fuel oil by the NRCA Air Quality Regulations 2006, stack targets and standards (schedule 10&11).

Ozone data which was compiled in 2012 for the first time will continue to be tracked during 2013. Although 14 breaches of the 1 hour JAAQS was observed during 2012 the Agency requires more data to inform the country on the current status of the air in relation to tropospheric (ground level) ozone.

Data quality and recovery improved to average of 65% over a low of 45% in 2011. This enhanced the level of assessment that was possible by the Agency and continued technical training during 2012 and 2013 will see the continued increase in data recovery and quality

The country has seen an overall increase in the levels of particulate matter present in ambient air during 2012. There has been an increase in the number of exceedances of both the daily JAAQS and the annual JAAQS. Breaches of the daily standards increased from 17 to 19 and annual breaches increased from 3 to 8. These increases are for the combined TSP and PM_{10} monitoring stations. Interventions will have to be made in those air sheds that have been identified by the current monitoring as compromised. Hayes Corn Piece Clarendon and the Rockfort Kingston are two locations that will have to be thoroughly assessed during 2013 and recommendations made for possible mitigations against the air emissions producing activities in those locations.

7.0 State Response

If Jamaica is to realize its goal of clean air by 2030[2], improvements and effective programmes have to be put in place to reduce the impact being created by the sources outlined in the in this report. Greater vigilance and enforcing of the various laws outside of the NRCA Air Quality Regulations must to be carried out. Regulations for vehicle emissions and vehicle emissions testing should be put in place. More campaigns against open burning and a crack down on illicit activity that create particulate emissions must be pursued.

The Agency has begun to improve its monitoring of the country by securing funding to purchase additional and more improved air monitoring devices. During 2012 data recovery overall for PM_{10} and TSP improved to about an average 85% up from 2011's average 72%. The additional equipment will further enhance the recovery and data quality results as well as offer more coverage to assess more sections of the country.

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[2] Vision Jamaica 2030- National development Plan

The Air Quality Management Programme is in its third year of implementation and has realized most of the objectives thus far which are a lined with the goal of clean air. The most significant of which is the raising of public awareness. During 2012 the reports of air pollution incidents and episodes from the public has increased. There is now greater vigilance from the general public and concern about air pollution and how it impacts the health of our nation and the environment. The programme will continue to implement the various strategies and make adjustments where necessary to accommodate new strategies and new technology.

As part of the programme the Agency has been offering a number of technical training courses and public awareness activities to improve the air quality management of both the source polluters and the impacted. During 2012 the Agency trained over a 140 persons in visual emissions observations and ambient air quality data validation. It launched a campaign against open burning and collaborated with the various stakeholders to encourage the nation to refrain from this activity. It also encouraged the Ministry of Transport to adapt the draft 2003 vehicular emissions standard as part of their revised act and include emission testing as a requirement for vehicle fitness certification. The Agency continued to improve its own and government stakeholder capacity by training of its technical staff in key technical areas of air quality management. These efforts will continue during 2013 along with the updating of the current NRCA Air Quality Regulations 2006 and the guideline document for ambient air quality monitoring, air dispersion modeling and emissions generation.

During 2013 the Agency will be focusing on some key areas of air quality concern and developing references and implementing special air quality assessments in these areas to provide technical recommendations for the mitigation of activities that are resulting in bad air quality. The Agency has also developed an Urban Exposure Air Quality Monitoring Plan which will see procurement of air monitoring devices to be placed in six urban centers across the island over the next 3 years. This plan allows will allow the Agency to confidently assess the country's most populated areas and provide information beneficial to the protection of public health.

APPENDICES A
Annual data Daily and Annual Average Trends

Figure 1A: Graph showing 24 hour average TSP concentrations at all monitoring stations in the Kingston and St. Andrew area for 2012

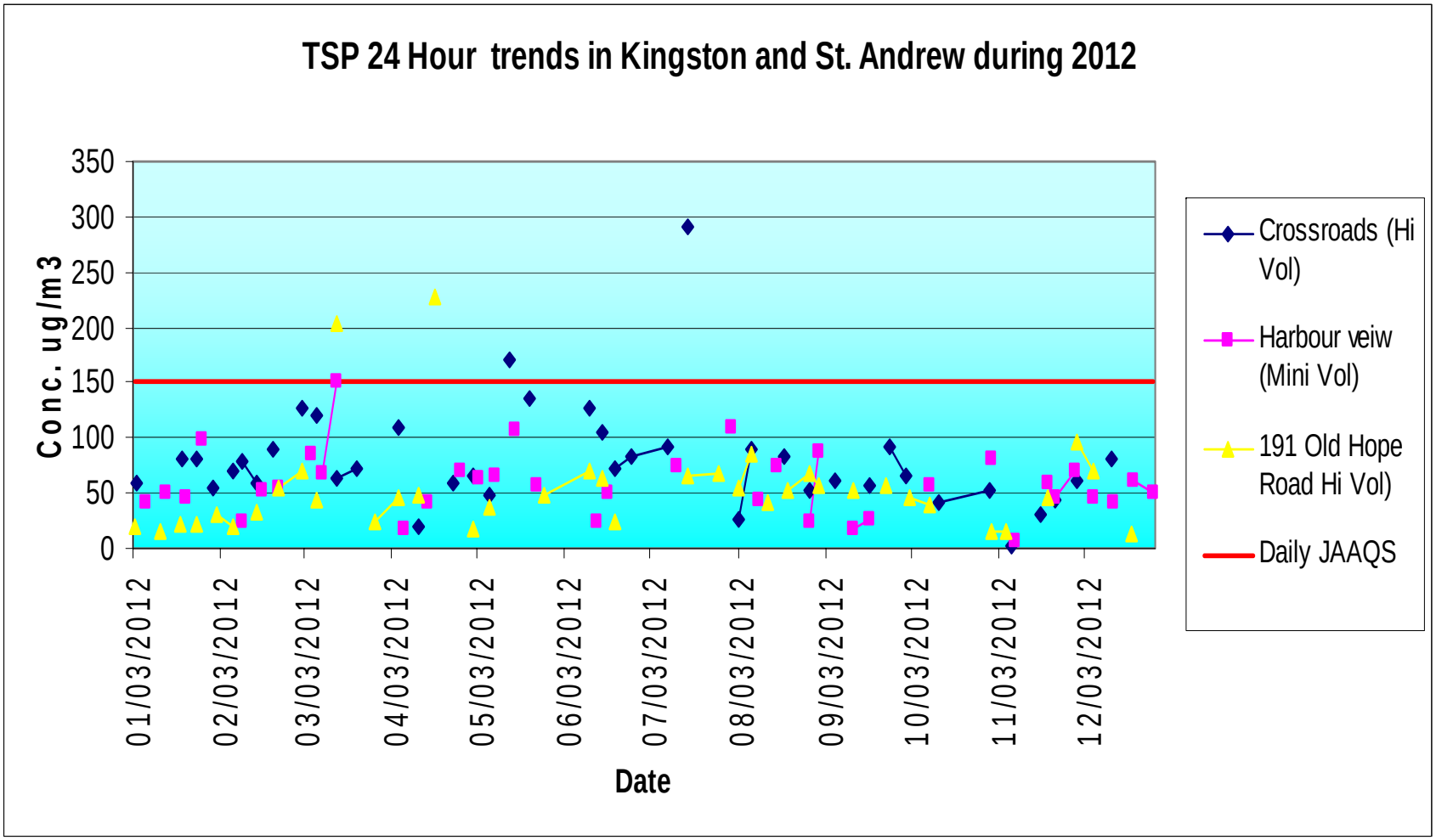


Figure 2A: Graph showing Annual TSP average concentrations at all monitoring stations in Kingston and St. Andrew area for 2012

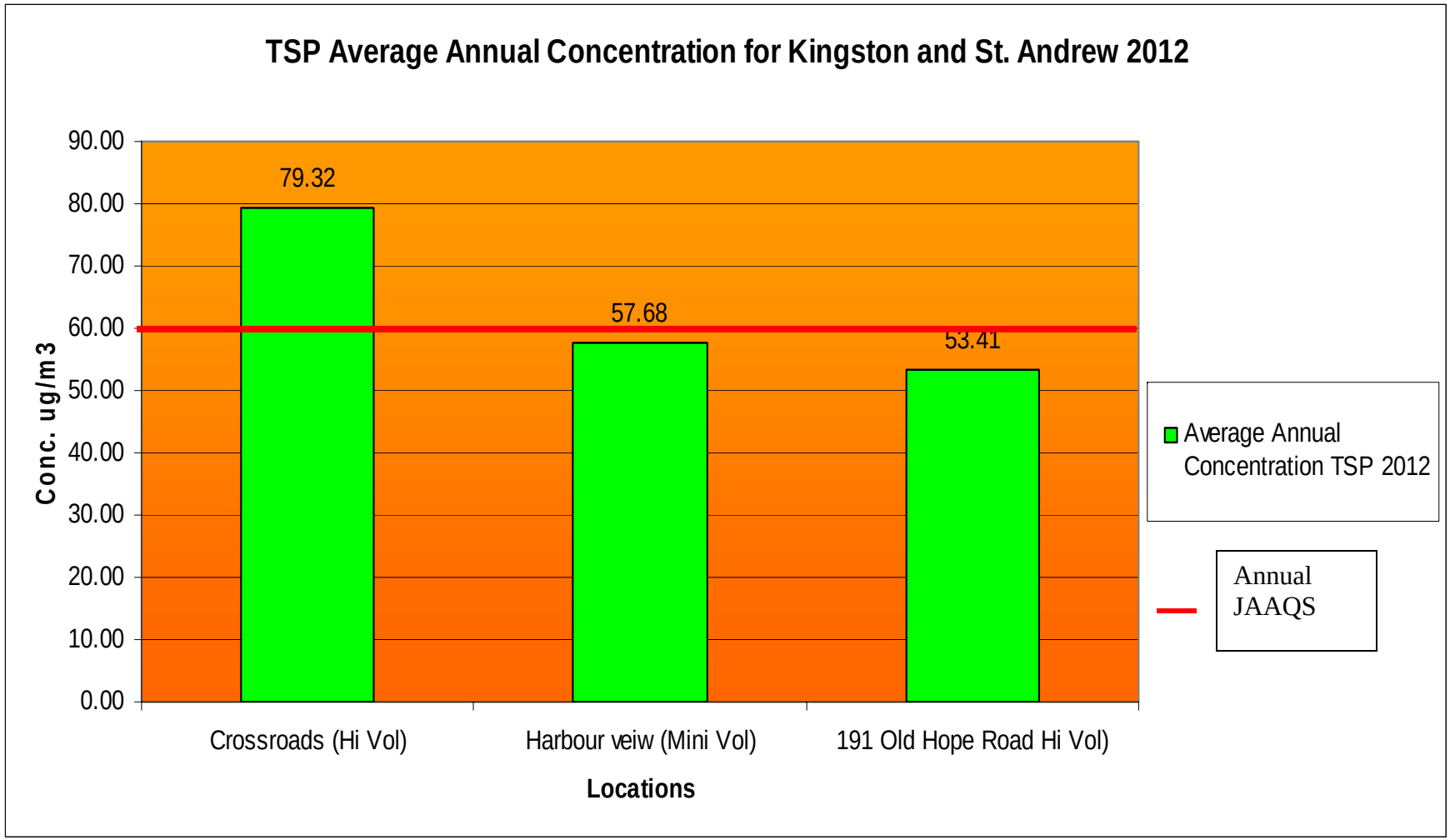


Figure 3A: Graph showing trend in ambient air quality for TSP at the six stations in the North St. Catherine Jan-Dec 2012

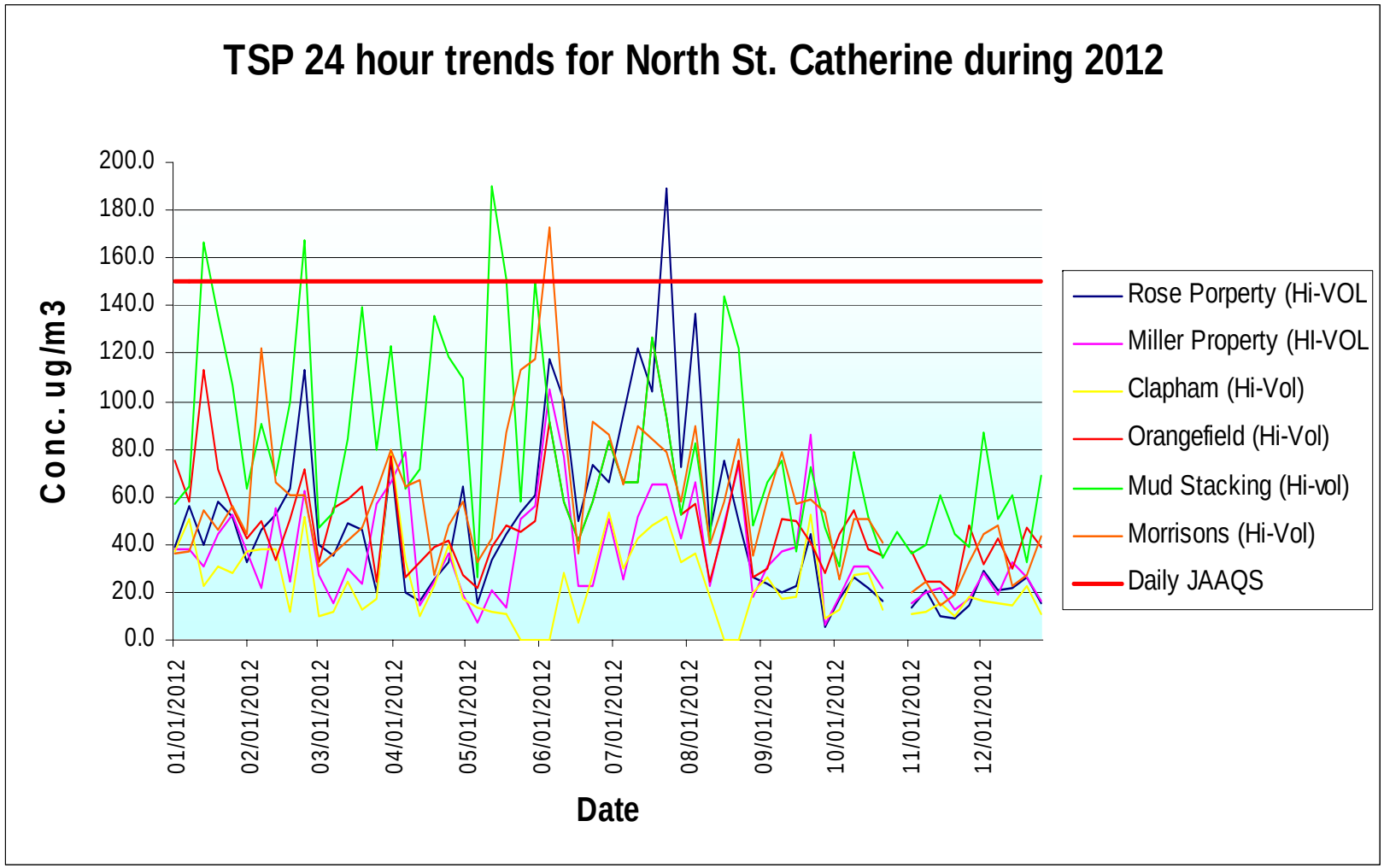


Figure 4A: Graph showing Annual TSP average concentrations at all monitoring stations in North St. Catherine for 2012

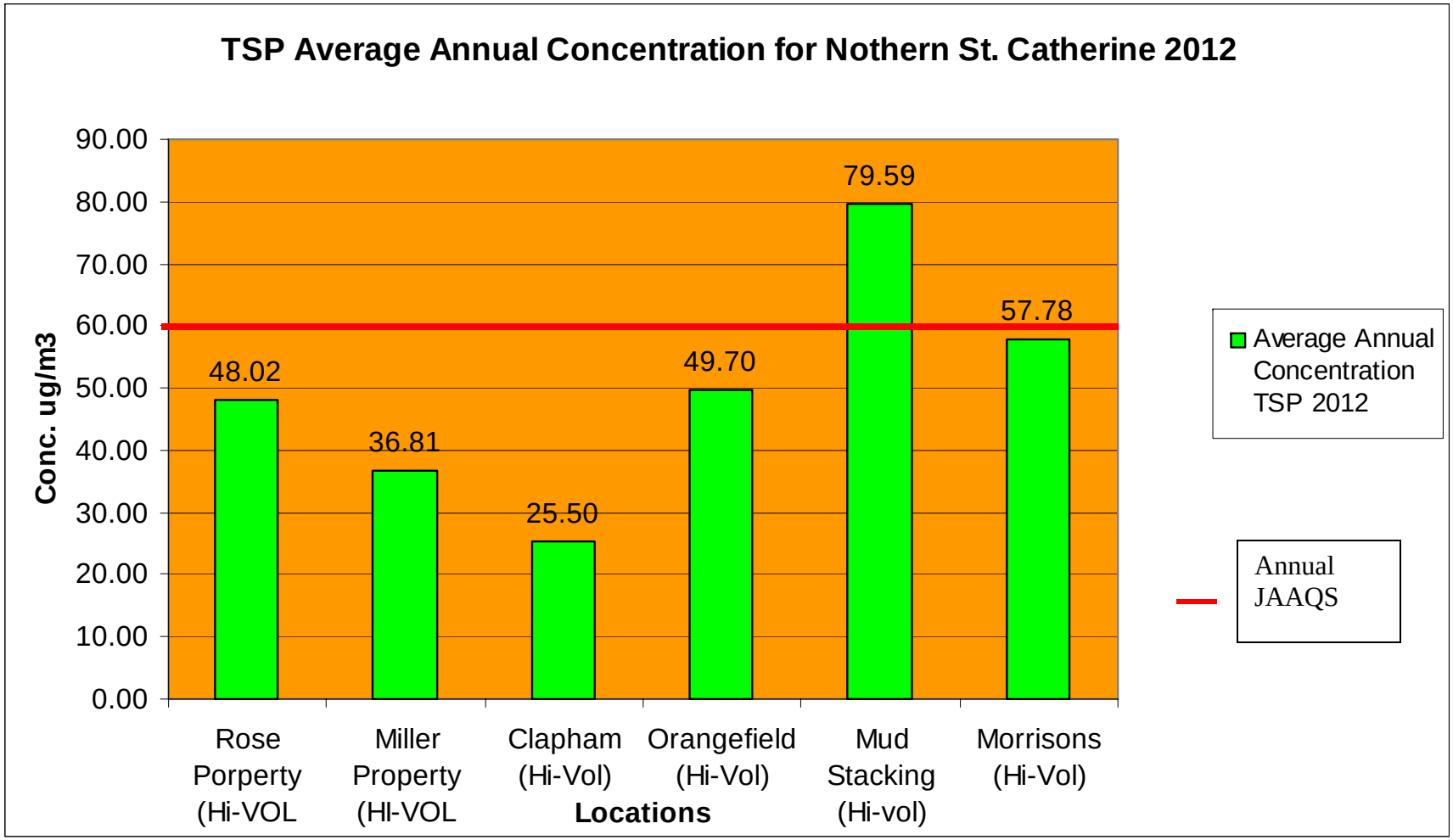


Figure 5A Graph showing trend in ambient air quality for TSP at the eight stations in the North Central Manchester Jan-Dec 2012

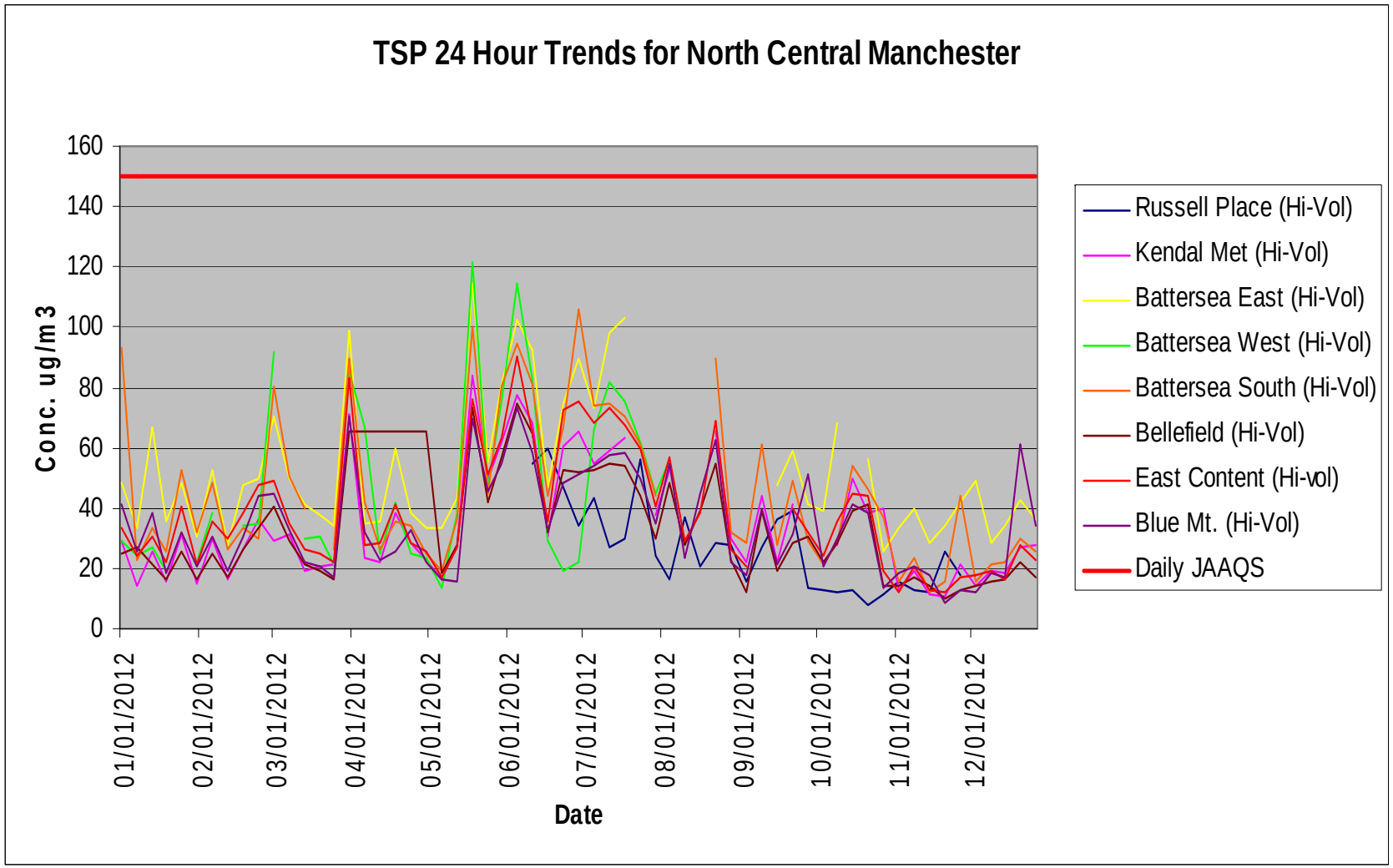


Figure 6A Graph showing Annual TSP average concentrations at all monitoring stations in North Central Manchester for 2012

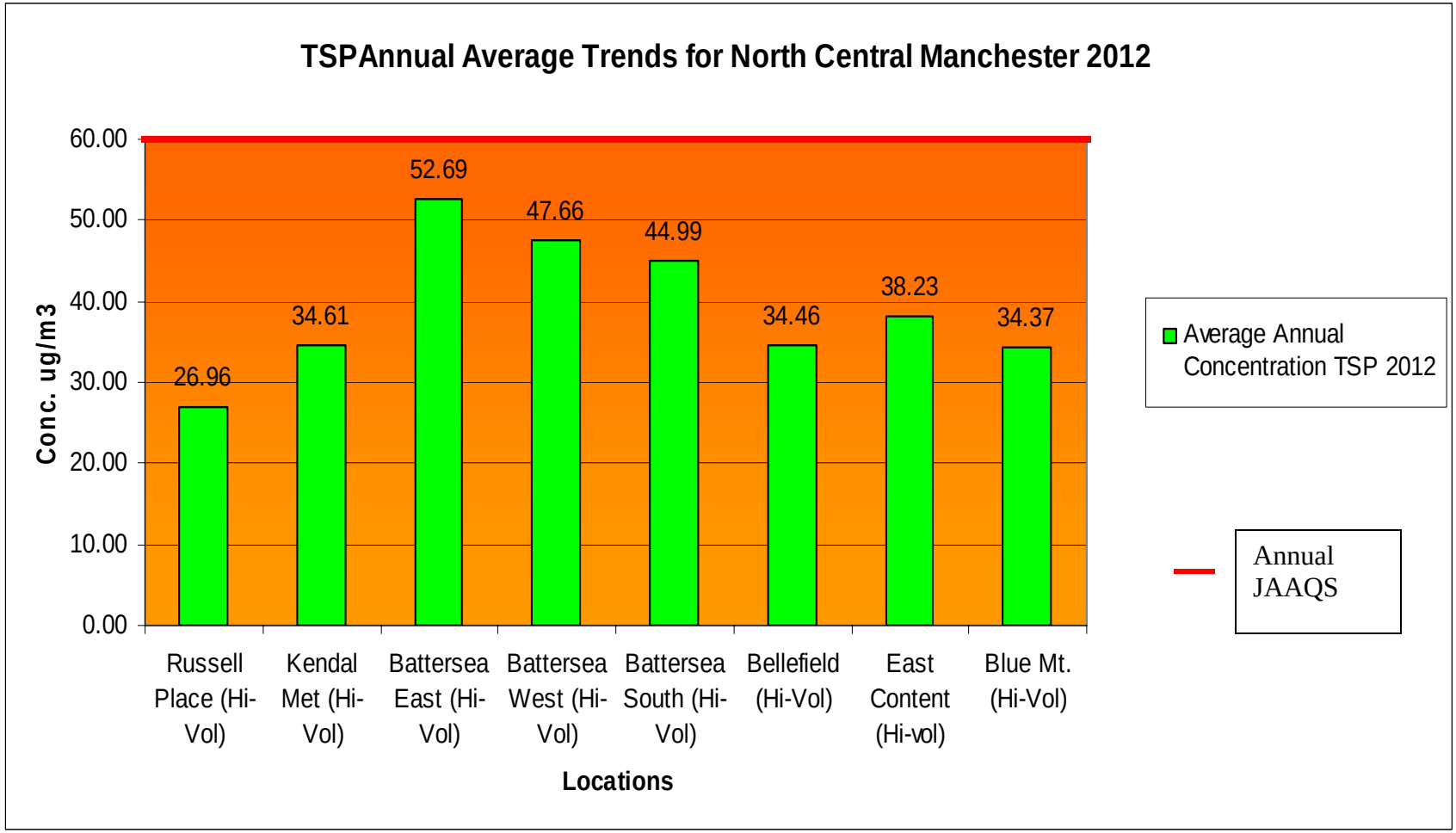


Figure 7A Graph showing trend in ambient air quality for TSP at the five stations in the South St. Elizabeth from Jan-Dec 2012

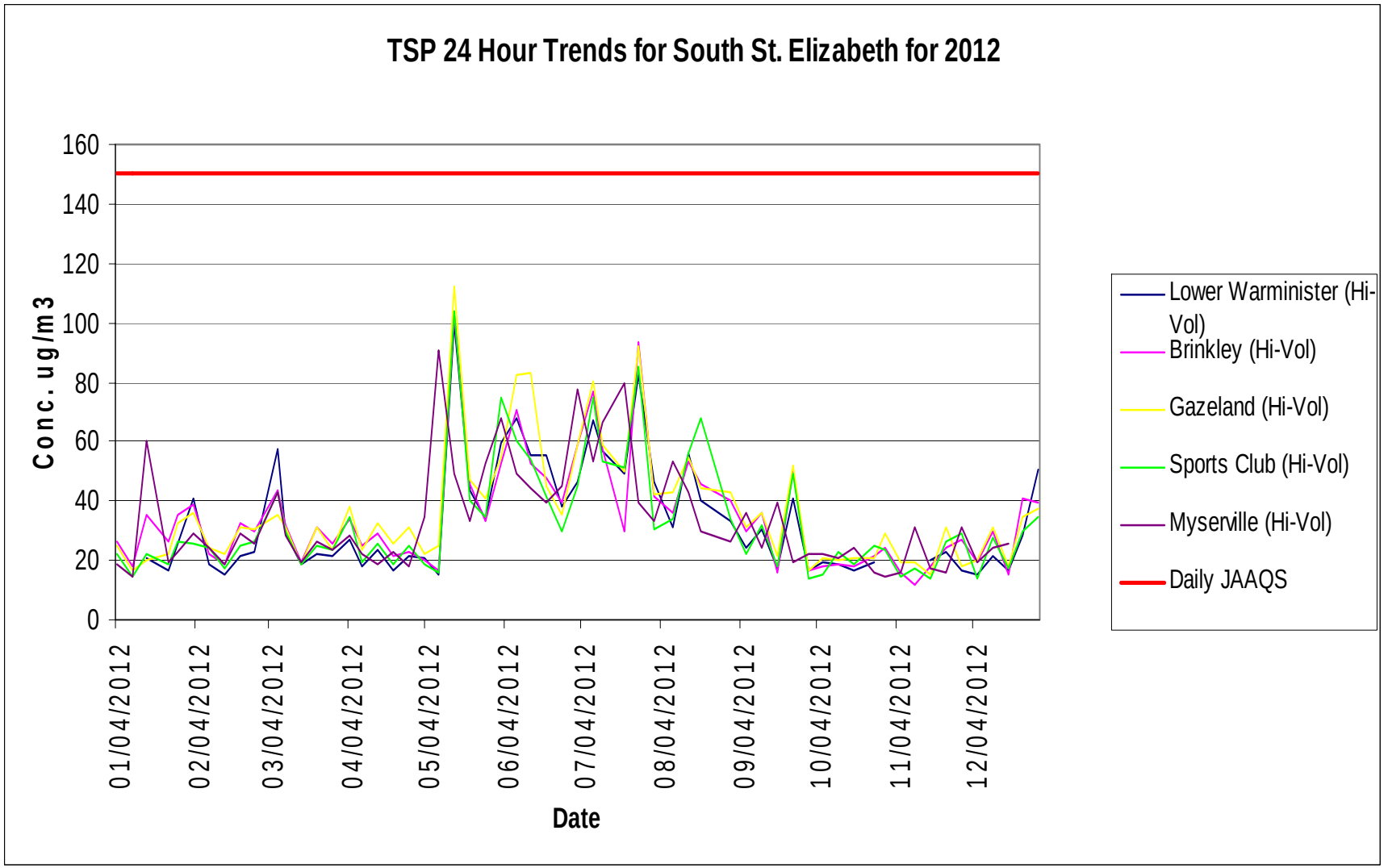


Figure 8A: Graph showing Annual TSP average concentrations at all monitoring stations in South St. Elizabeth for 2012

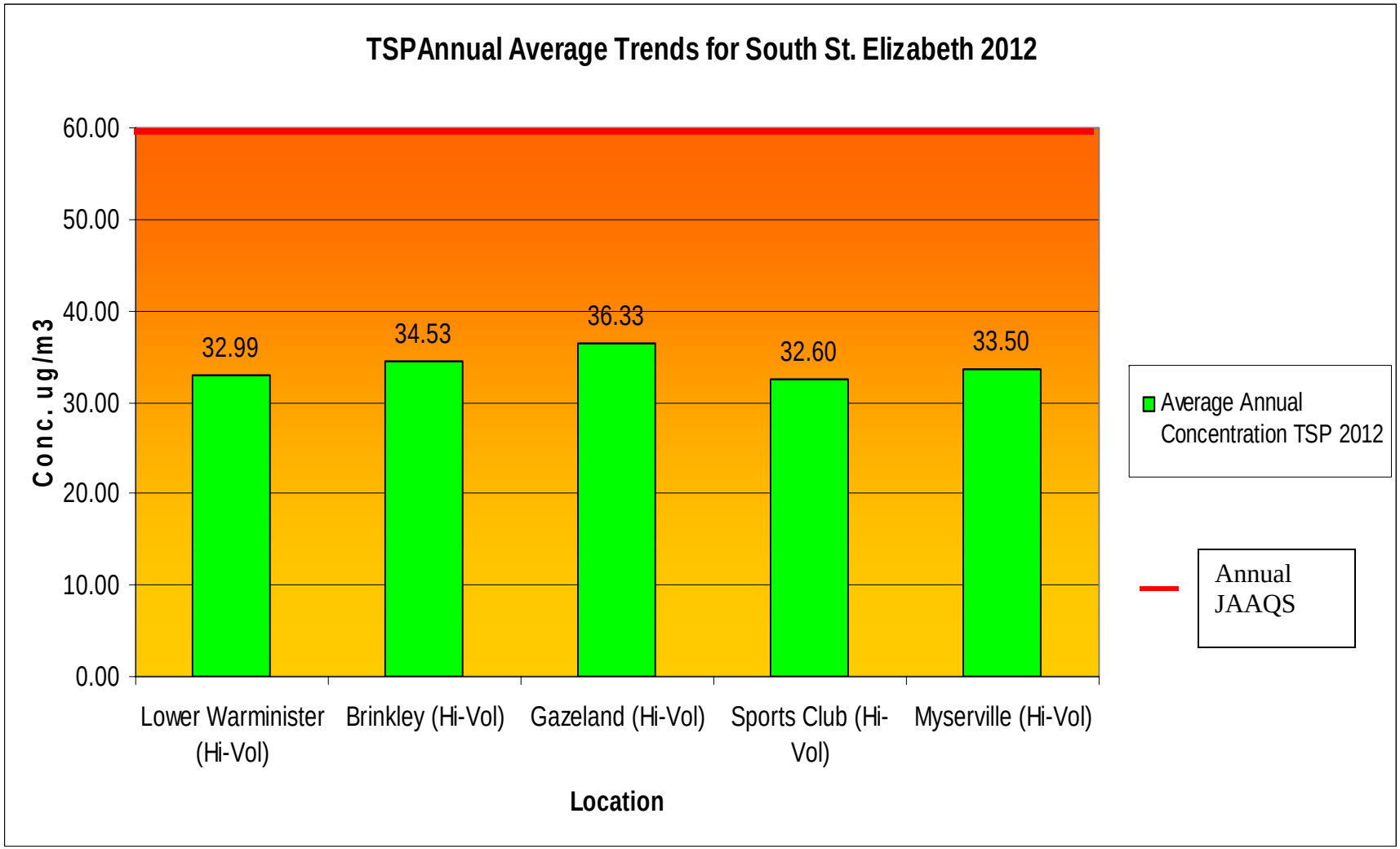


Figure 9A Graph showing trend in ambient air quality for TSP at the five stations in the North Eastern St. Ann from Jan-Dec 2012

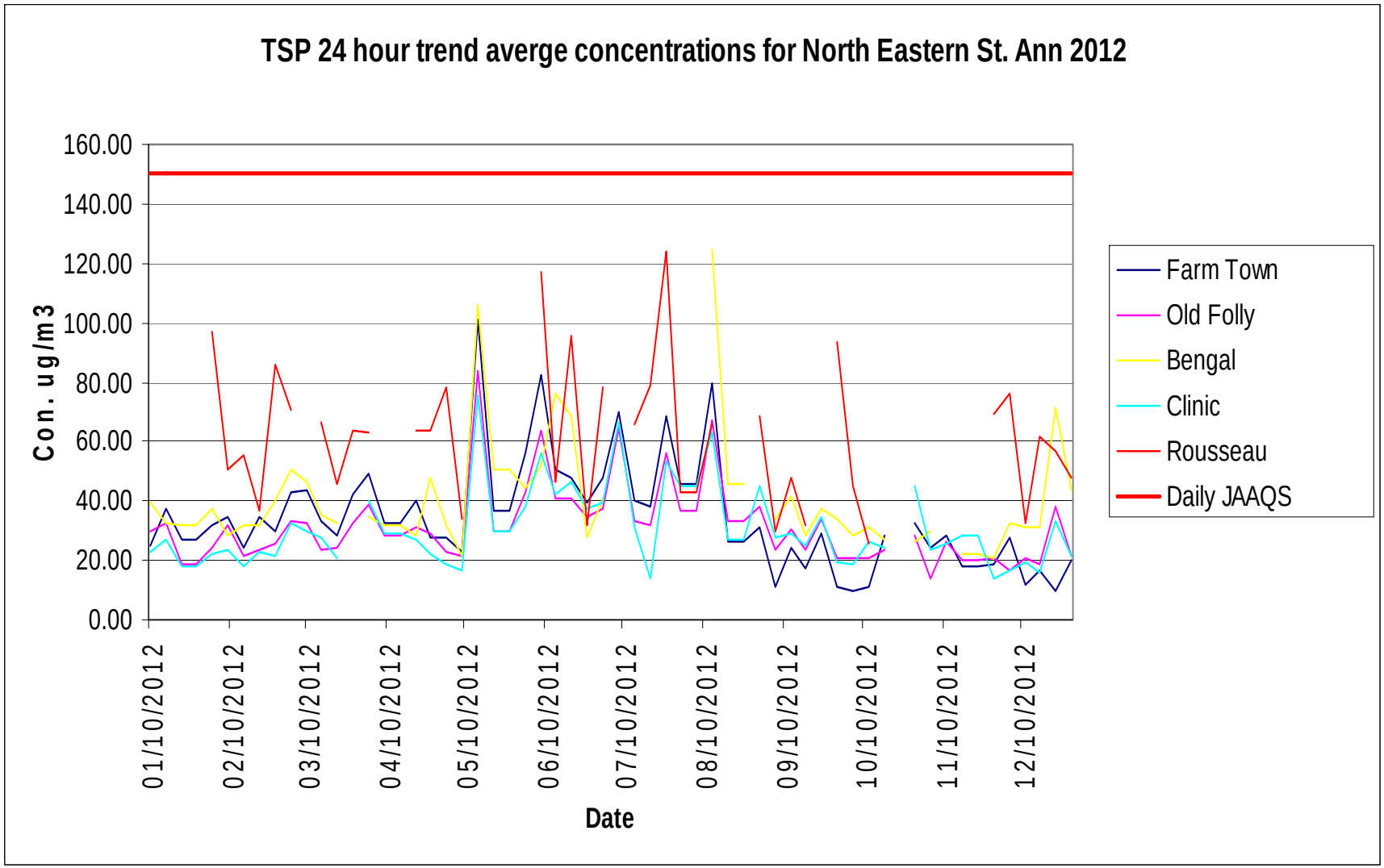


Figure 10A: Graph showing Annual TSP average concentrations at all monitoring stations in North Eastern St. Ann for 2012

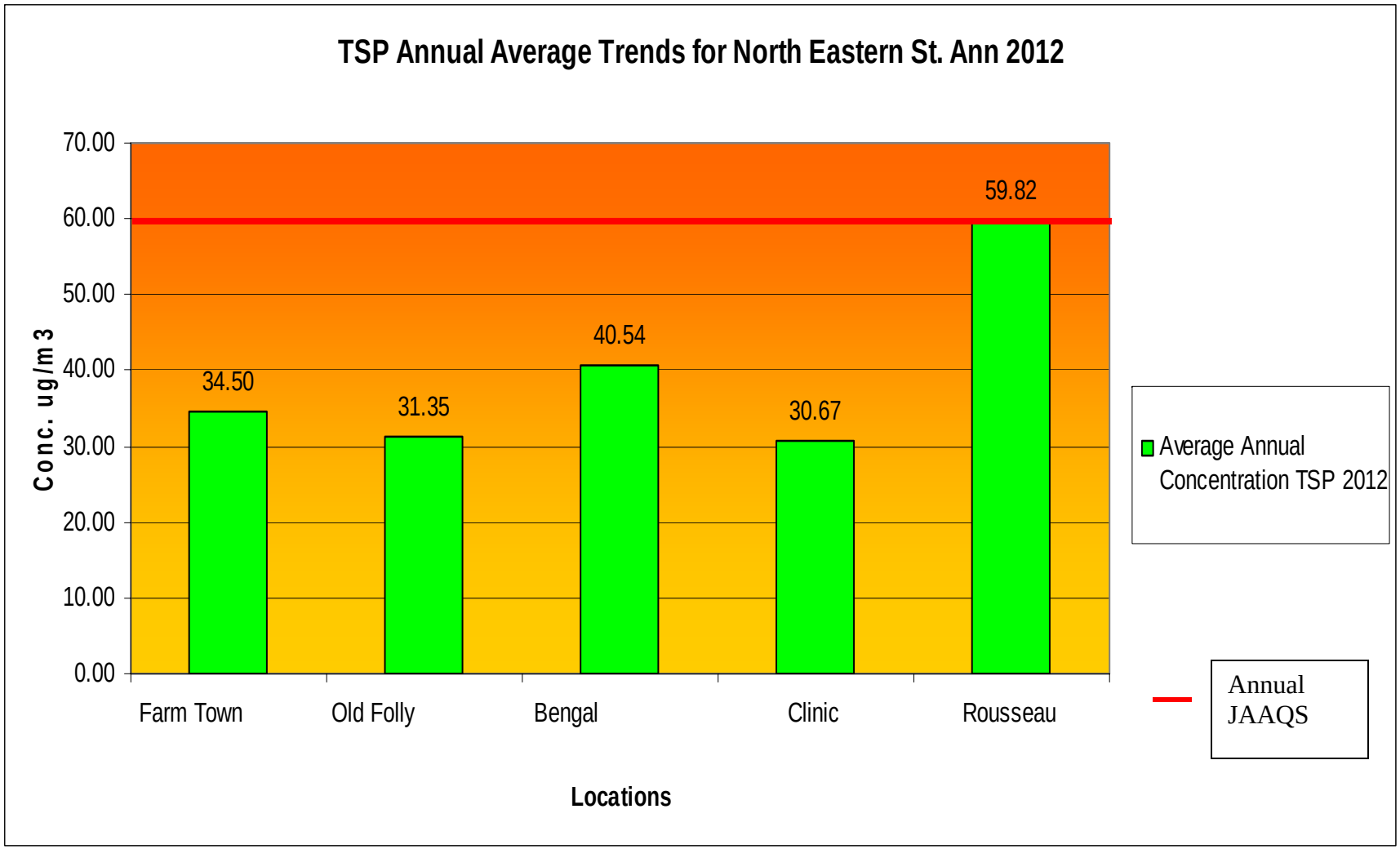


Figure 11A Graph showing trend in ambient air quality for TSP at the three stations in the South Central St. Ann from Jan-Dec 2012

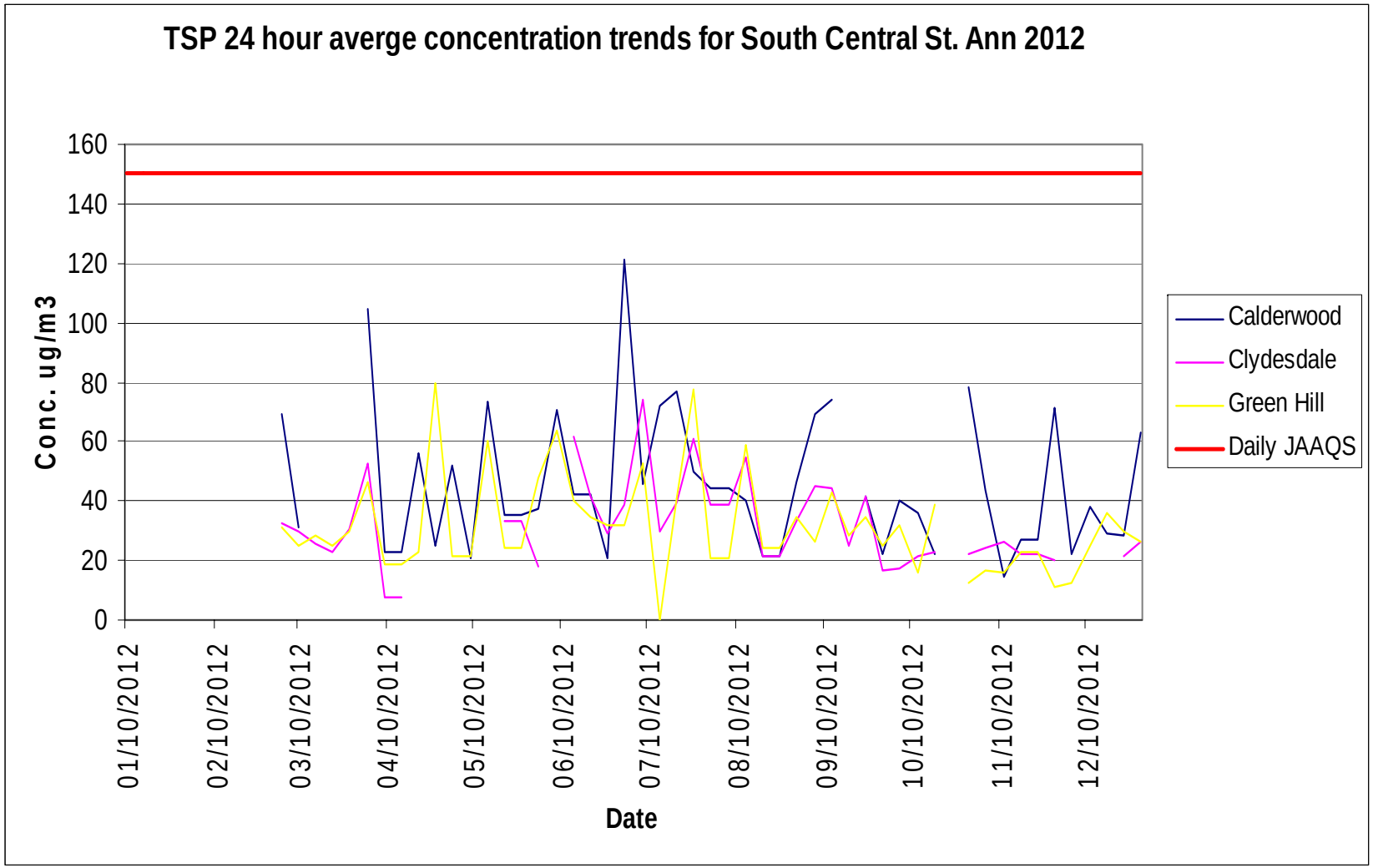
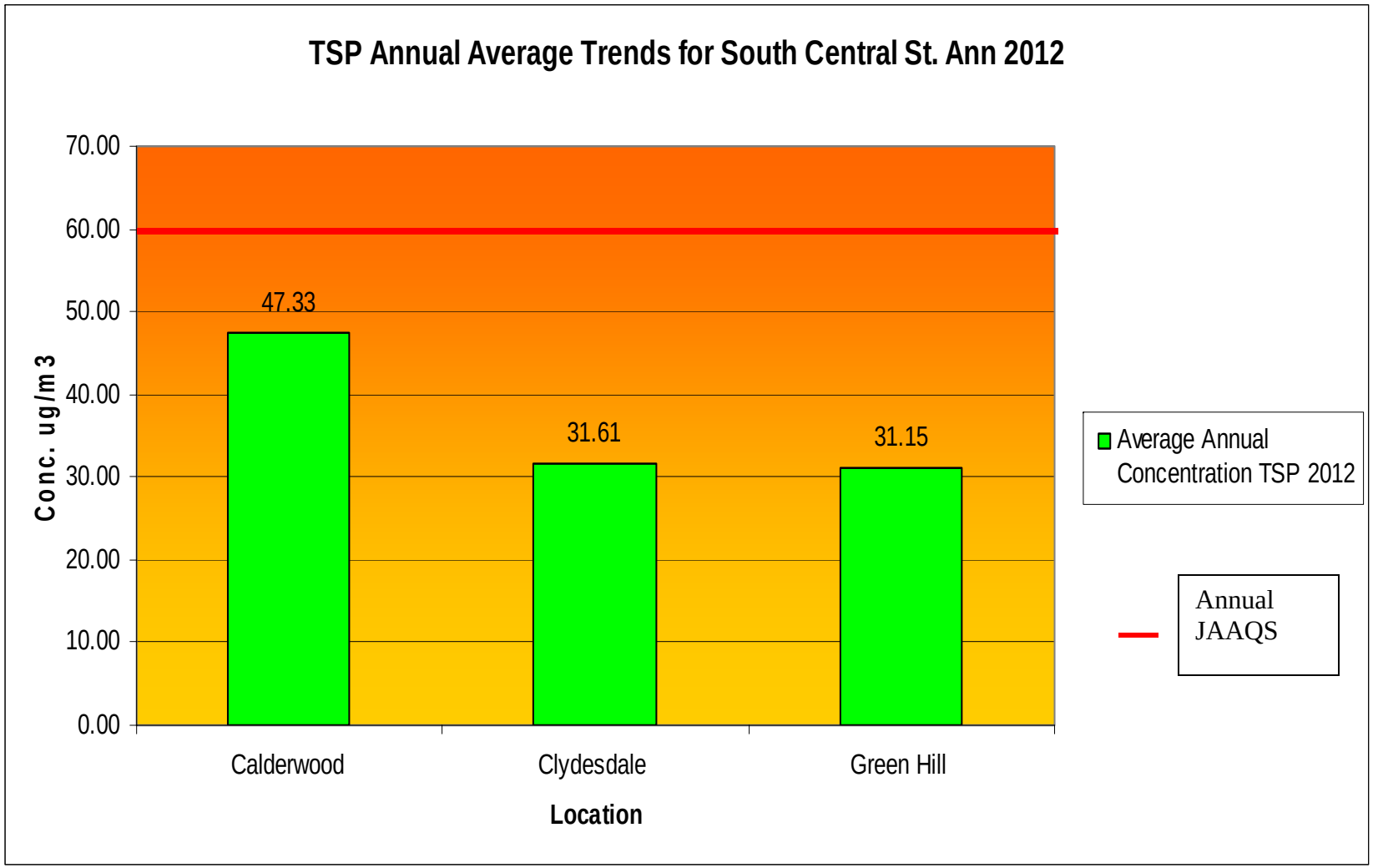


Figure 12A: Graph showing Annual TSP average concentrations at all monitoring stations in South Central St. Ann for 2012



Particulate Matter Less than 10 Microns (PM_{10})

Figure 13A: Graph showing trend in ambient air quality for PM_{10} at the three continuous monitoring stations in the Kingston and St. Andrew region from Jan-Dec 2012

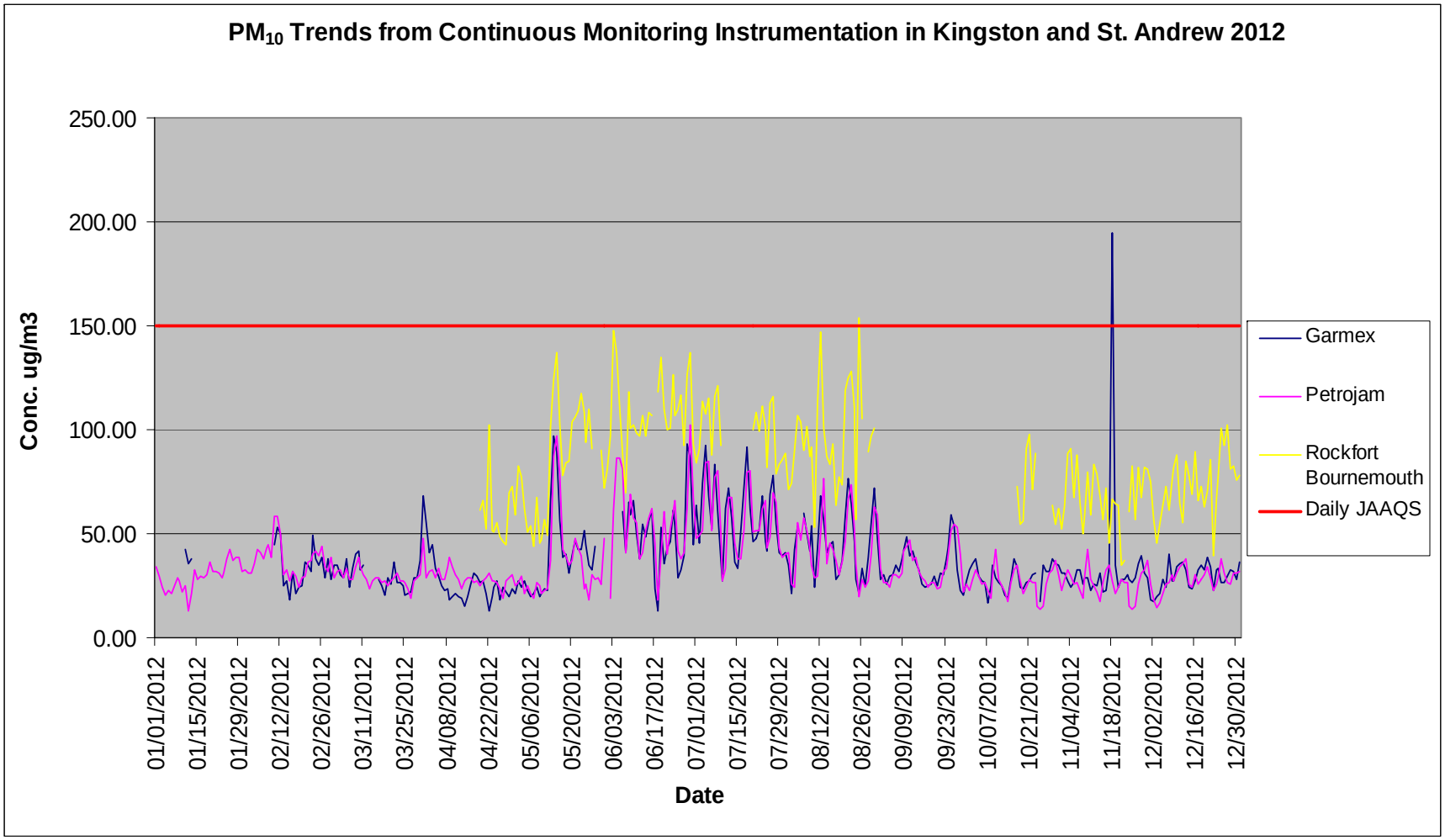


Figure 14A: Graph showing trend in ambient air quality for PM_{10} at the seven semi continuous monitoring stations in the Kingston and St. Andrew region from Jan-Dec 2012

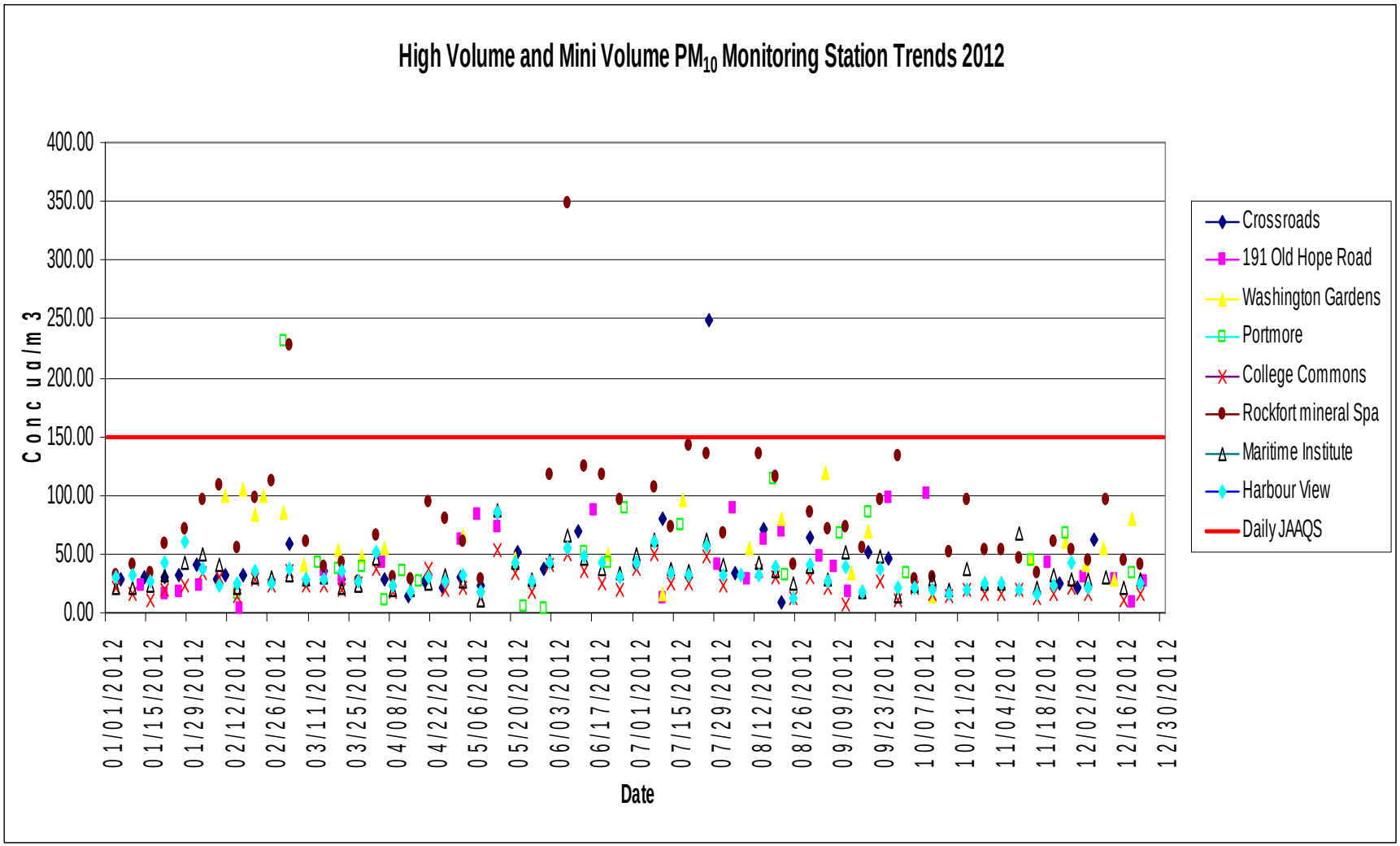


Figure 15A: Graph showing trend in ambient air quality for PM_{10} at the monitoring stations in Rockfort Kingston and St. Andrew region from Jan-Dec 2012

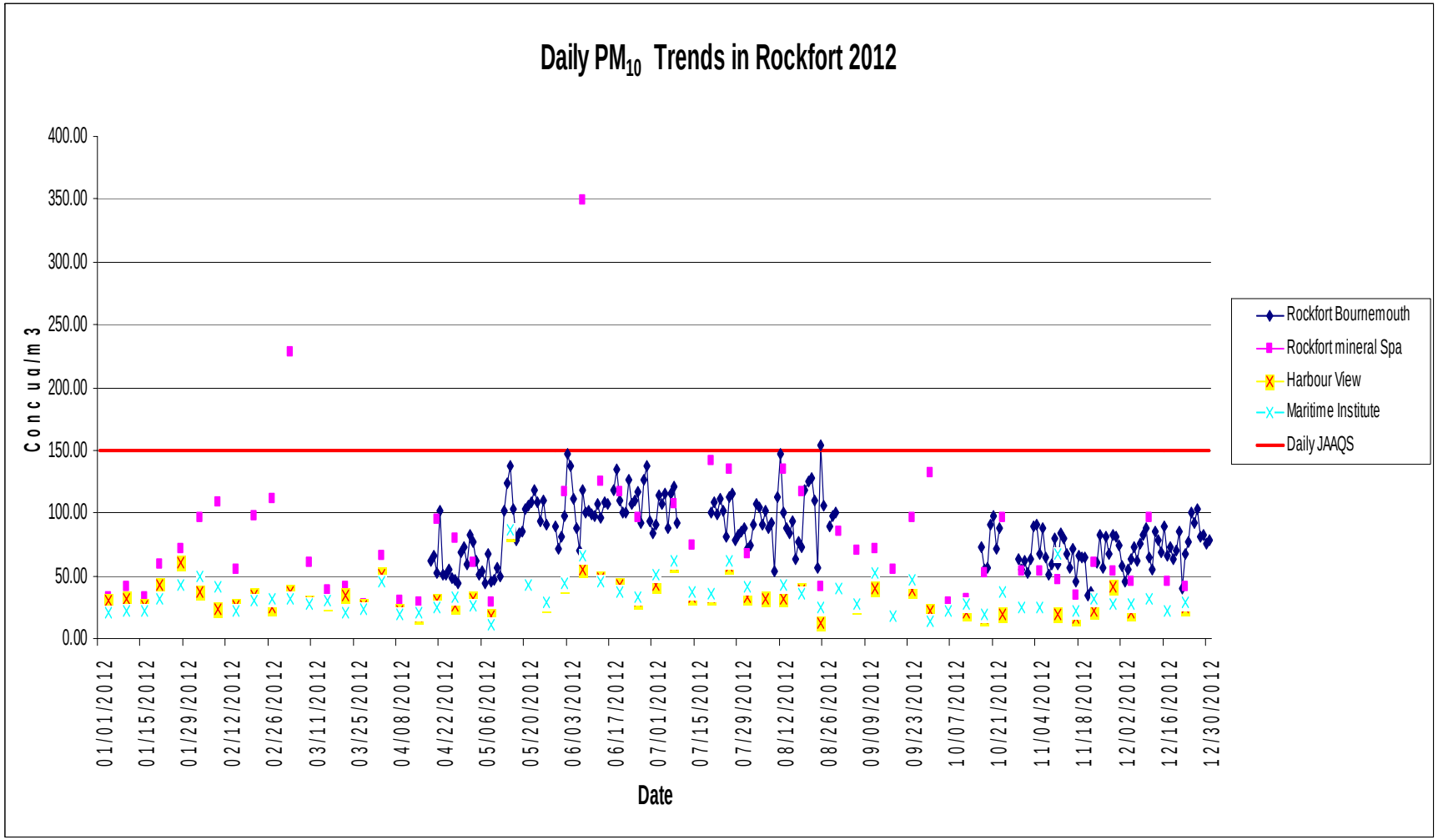


Figure 16A: Graph showing Annual PM_{10} average concentrations at all monitoring stations in Portmore and Kingston and St. Andrew for 2012

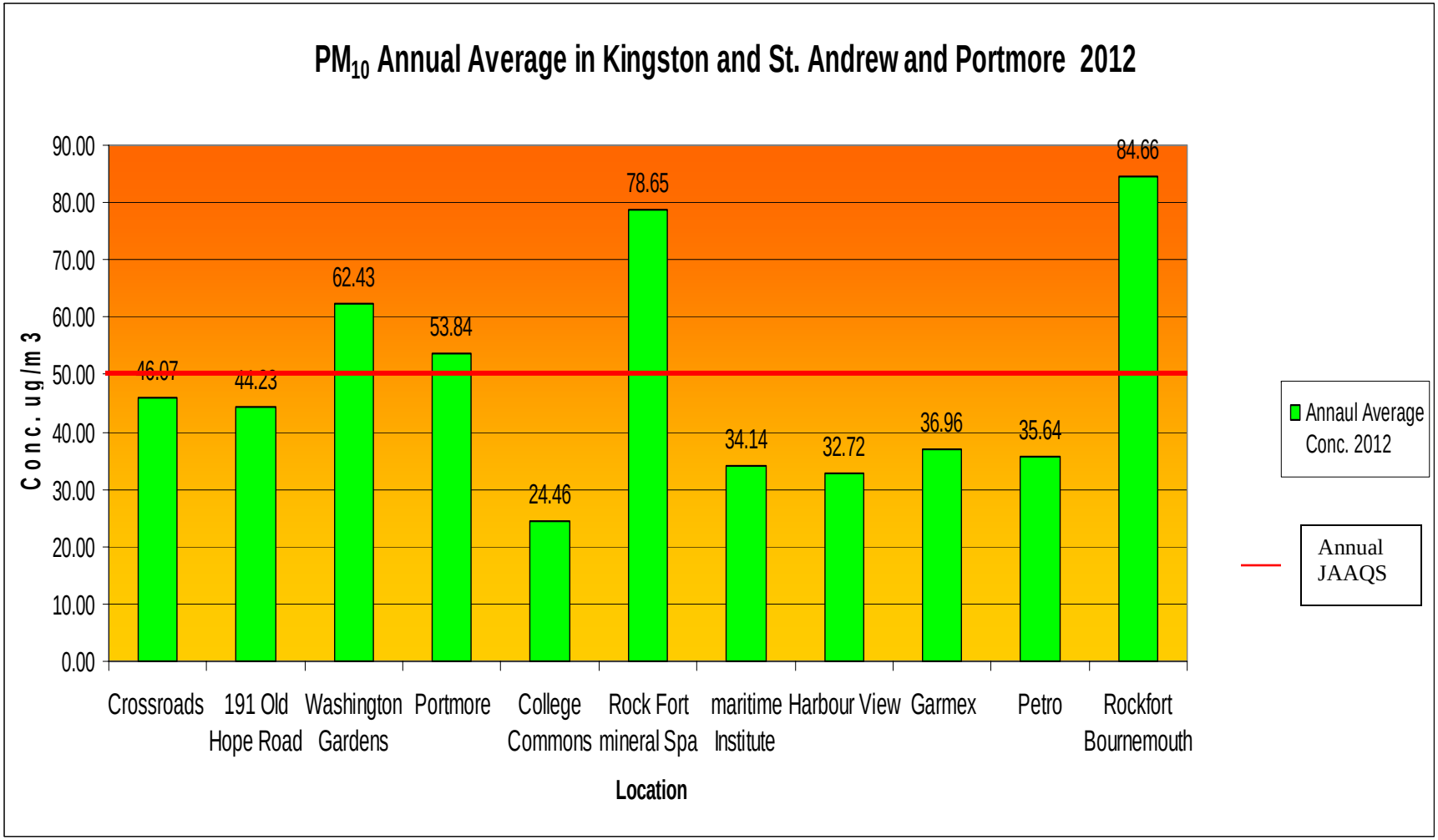


Figure 17A: Graph showing trend in ambient air quality for PM_{10} at the three stations in the Old Harbour Bay Plains, St. Catherine from Jan-Dec 2012

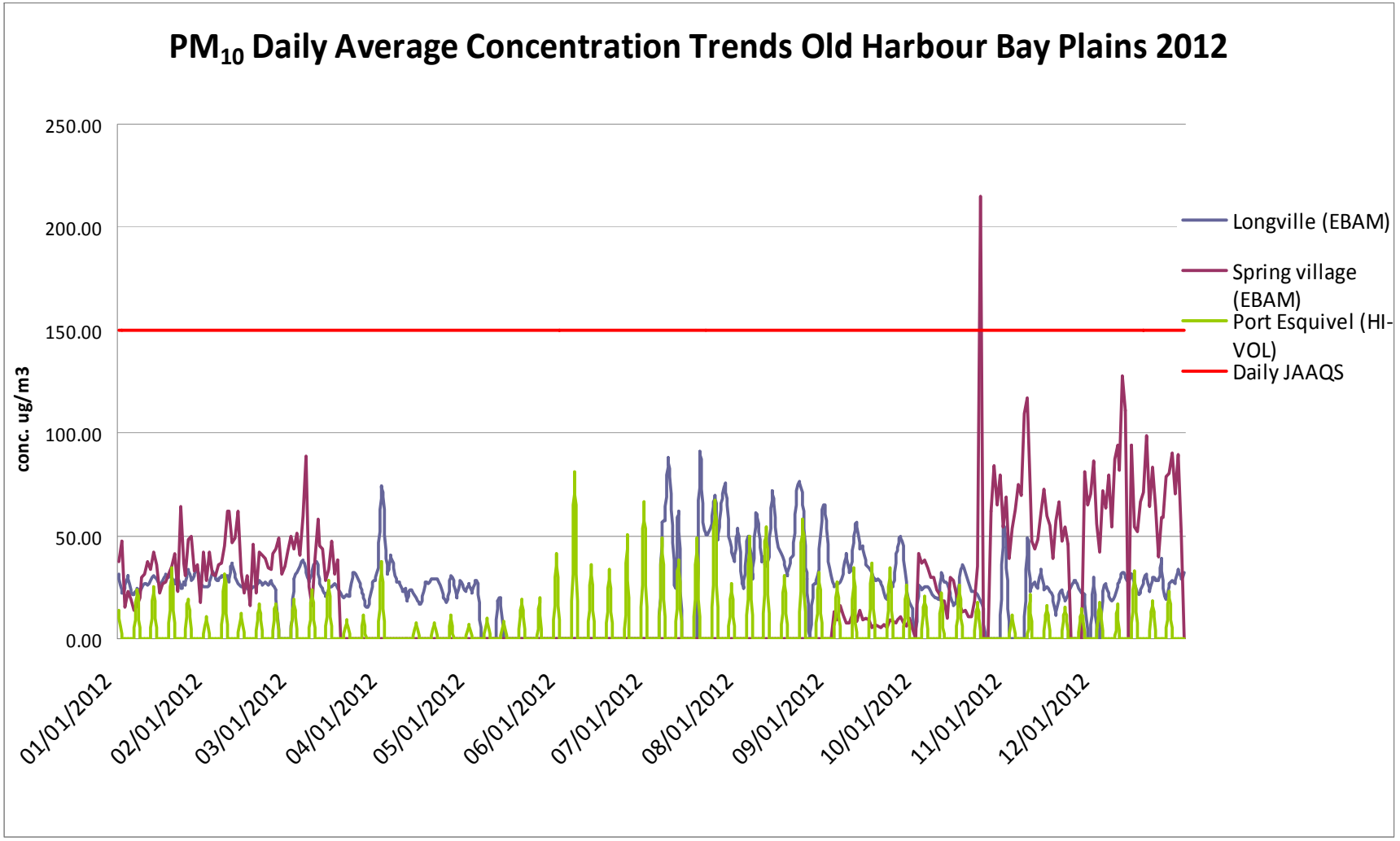


Figure 18A: Graph showing Annual PM_{10} average concentrations at all monitoring stations in Old Harbour Bay Plains, St. Catherine for 2012

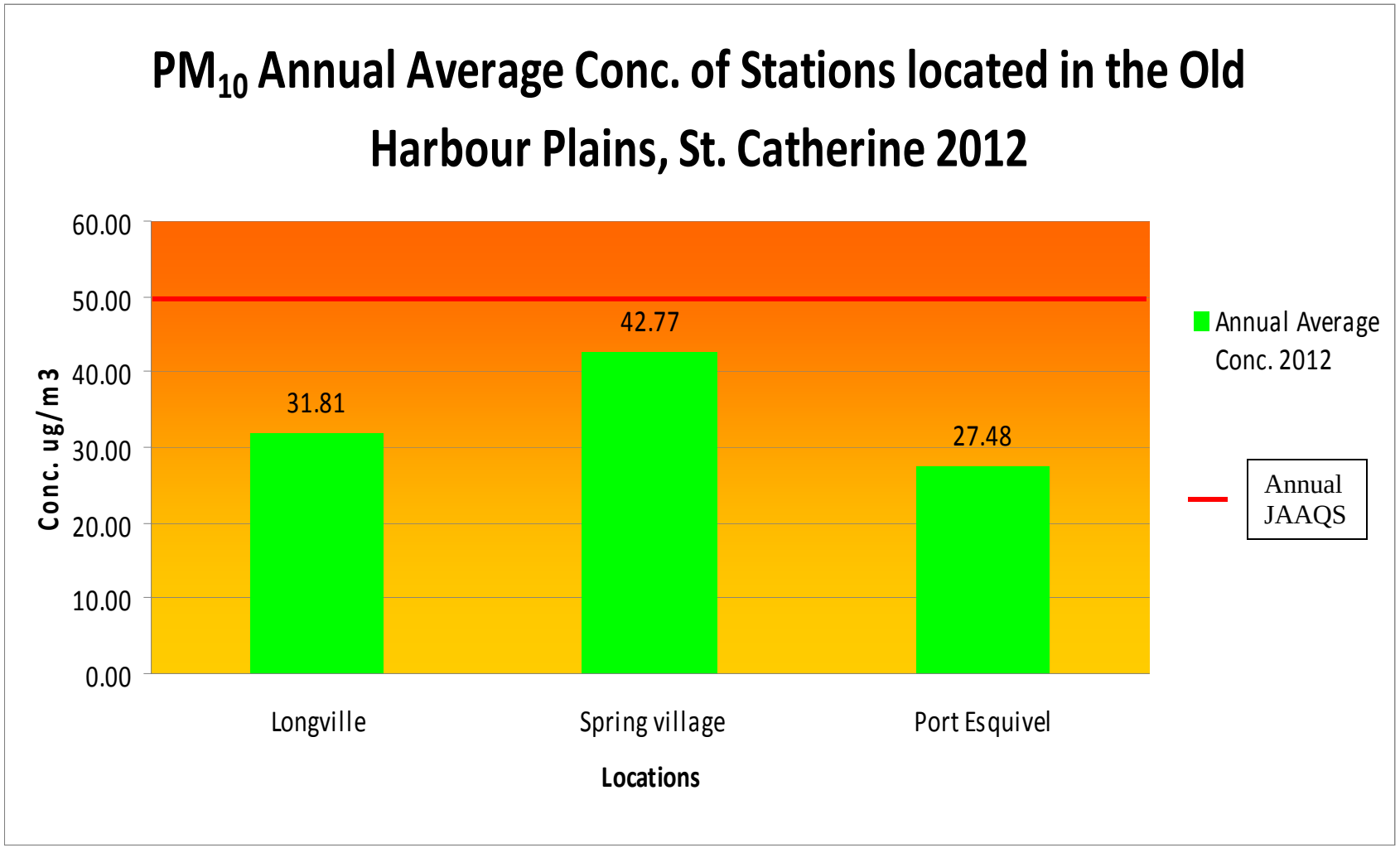


Figure 19A: Graph showing trend in ambient air quality for PM10 at the three stations in Northern St. Catherine and South Eastern St. Ann from Jan-Dec 2012

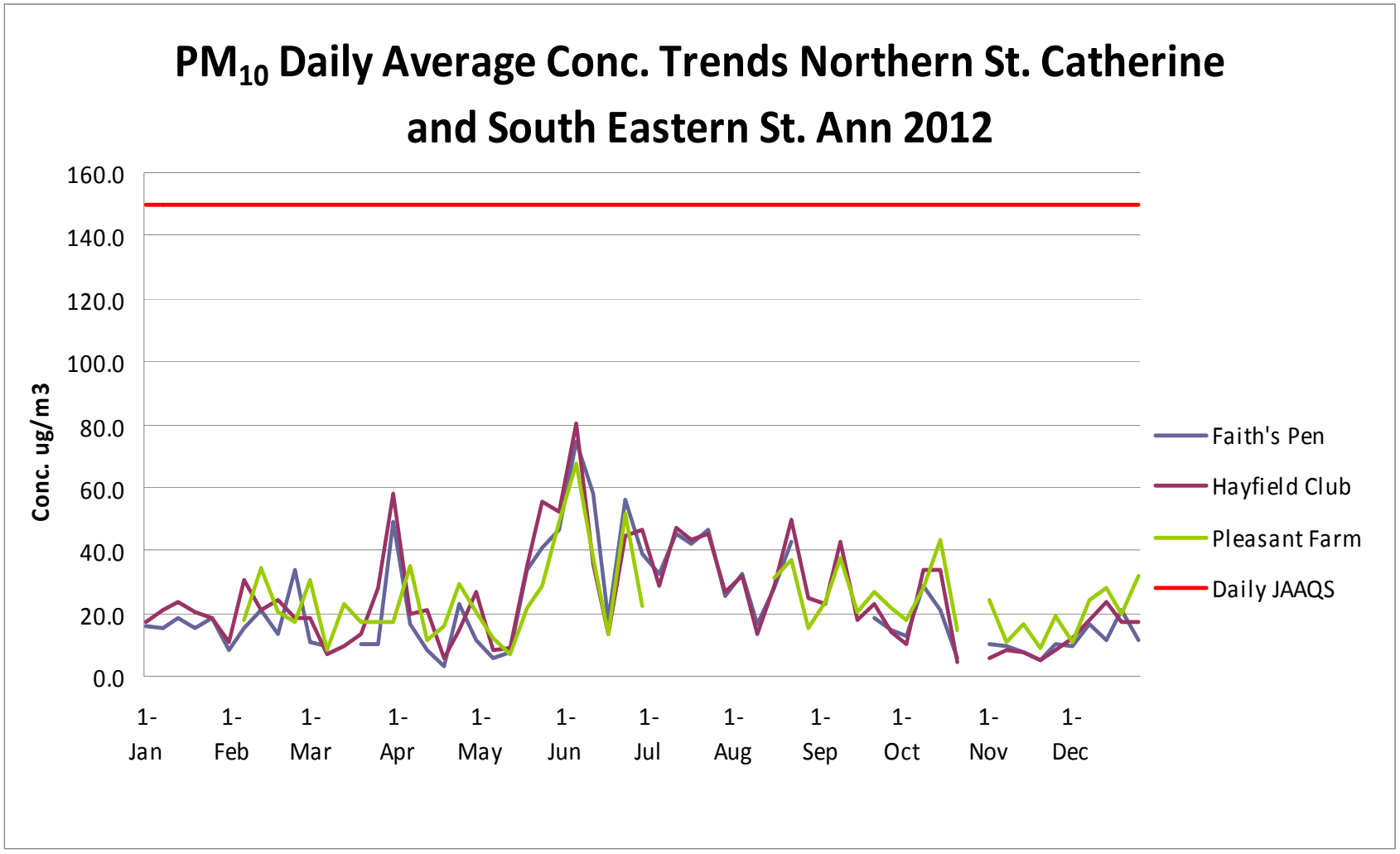


Figure 20A: Graph showing Annual PM_{10} average concentrations at all monitoring stations in Northern St. Catherine and South Eastern St. Ann for 2012

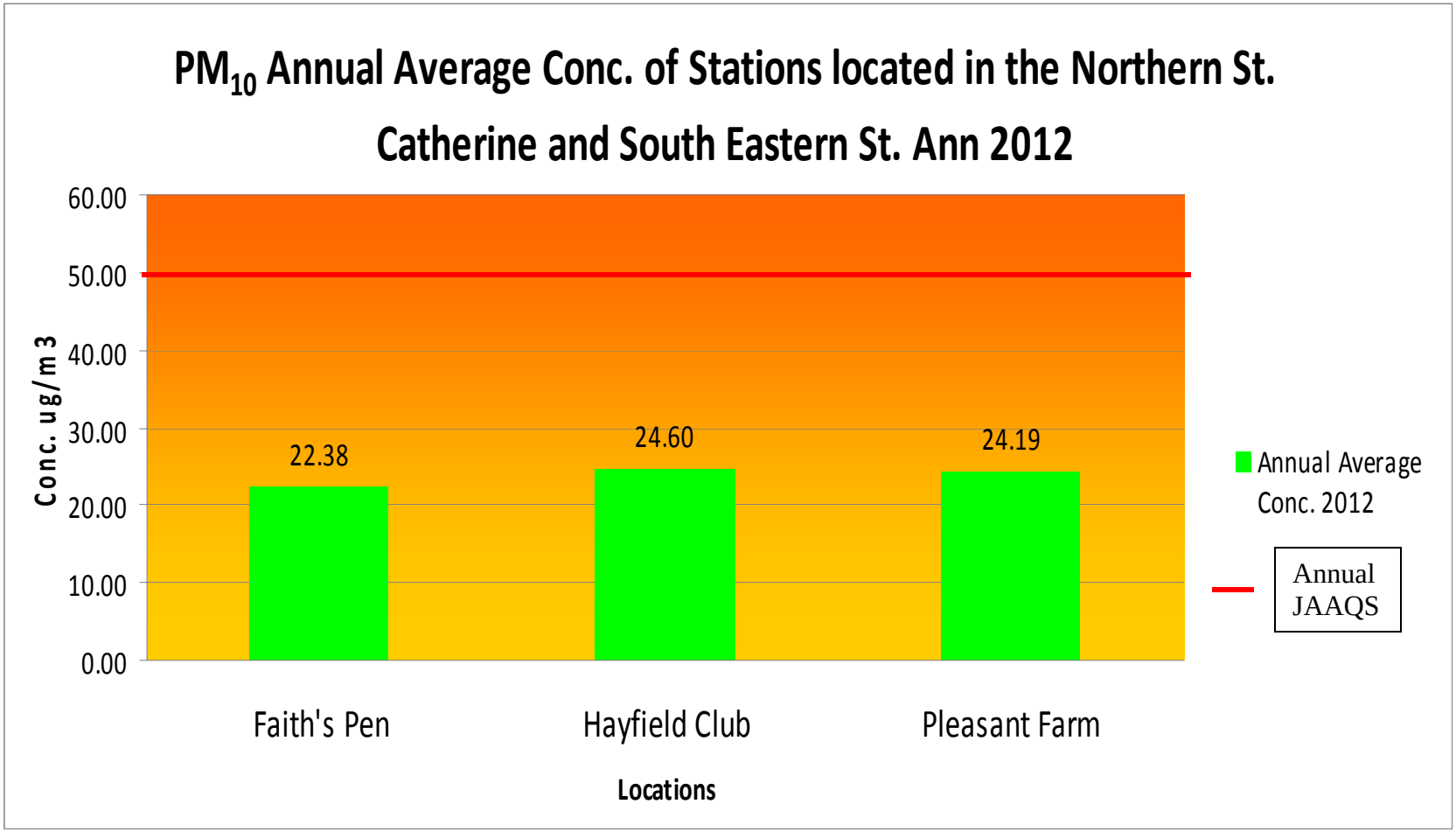


Figure 21A: Graph showing trend in ambient air quality for PM_{10} at the two stations on the Vere Plains, Clarendon from Jan-Dec 2012

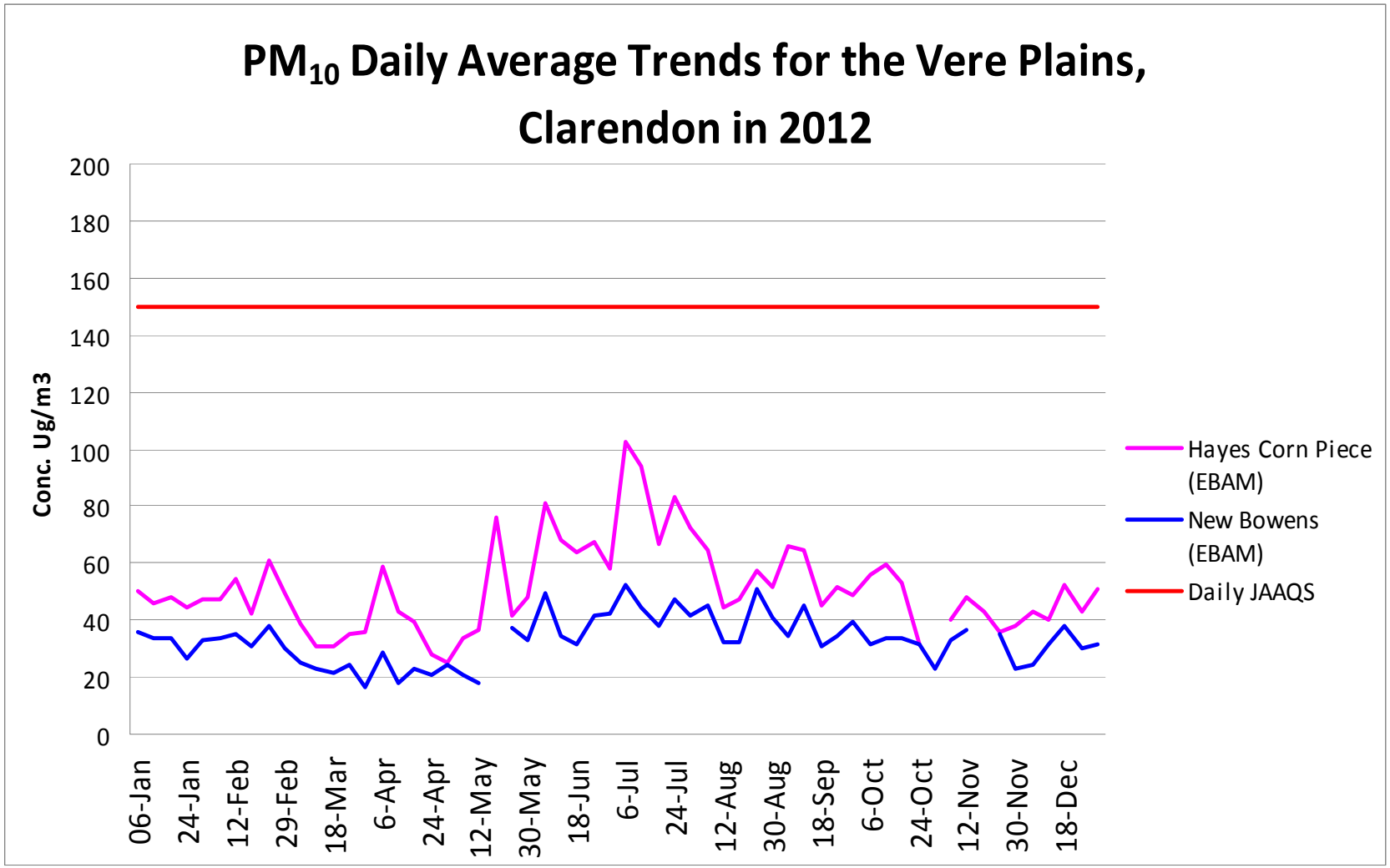


Figure 22A: Graph showing Annual PM_{10} average concentrations at the monitoring station in Vere Plains, Clarendon for 2012

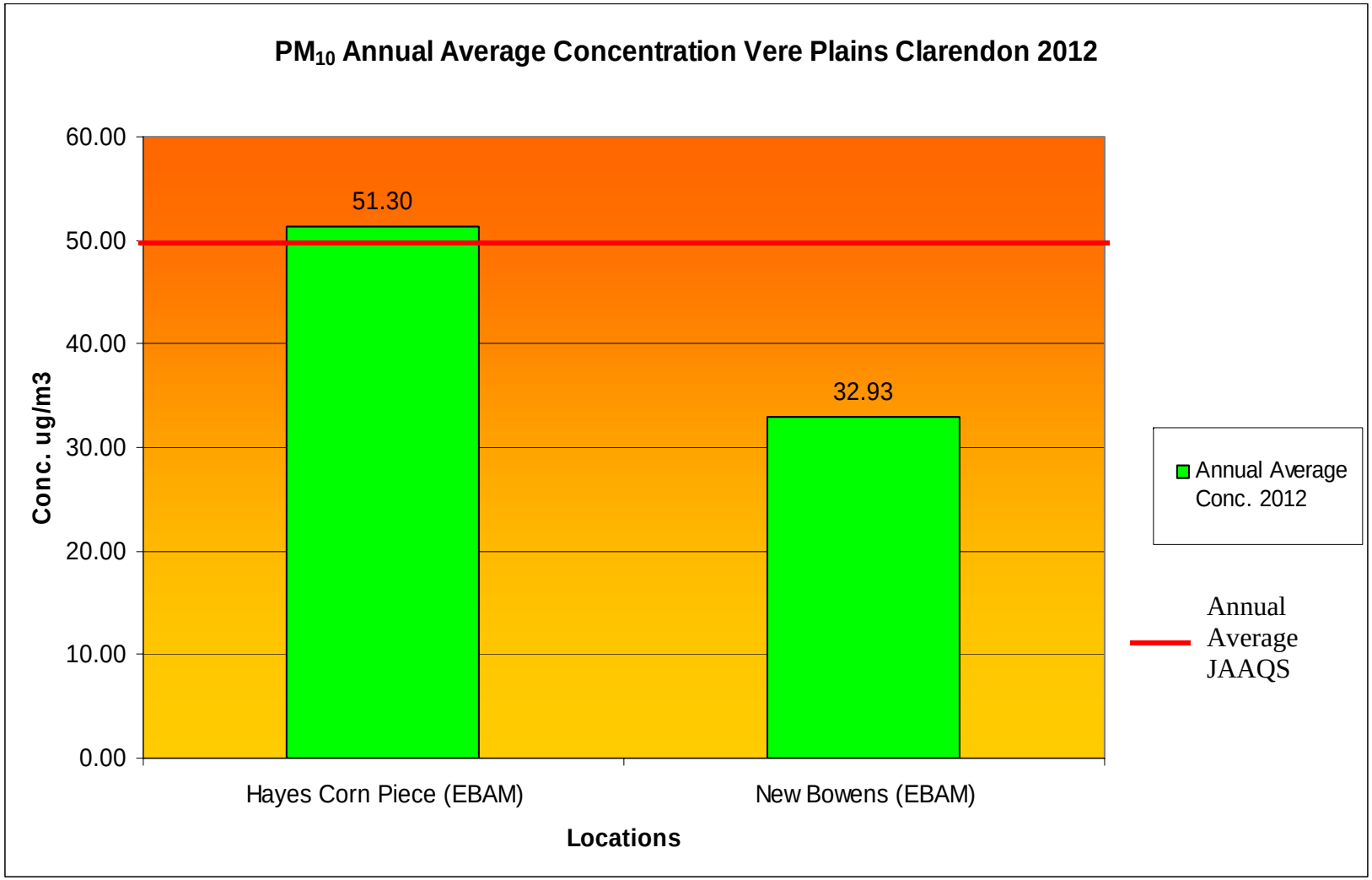


Figure 23A: Graph showing trend in ambient air quality for PM_{10} at the five stations in South Eastern Manchester from Jan-Dec 2012

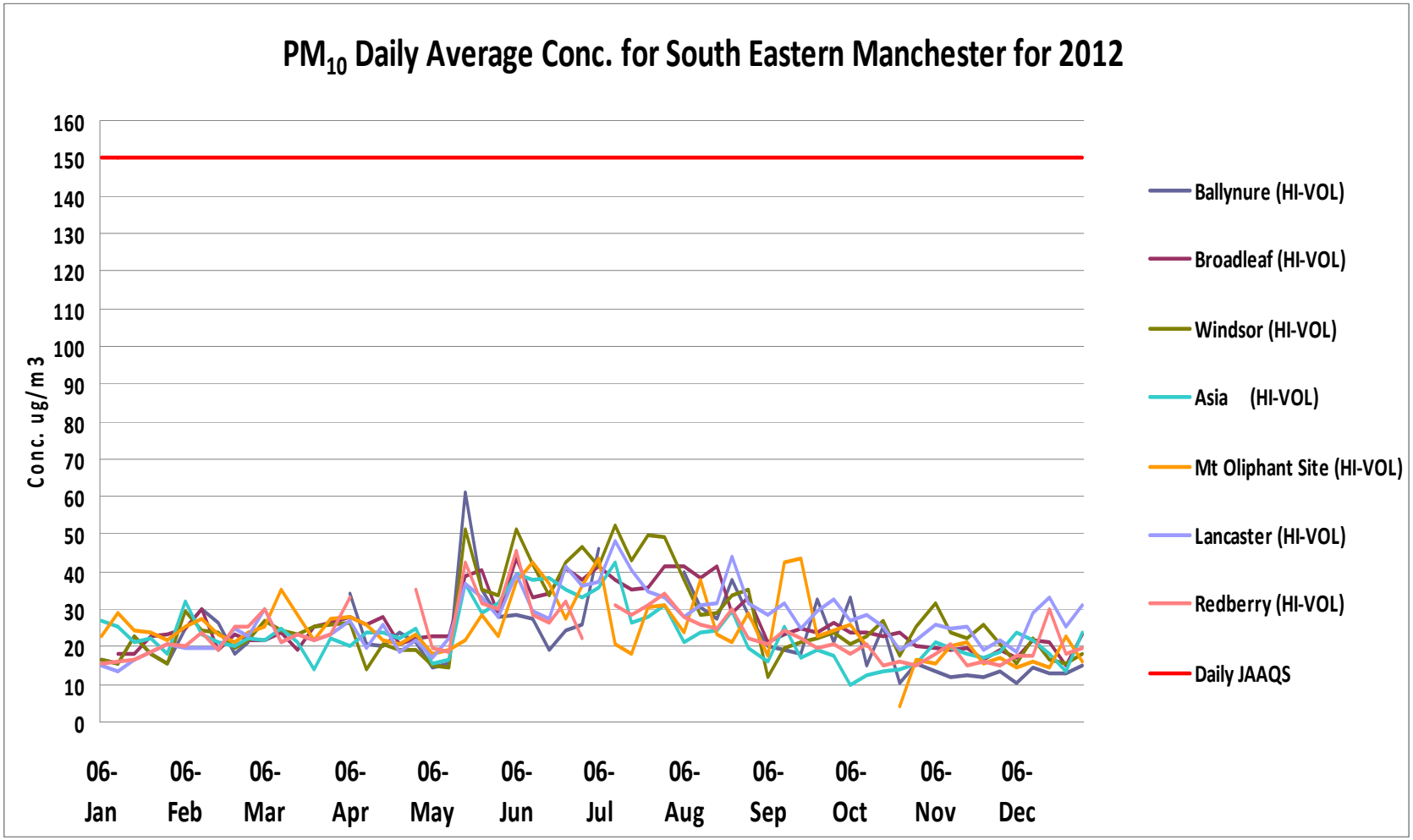


Figure 24A: Graph showing Annual PM_{10} average concentrations at the monitoring station in South Eastern Manchester for 2012

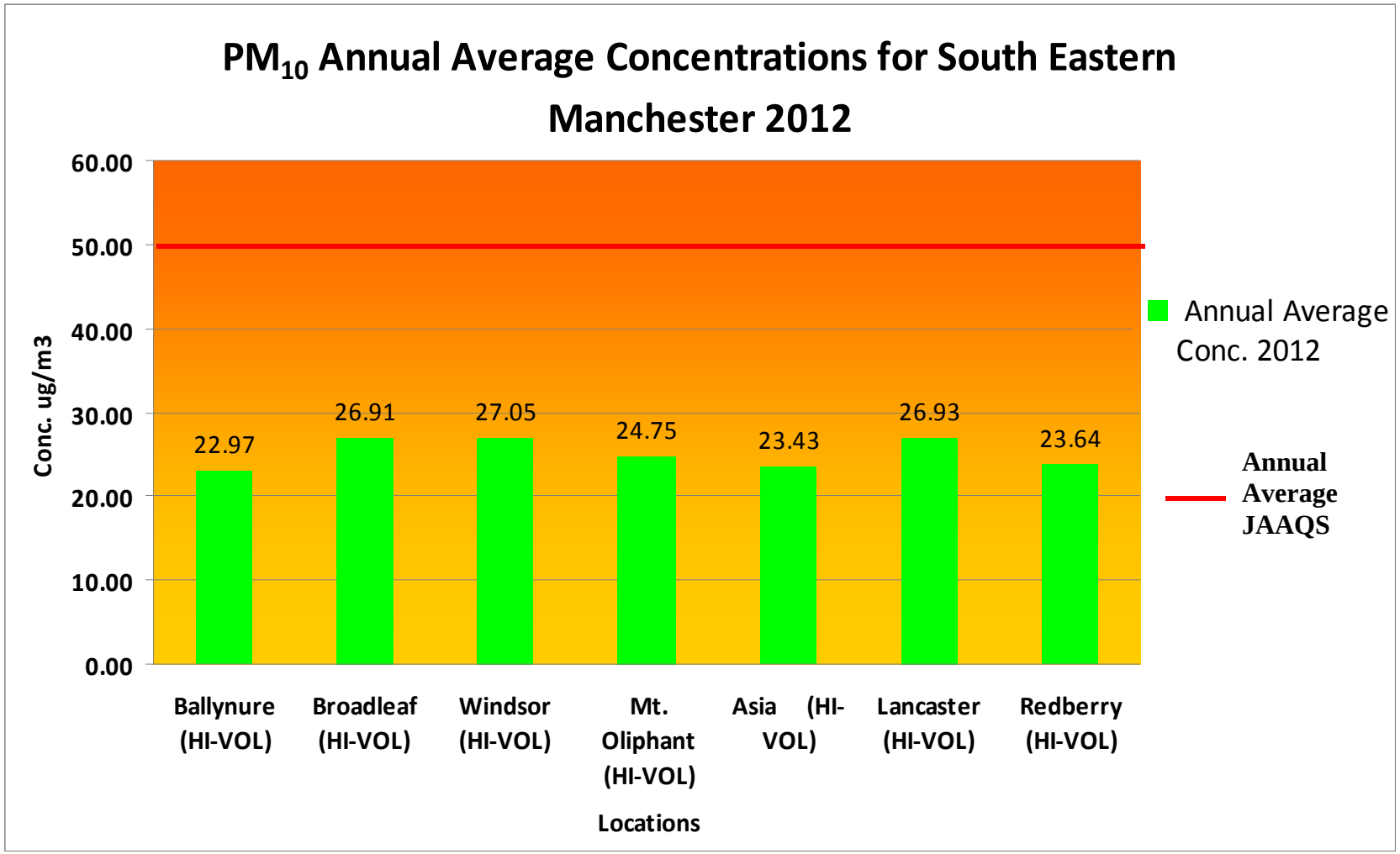


Figure 25A: Graph showing trend in ambient air quality for PM_{10} at the four stations in North Central Manchester from Jan-Dec 2012

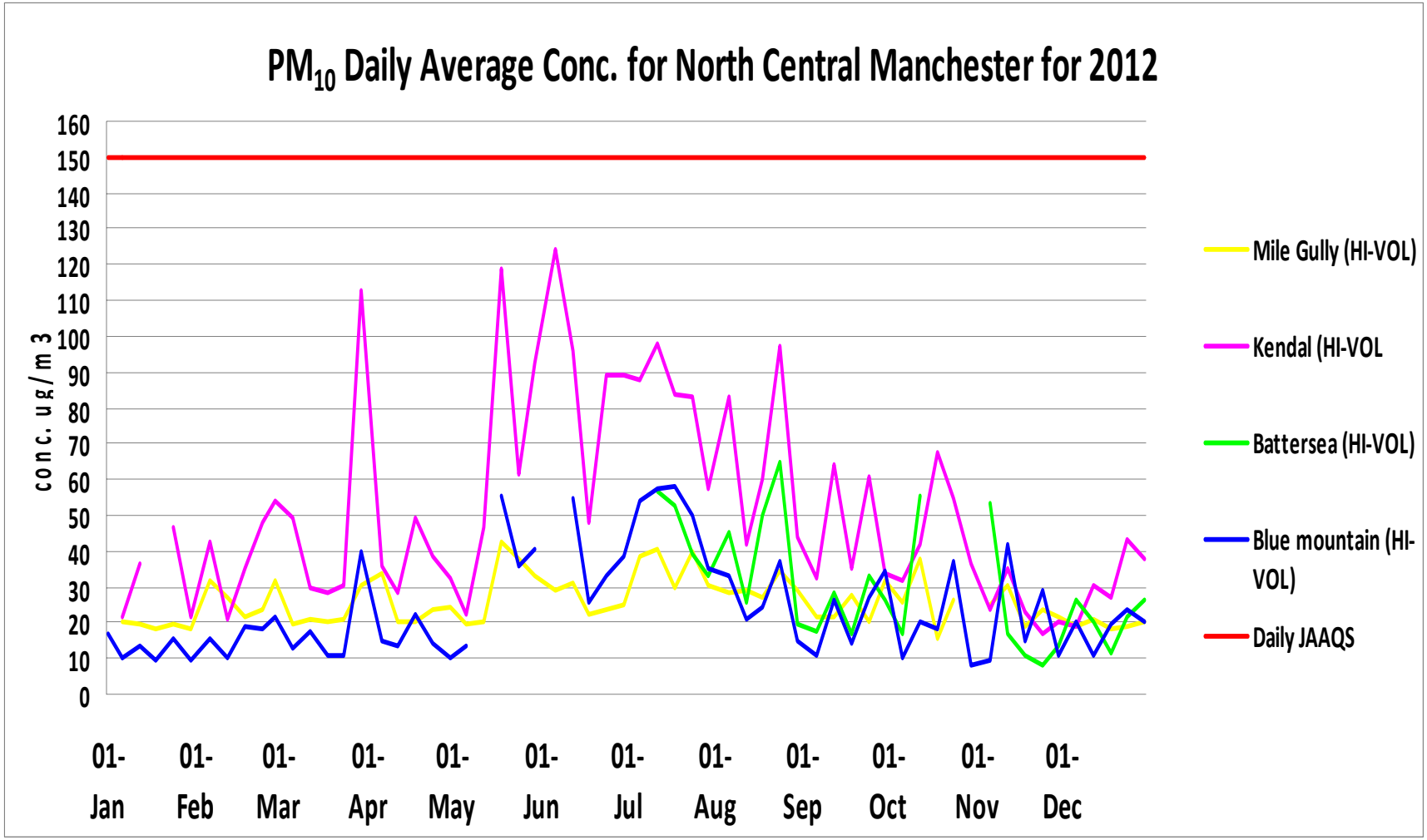


Figure 26A: Graph showing Annual PM_{10} average concentrations at the monitoring station in North Central Manchester for 2012

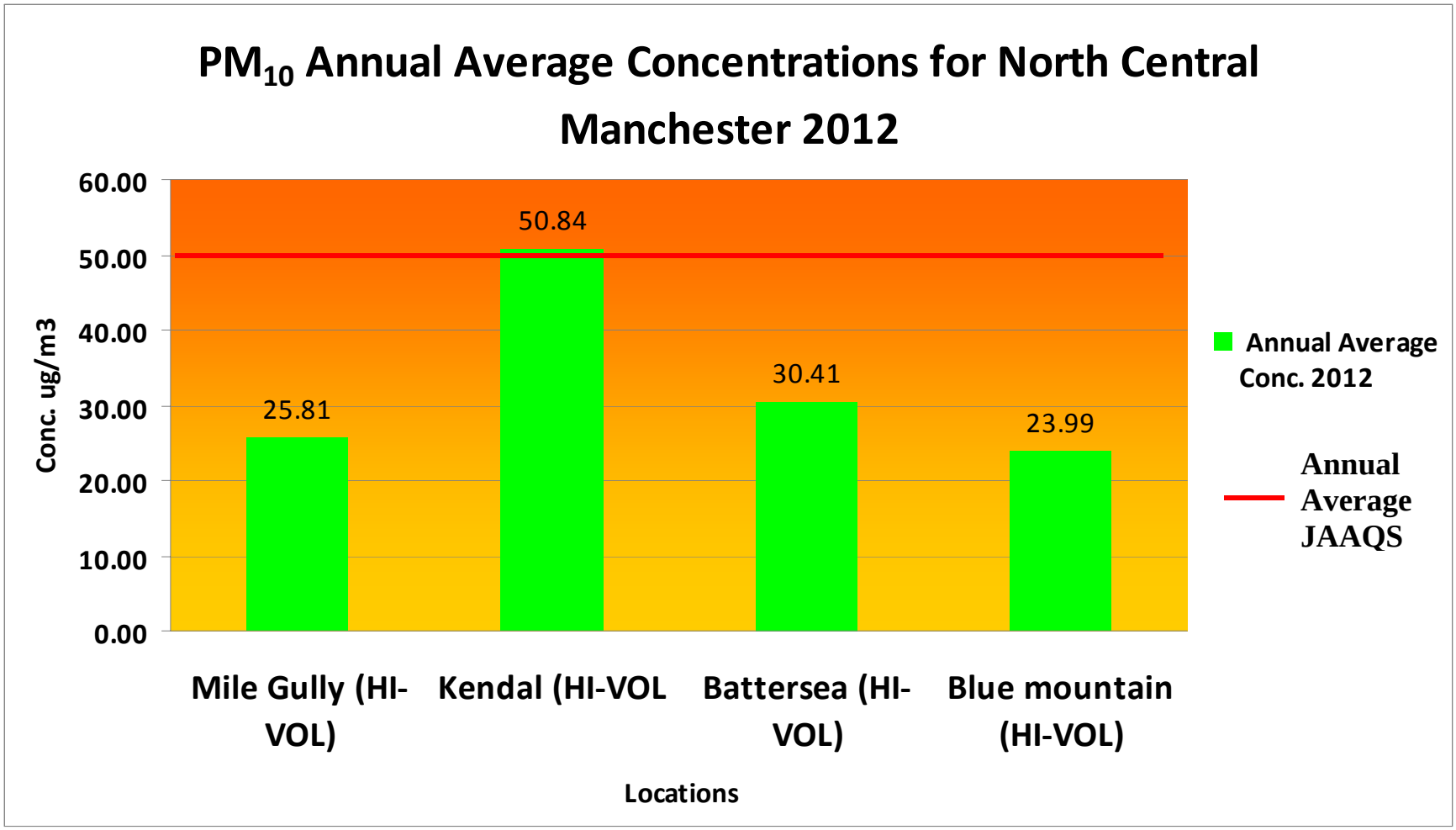


Figure 27A: Graph showing trend in ambient air quality for PM_{10} at the station in North Eastern St. Ann from Jan-Dec 2012

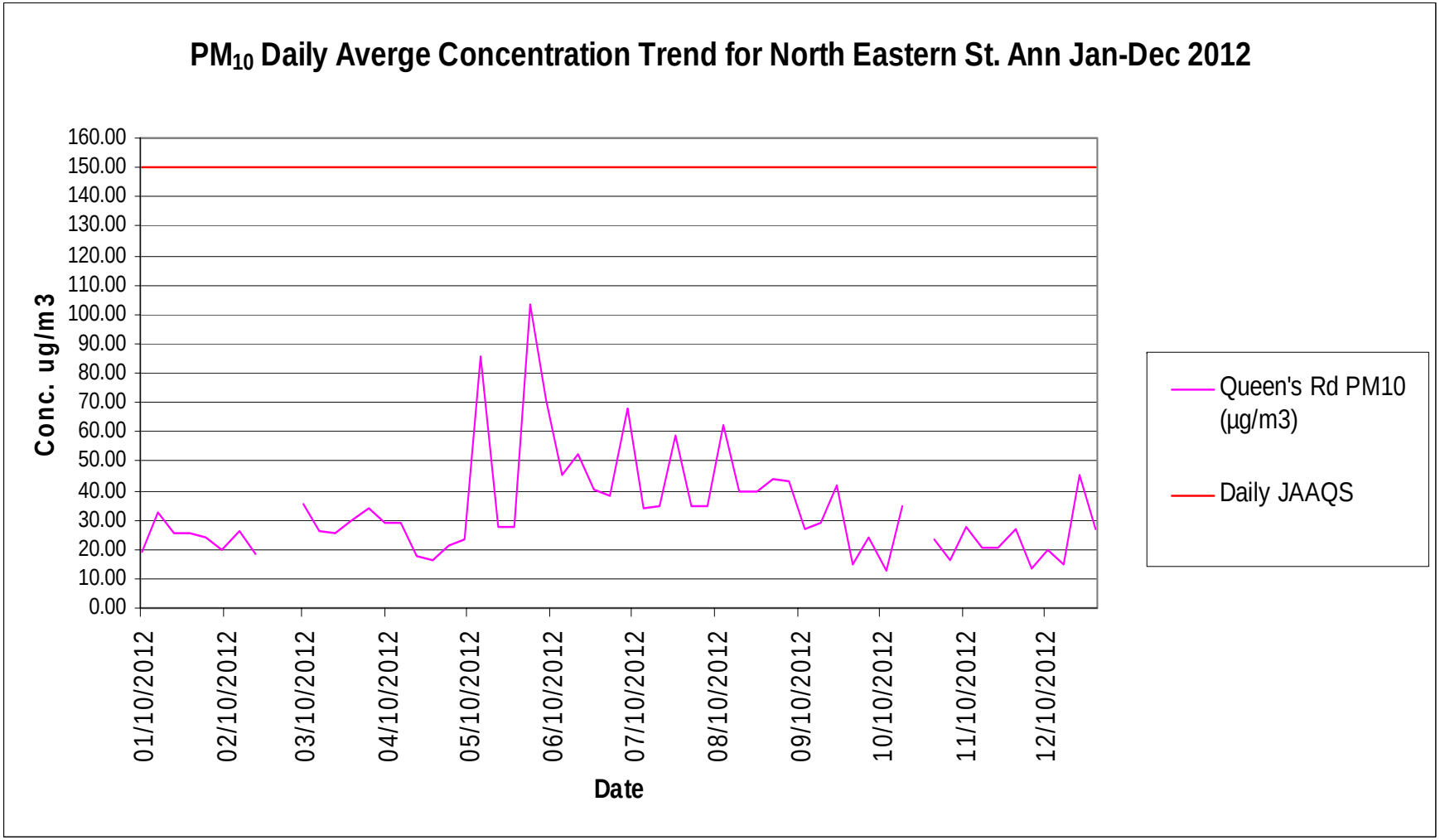
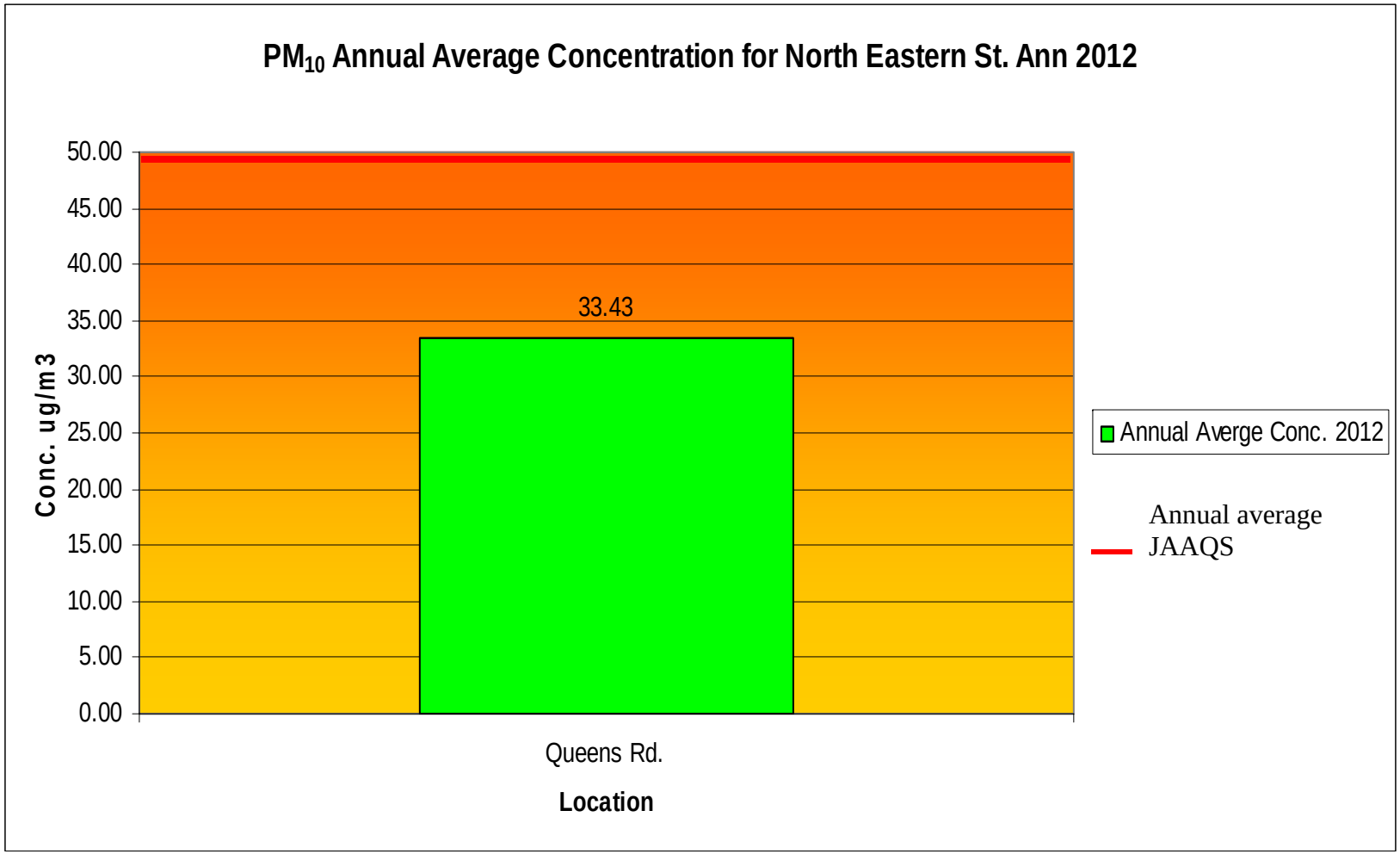


Figure 28A: Graph showing Annual PM_{10} average concentrations at the monitoring station in North Eastern St. Ann for 2012



Sulphur Dioxide

Figure 29A: Graph showing trend in ambient air quality for Sulphur Dioxide at the three stations in Kingston and St. Andrew from Jan-Dec 2012

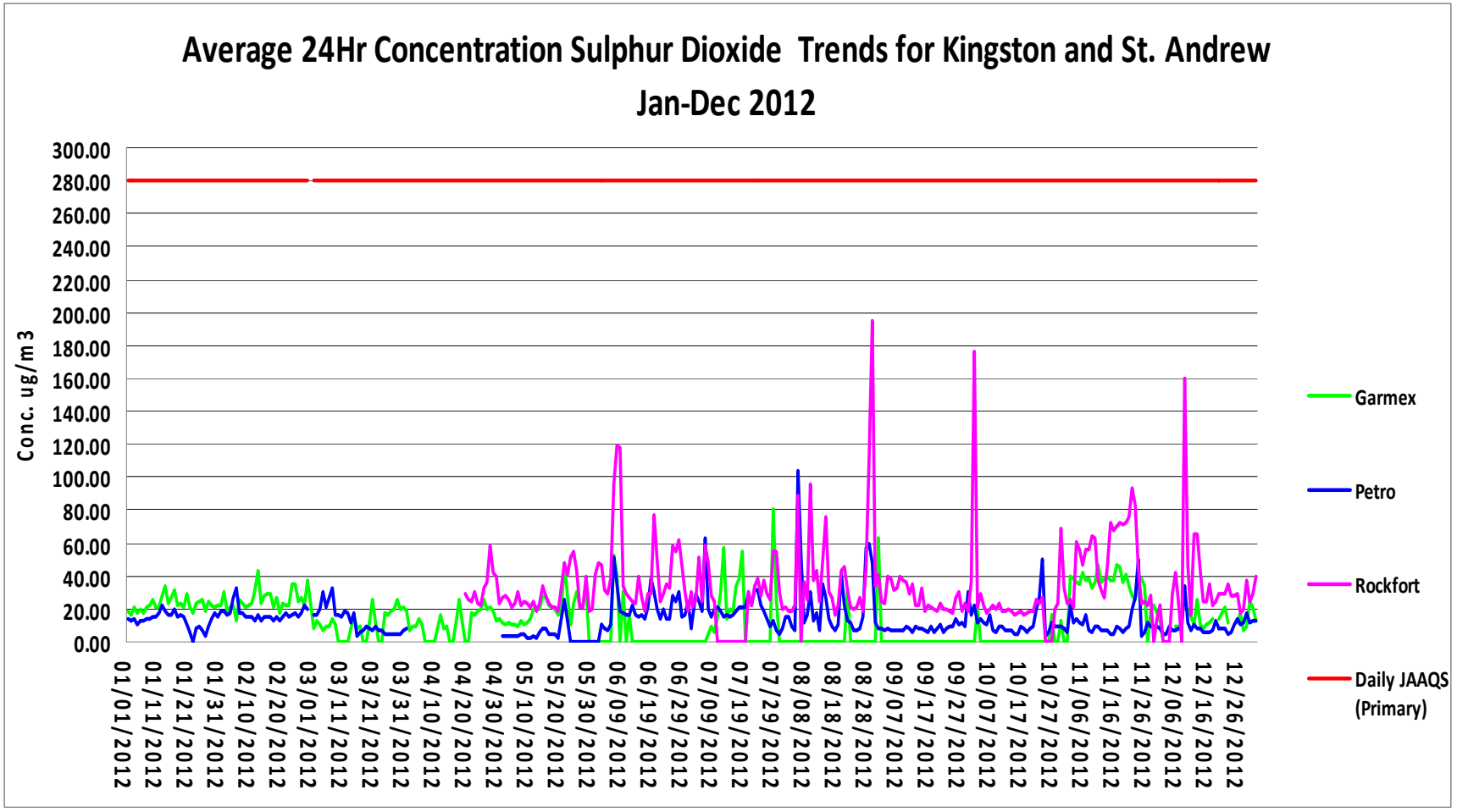


Figure 30A: Graph showing Annual Sulphur Dioxide average concentrations at all monitoring stations in Kingston and St. Andrew for 2012

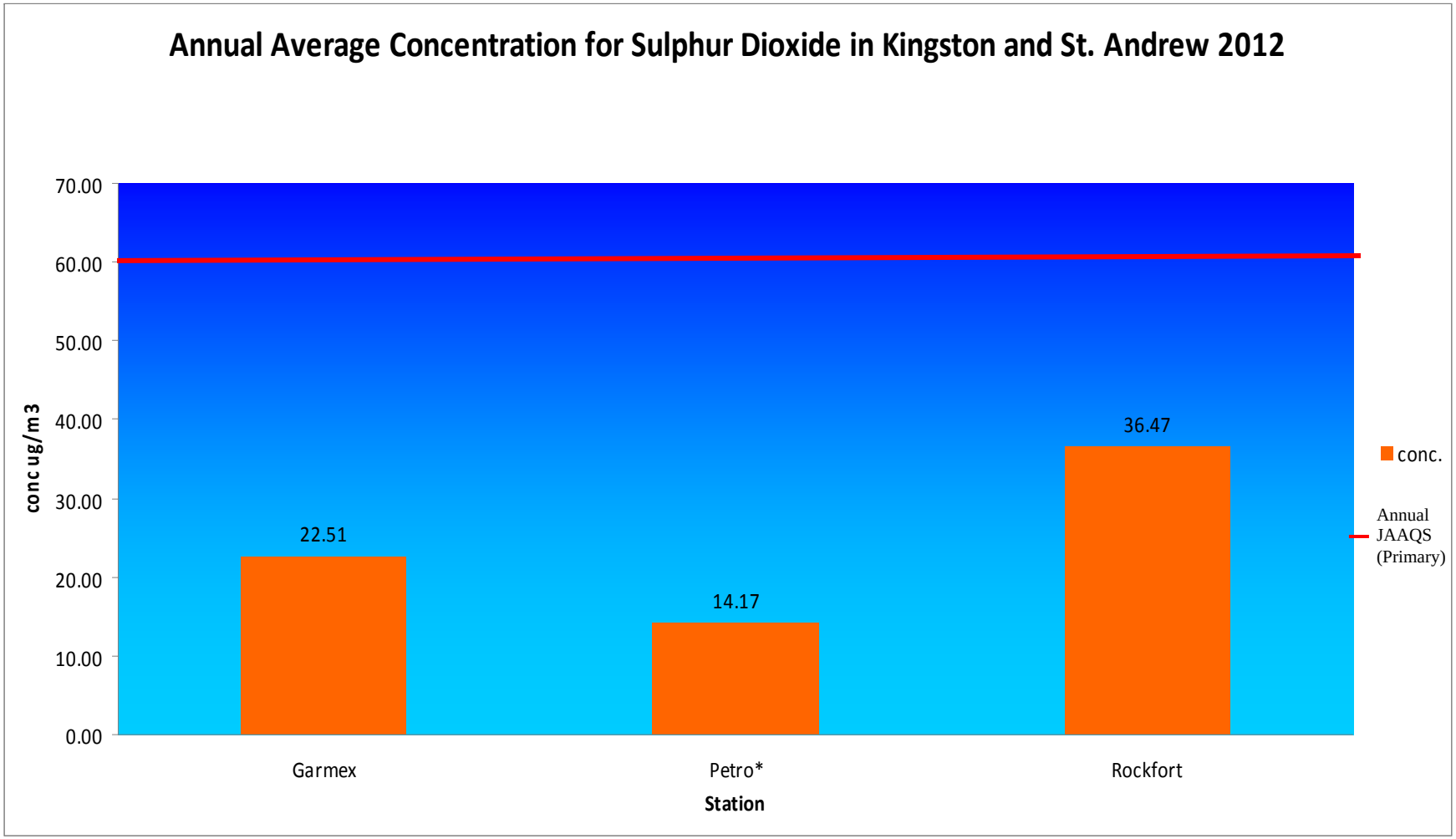


Figure 31A: Graph showing trend in ambient air quality for Sulphur Dioxide at the station in Montego Bay from Jan-Dec 2012

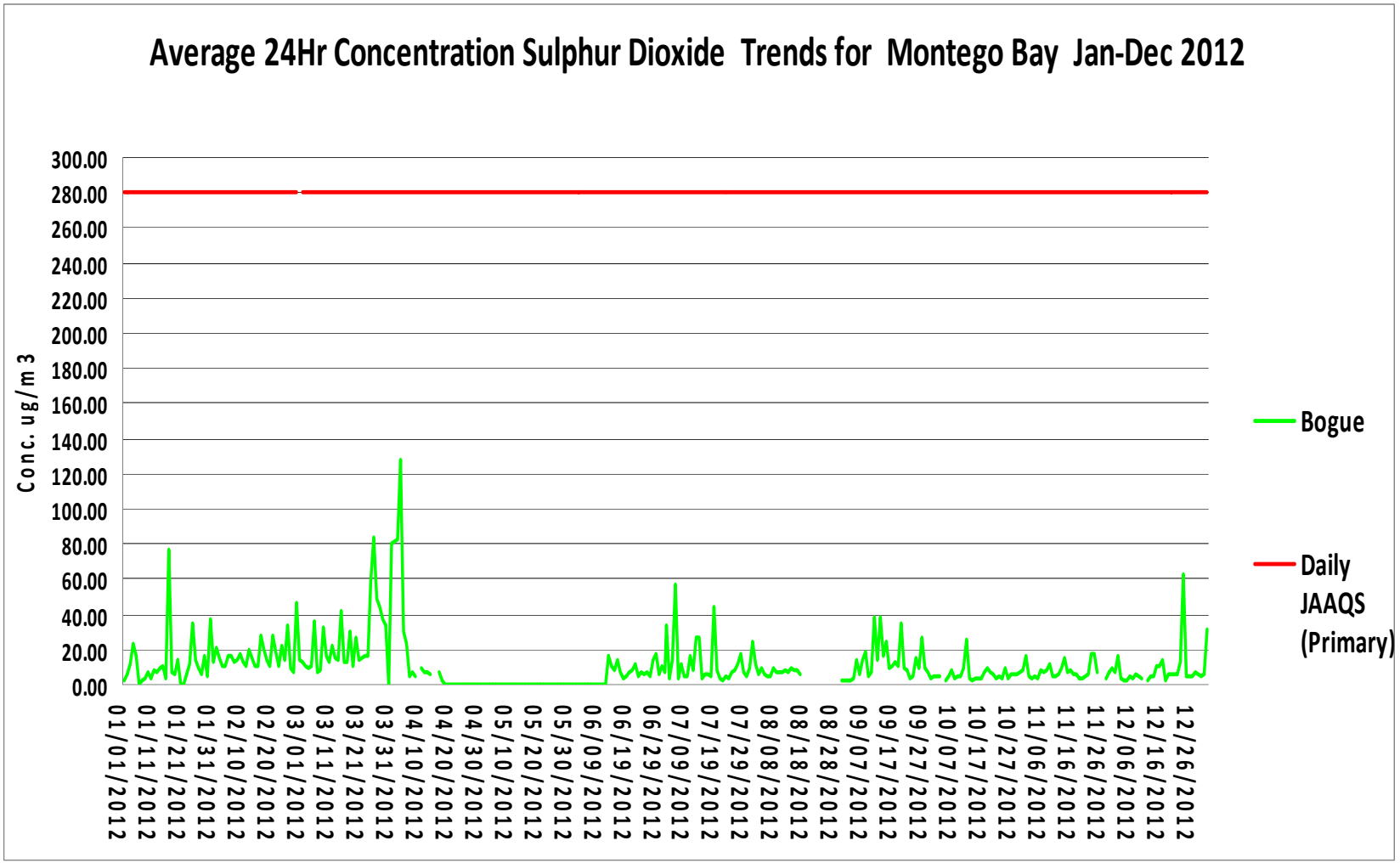


Figure 32A: Graph showing Annual Sulphur Dioxide average concentrations at all monitoring stations in Montego Bay for 2012

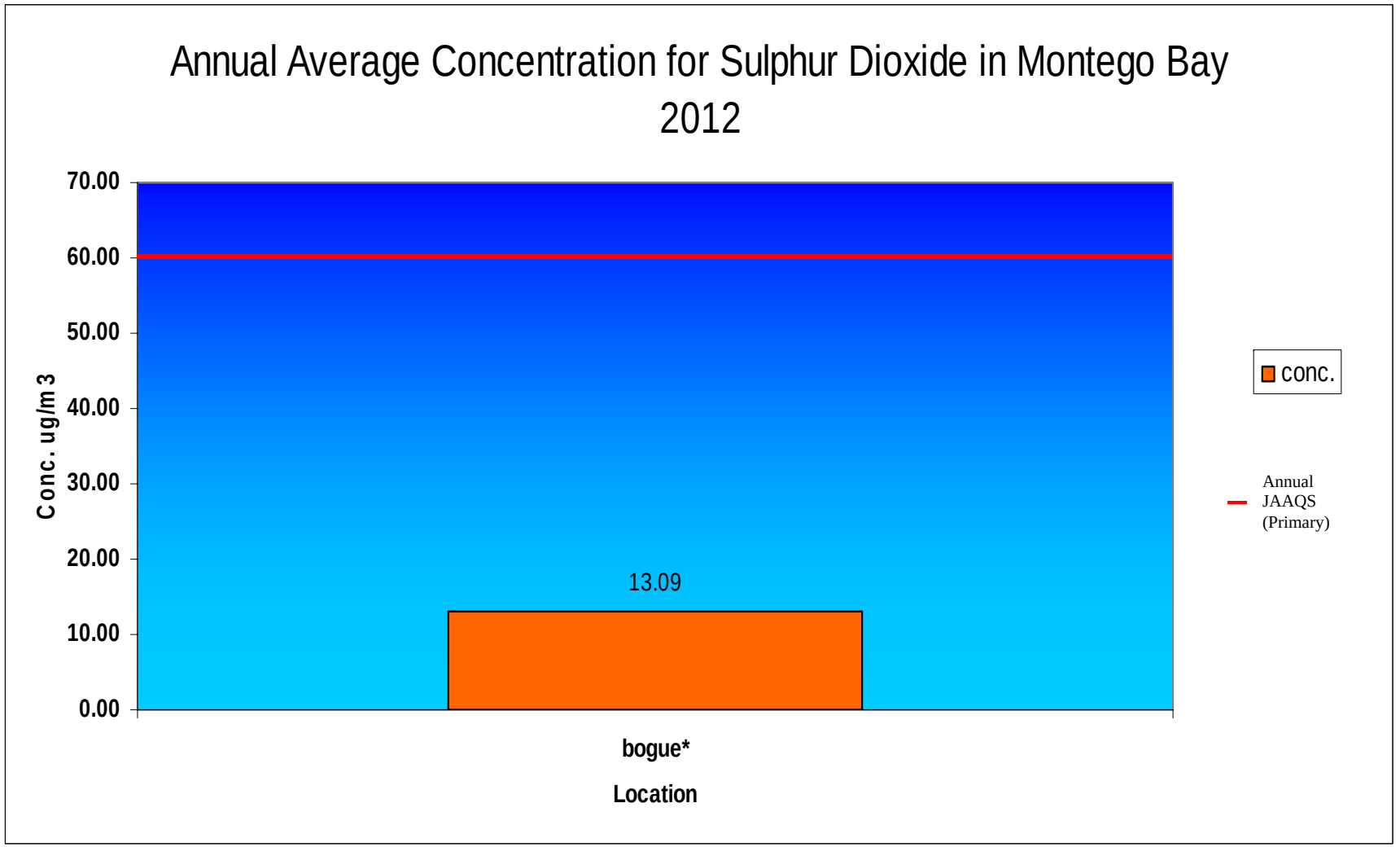


Figure 33A: Graph showing trend in ambient air quality for Sulphur Dioxide at the two stations Northern St. Catherine from Jan-Dec 2012

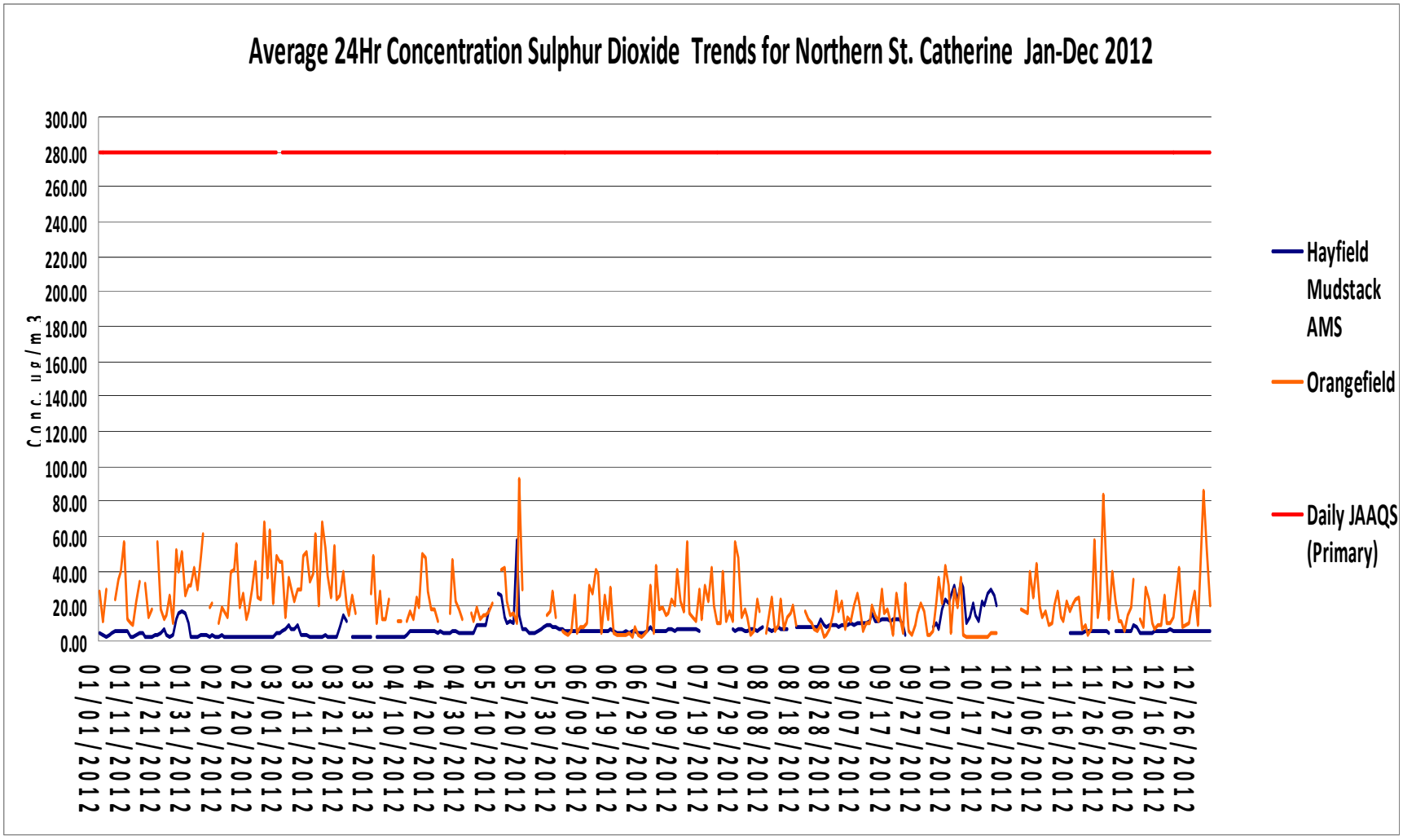


Figure 34A: Graph showing Annual Sulphur Dioxide average concentrations at all monitoring stations in Northern St. Catherine for 2012

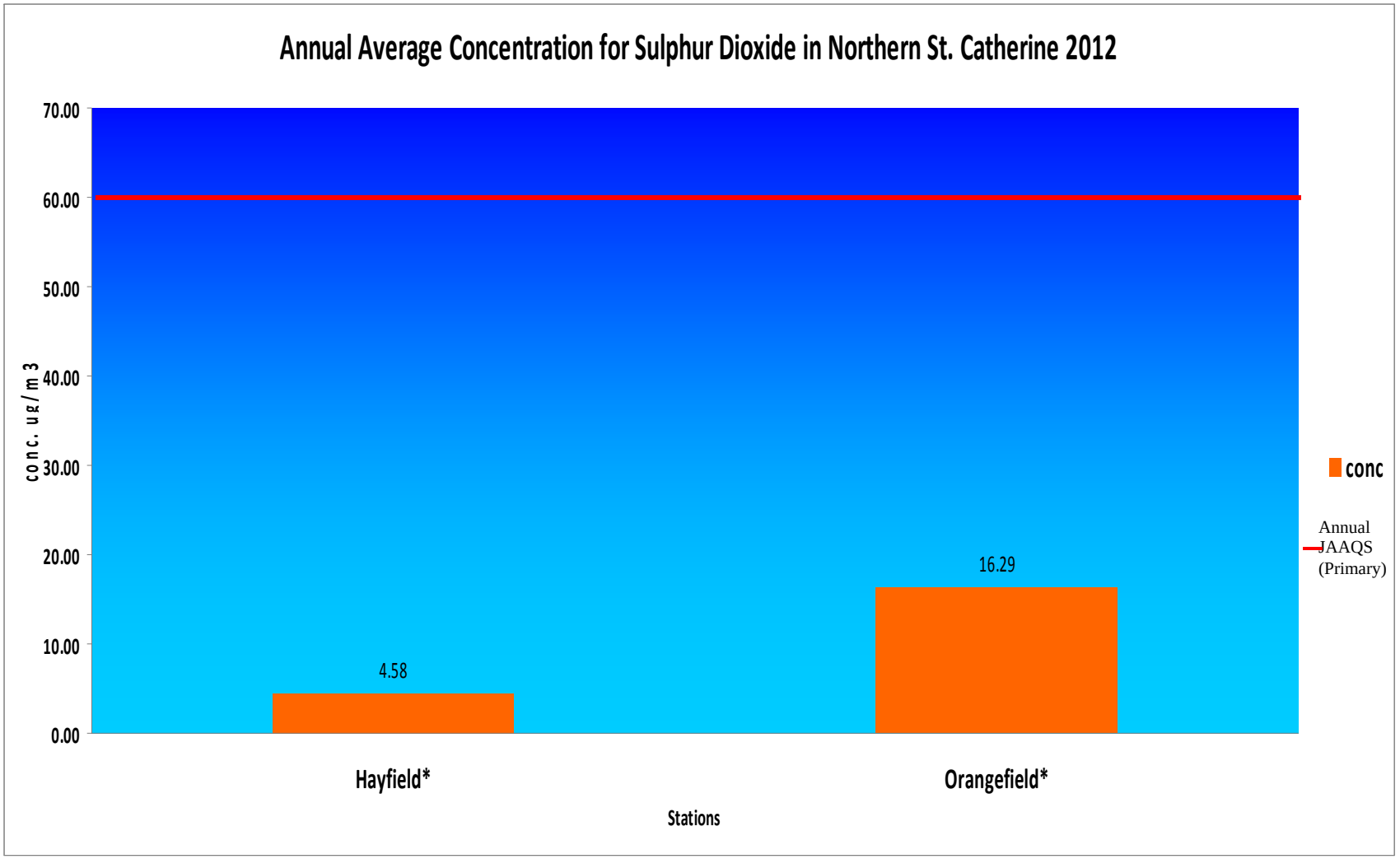


Figure 35A: Graph showing trend in ambient air quality for Sulphur Dioxide at the three stations for Old Harbour Bay, St. Catherine from Jan-Dec 2012

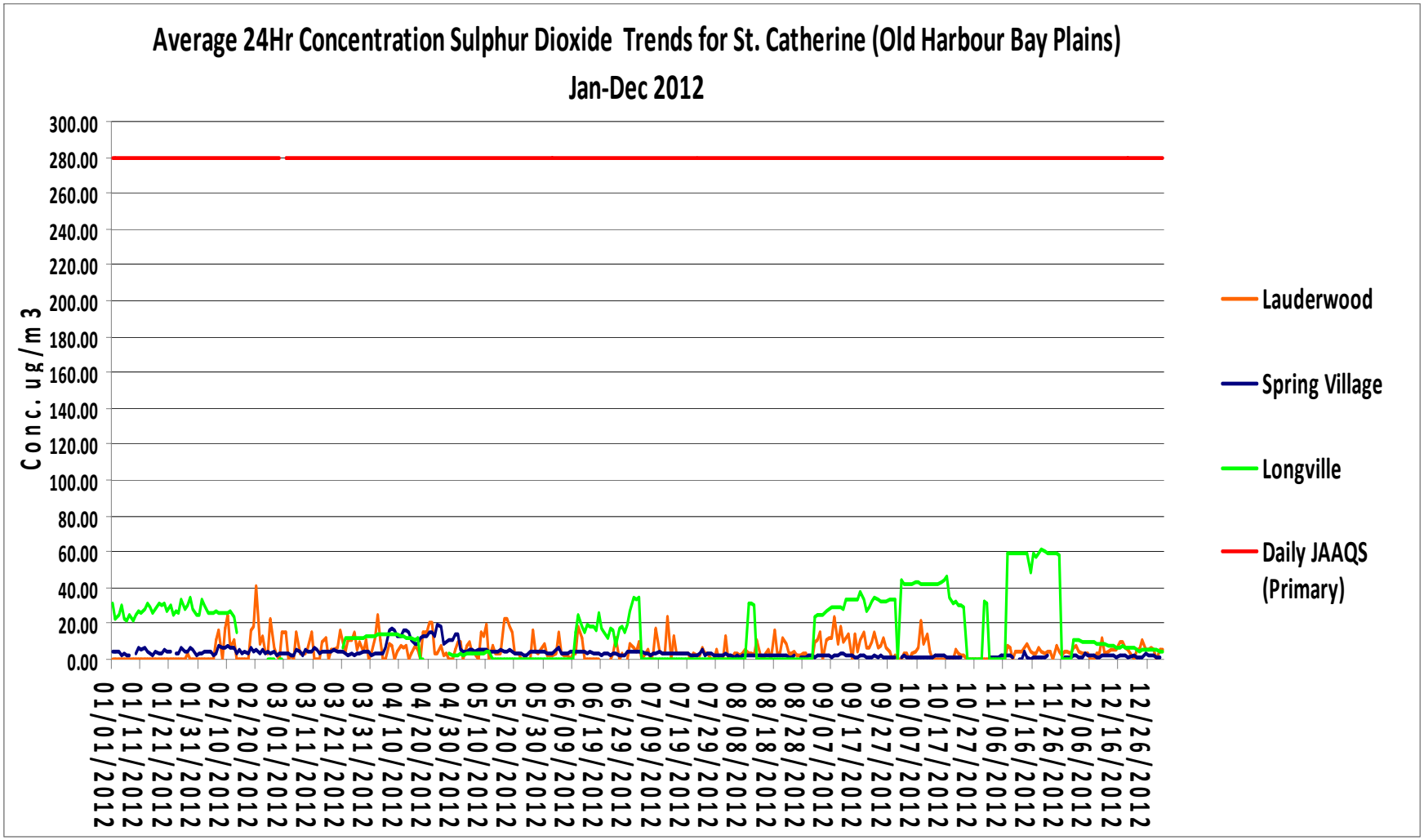


Figure 36A: Graph showing Annual Sulphur Dioxide average concentrations at all monitoring stations in Old Harbour Bay, St. Catherine for 2012

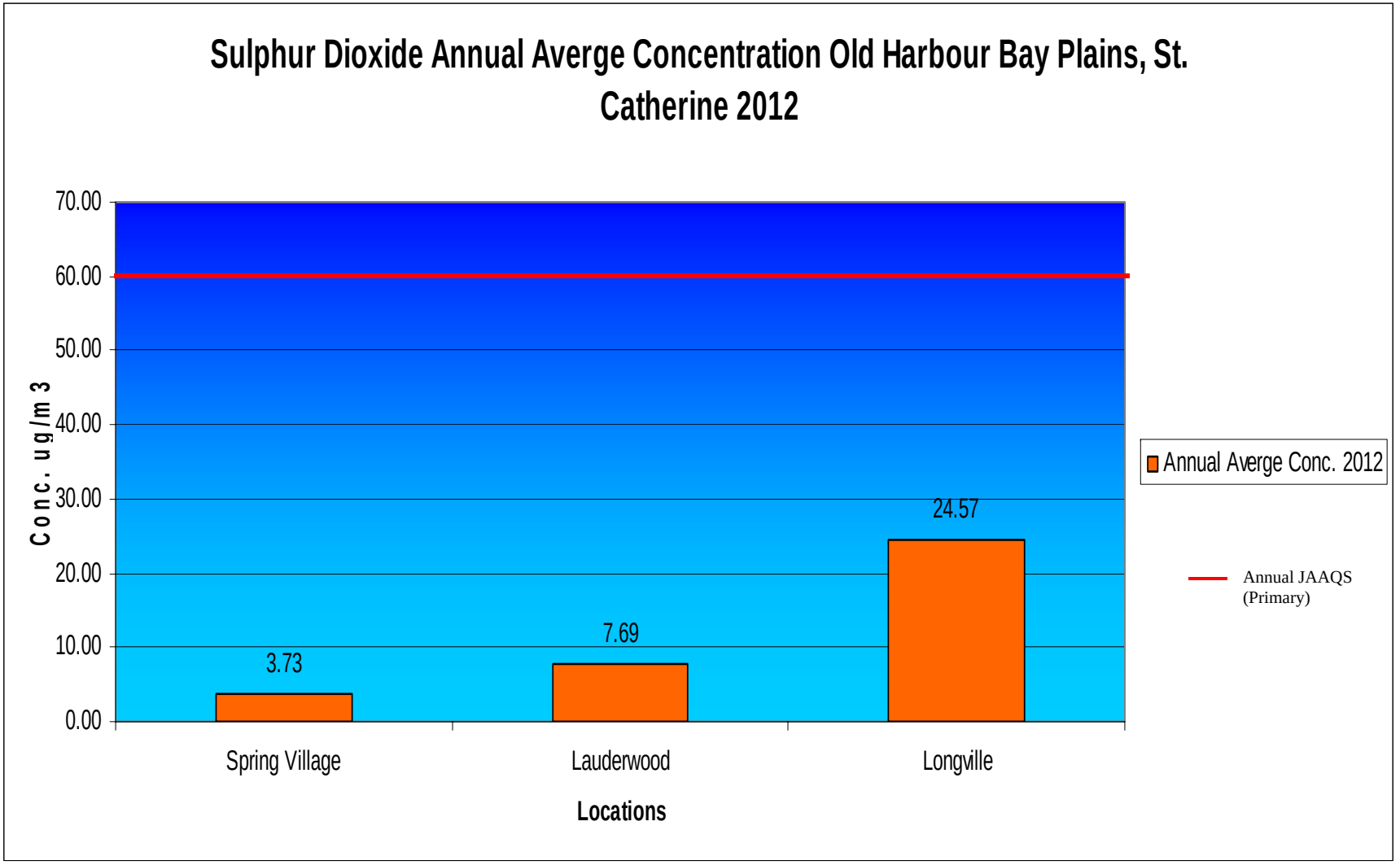


Figure 37A: Graph showing trend in ambient air quality for Sulphur Dioxide at the three stations for Vere Plains, Clarendon from Jan-Dec 2012

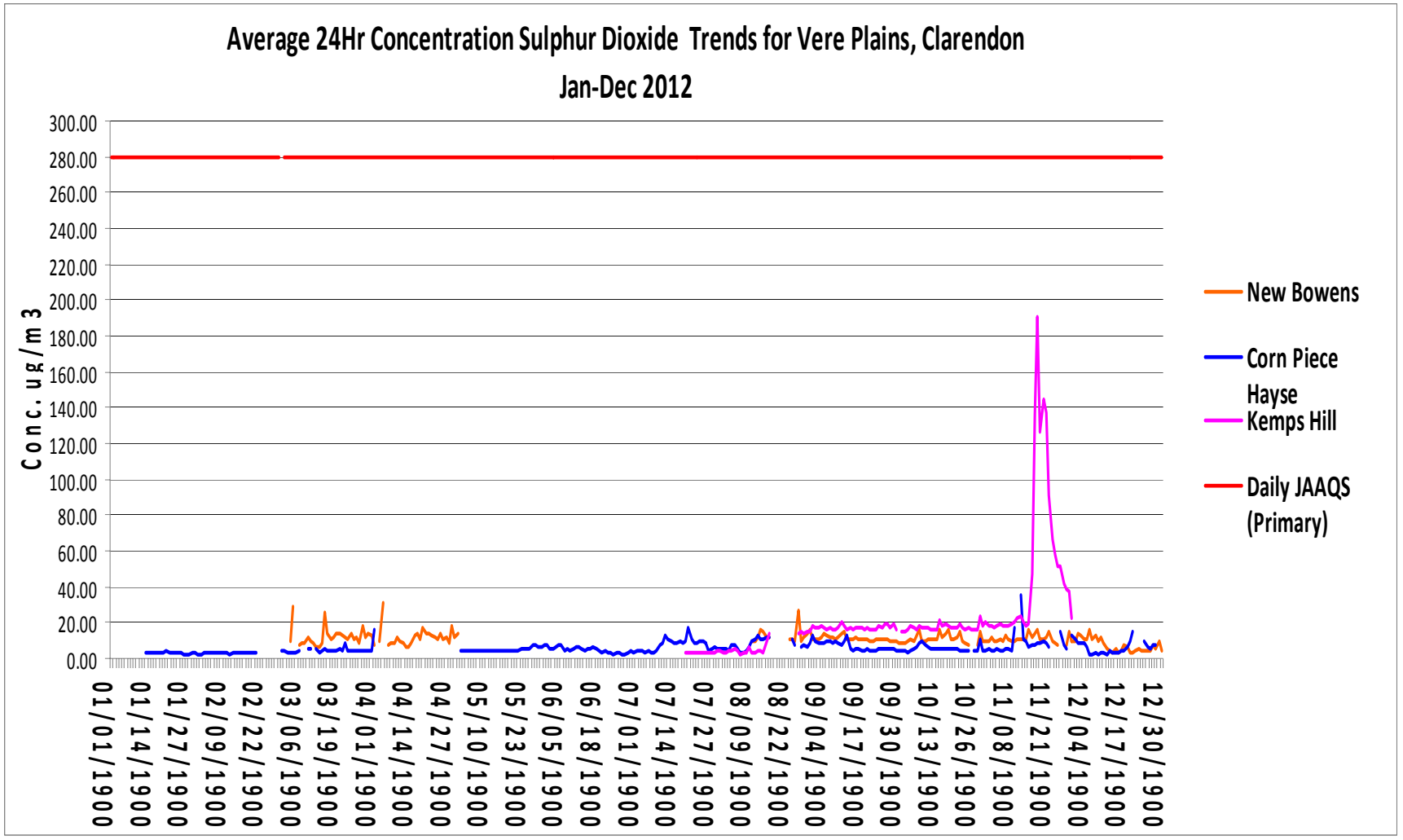
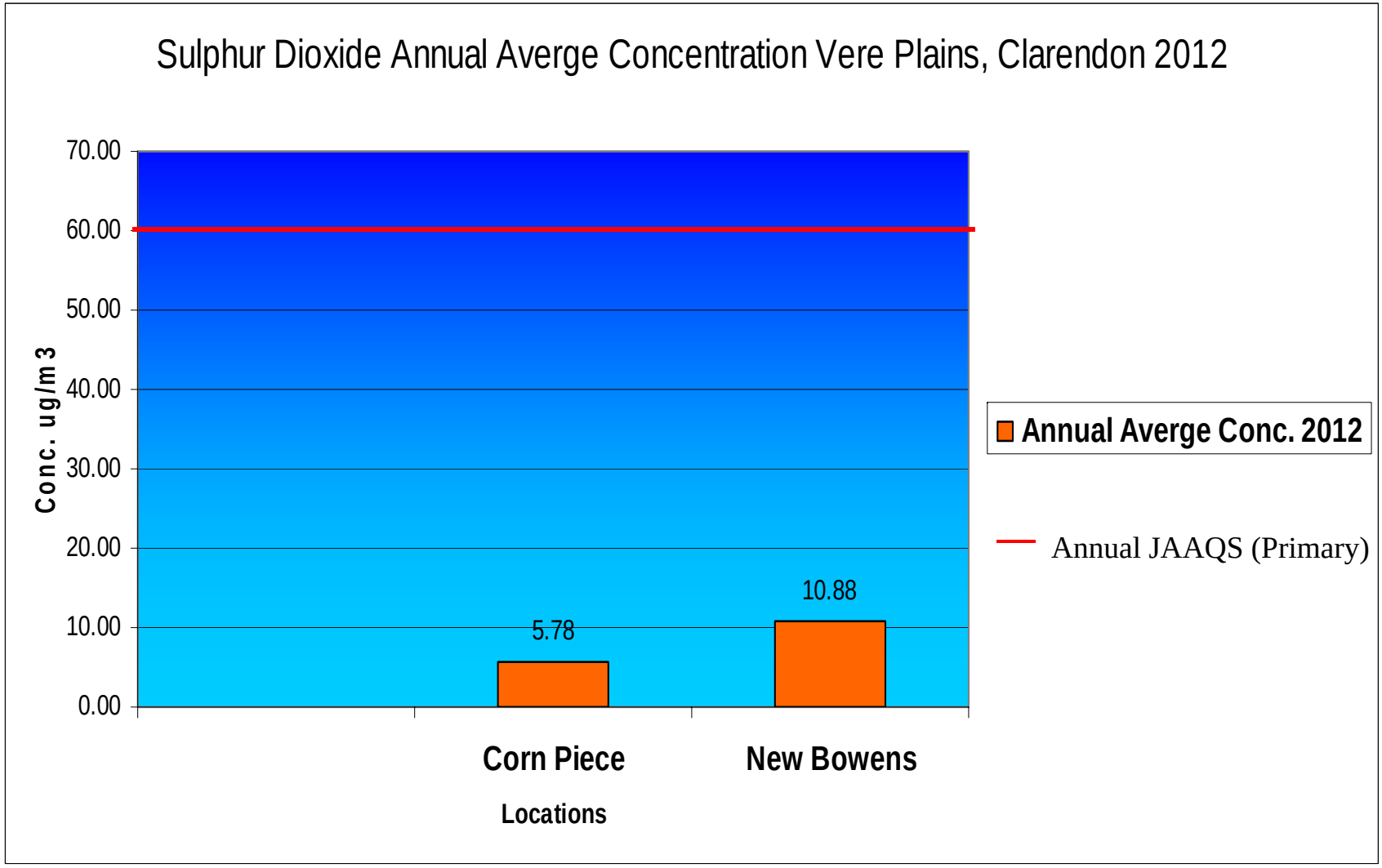
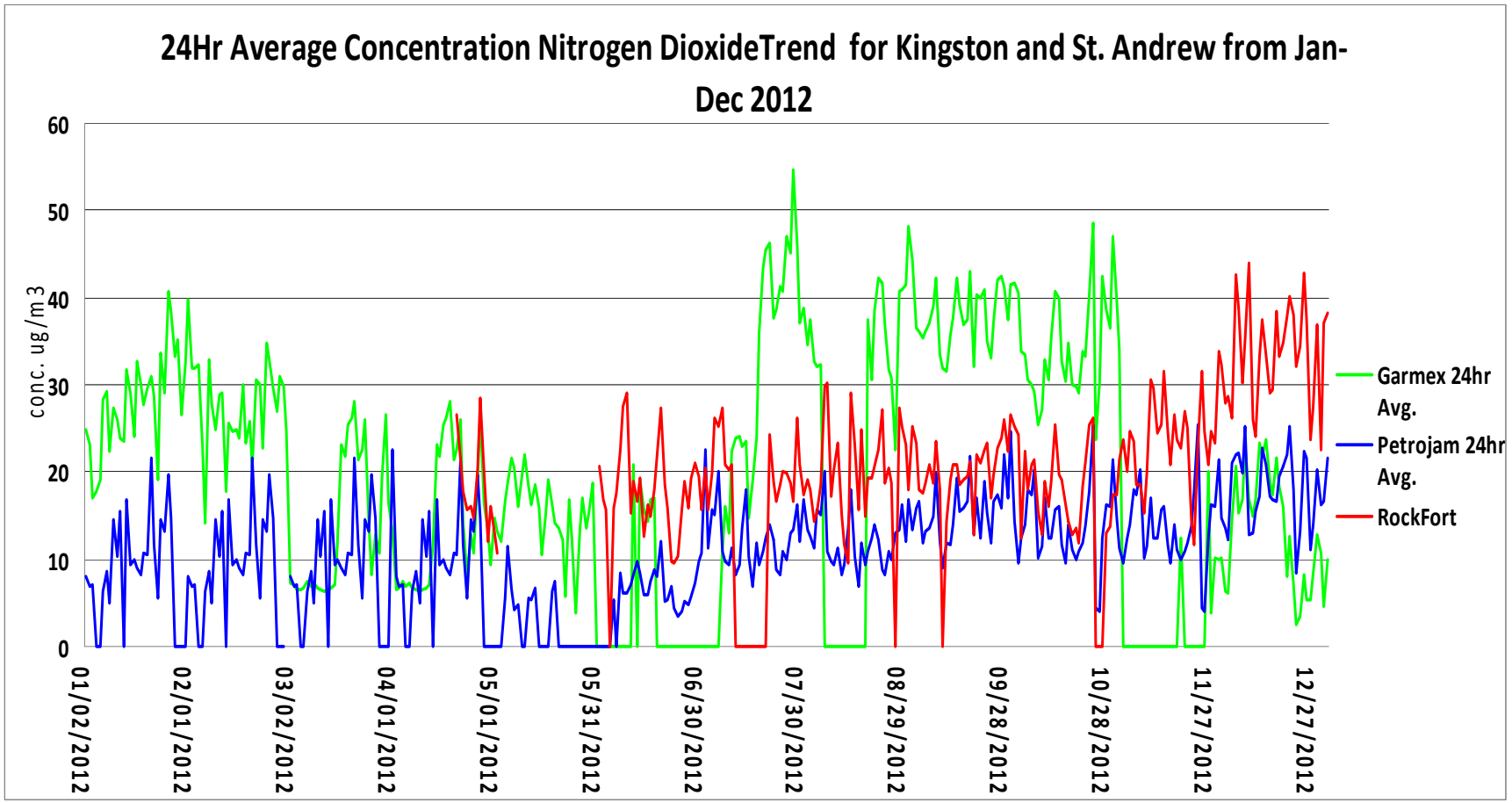


Figure 38A: Graph showing Annual Sulphur Dioxide average concentrations at all monitoring stations in Vere Plains, Clarendon for 2012



Nitrogen Dioxide

Figure 39A: Graph showing trend in ambient air quality for Nitrogen Dioxide at the stations in Kingston and St. Andrew from Jan-Dec 2012



***No daily standard exists for Nitrogen Dioxide; however, a guideline 1 hour standard of 400ug/m³ was developed by the NRCA**

Figure 40A: Graph showing Annual Nitrogen Dioxide average concentrations at all monitoring stations in Kingston and St. Andrew for 2012

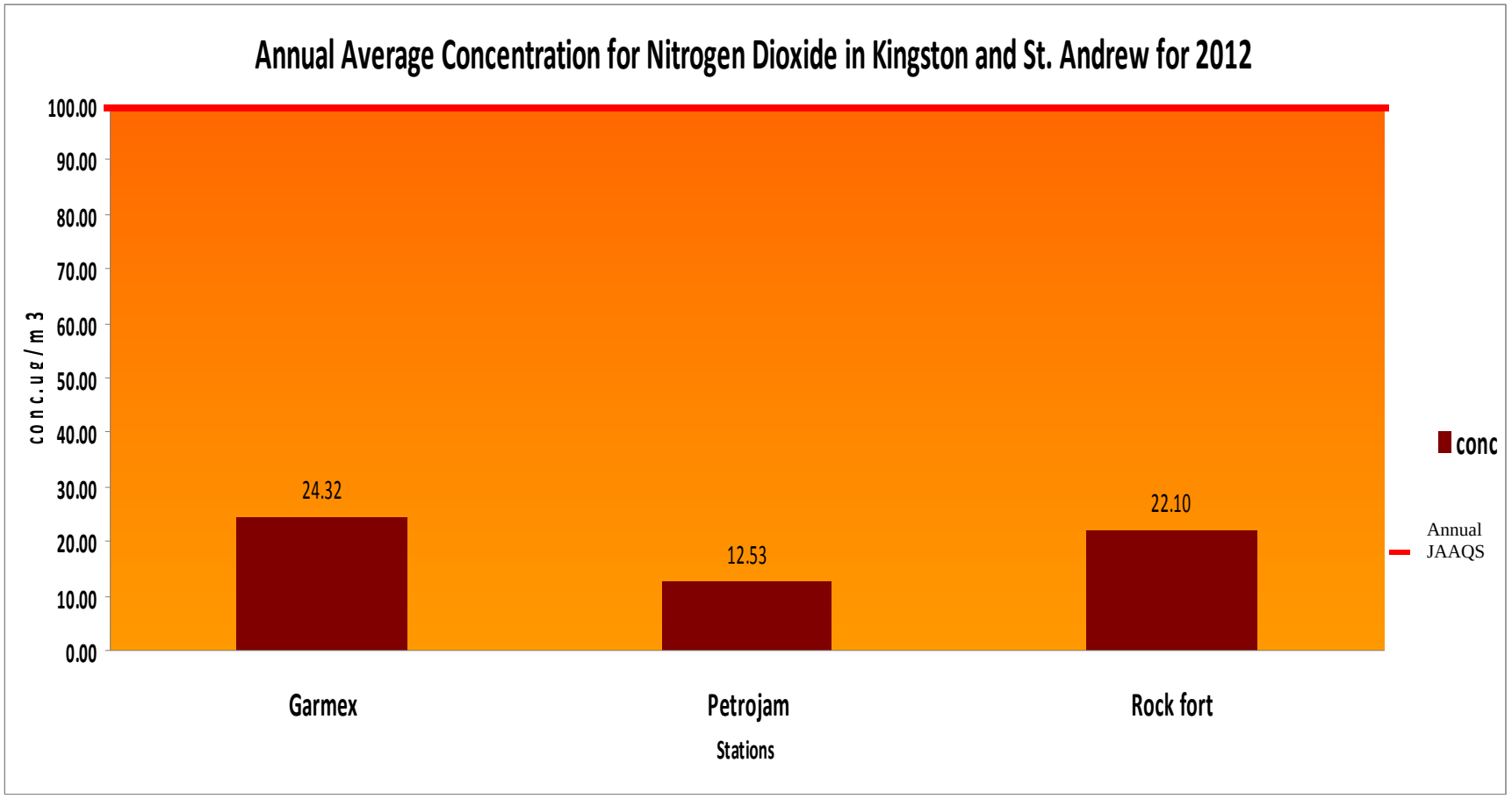
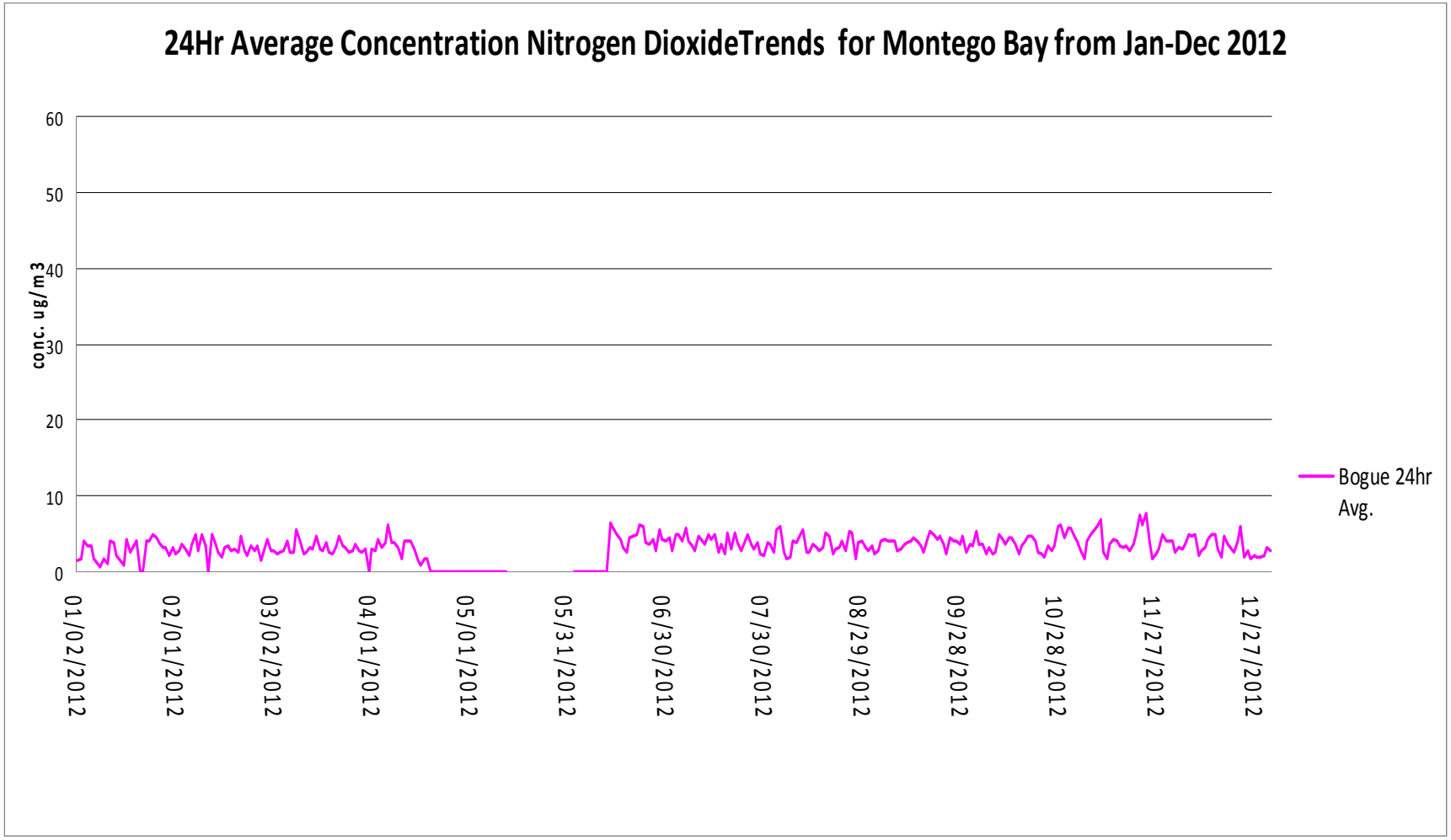


Figure 41A: Graph showing trend in ambient air quality for Nitrogen Dioxide at the stations in Montego Bay from Jan-Dec 2012



***No daily standard exists for Nitrogen Dioxide; however, a guideline 1 hour standard of 400ug/m³ was developed by the NRCA**

Figure 42A: Graph showing Annual Nitrogen Dioxide average concentrations at all monitoring stations in Montego Bay for 2012

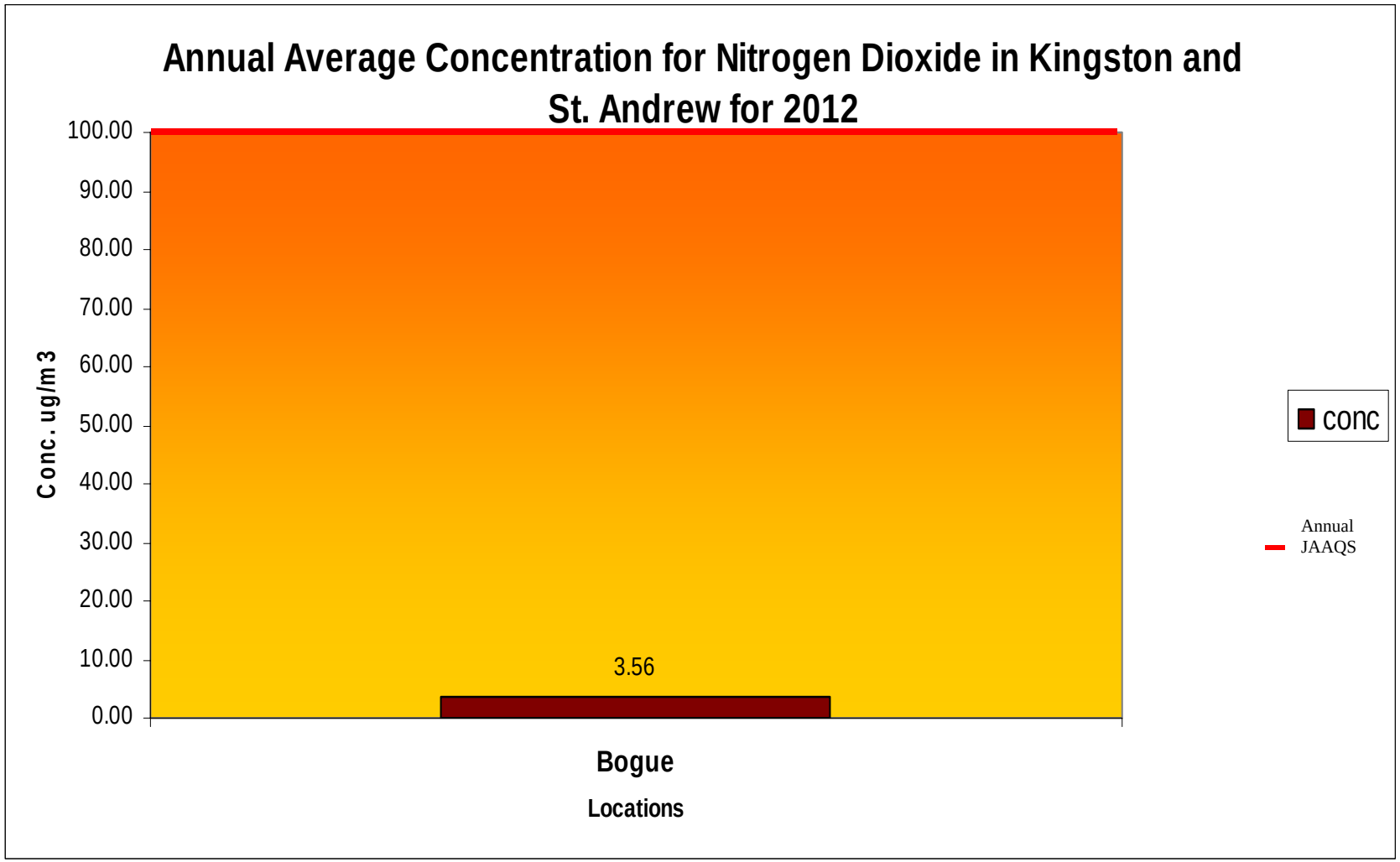
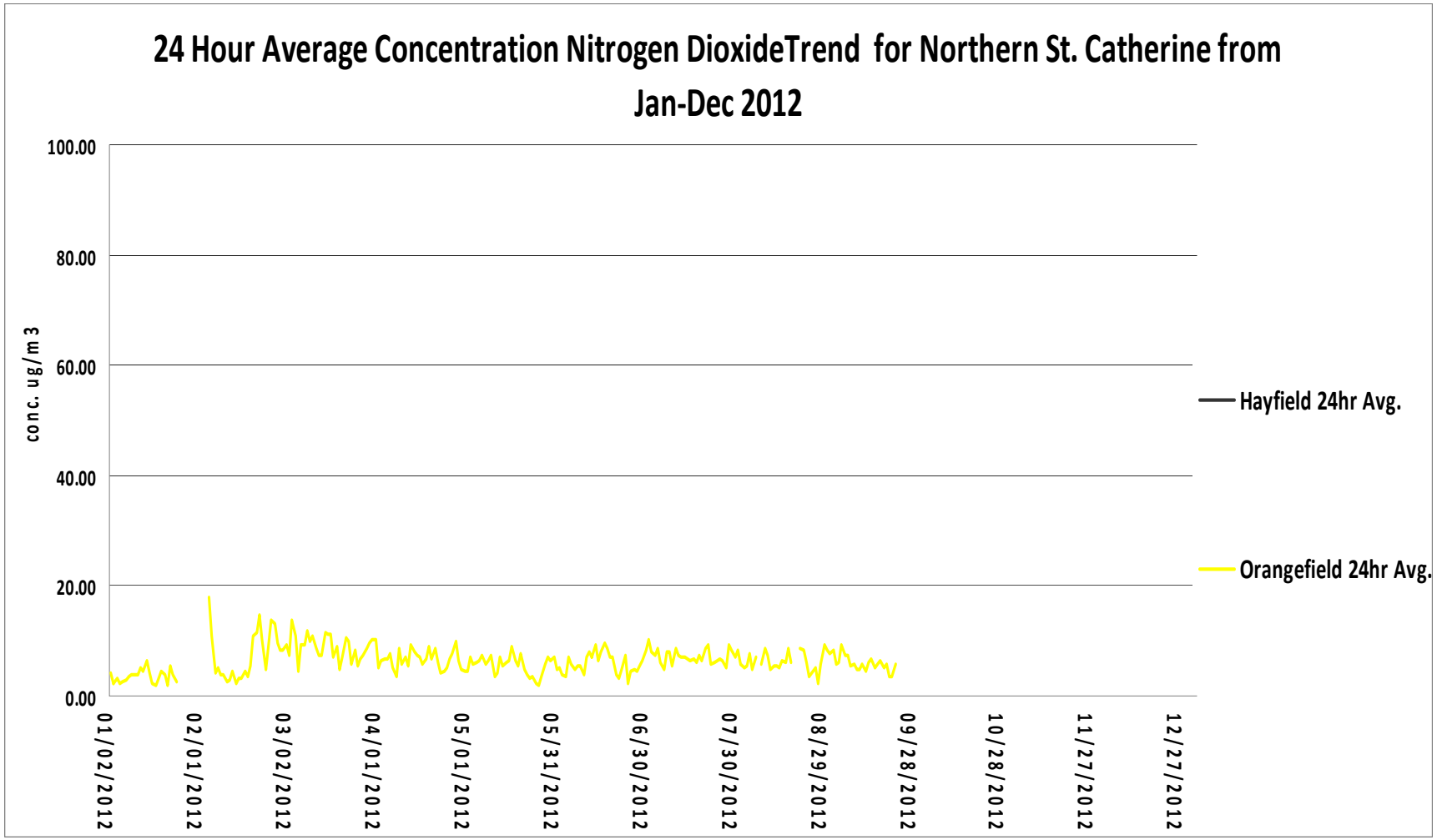


Figure 43A: Graph showing trend in ambient air quality for Nitrogen Dioxide at the stations in Northern St. Catherine from Jan-Dec 2012



***No daily standard exists for Nitrogen Dioxide; however, a guideline 1 hour standard of 400ug/m³ was prepared and used**

Figure 44A: Graph showing Annual Nitrogen Dioxide average concentrations at all monitoring stations in Northern St. Catherine for 2012

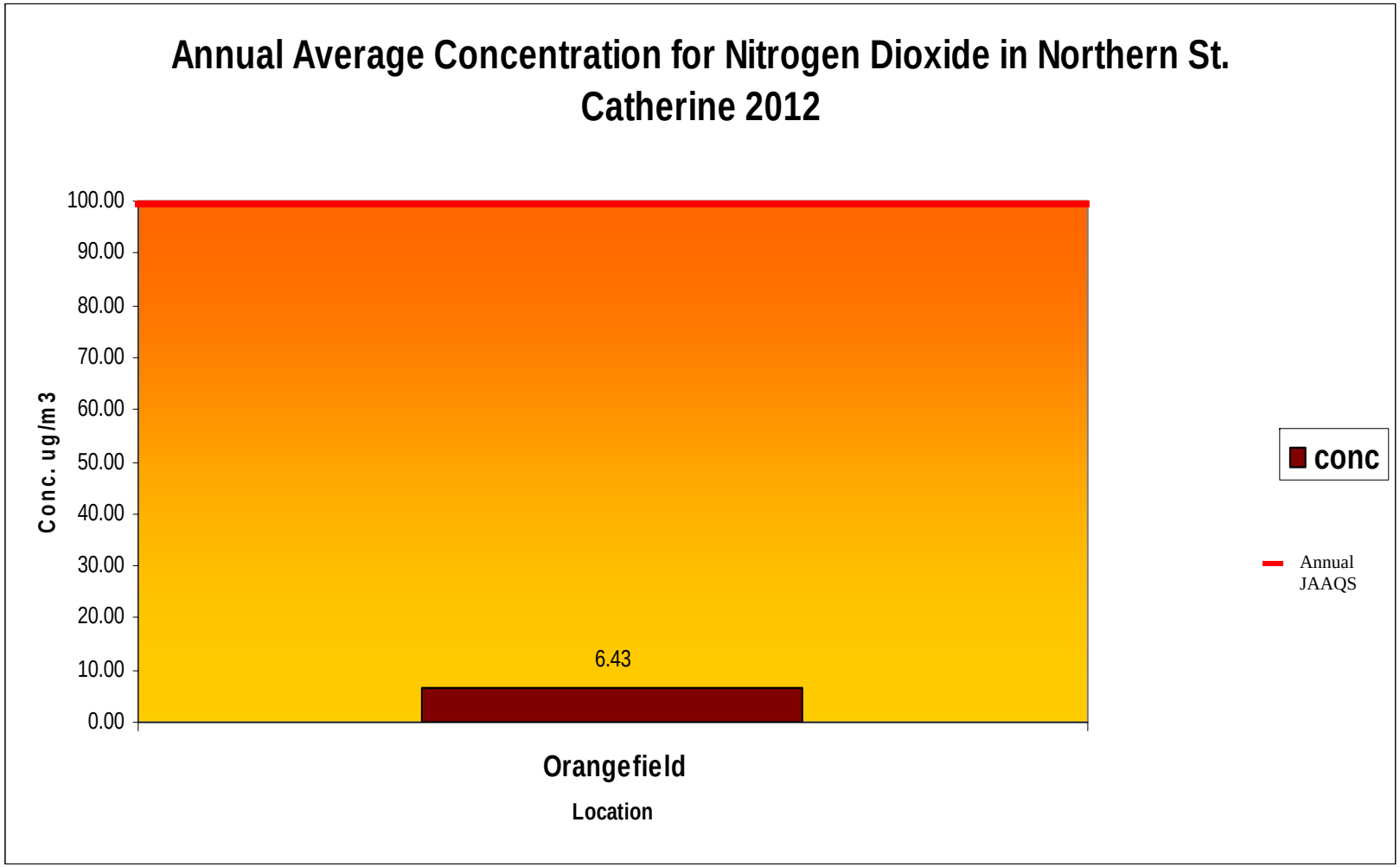
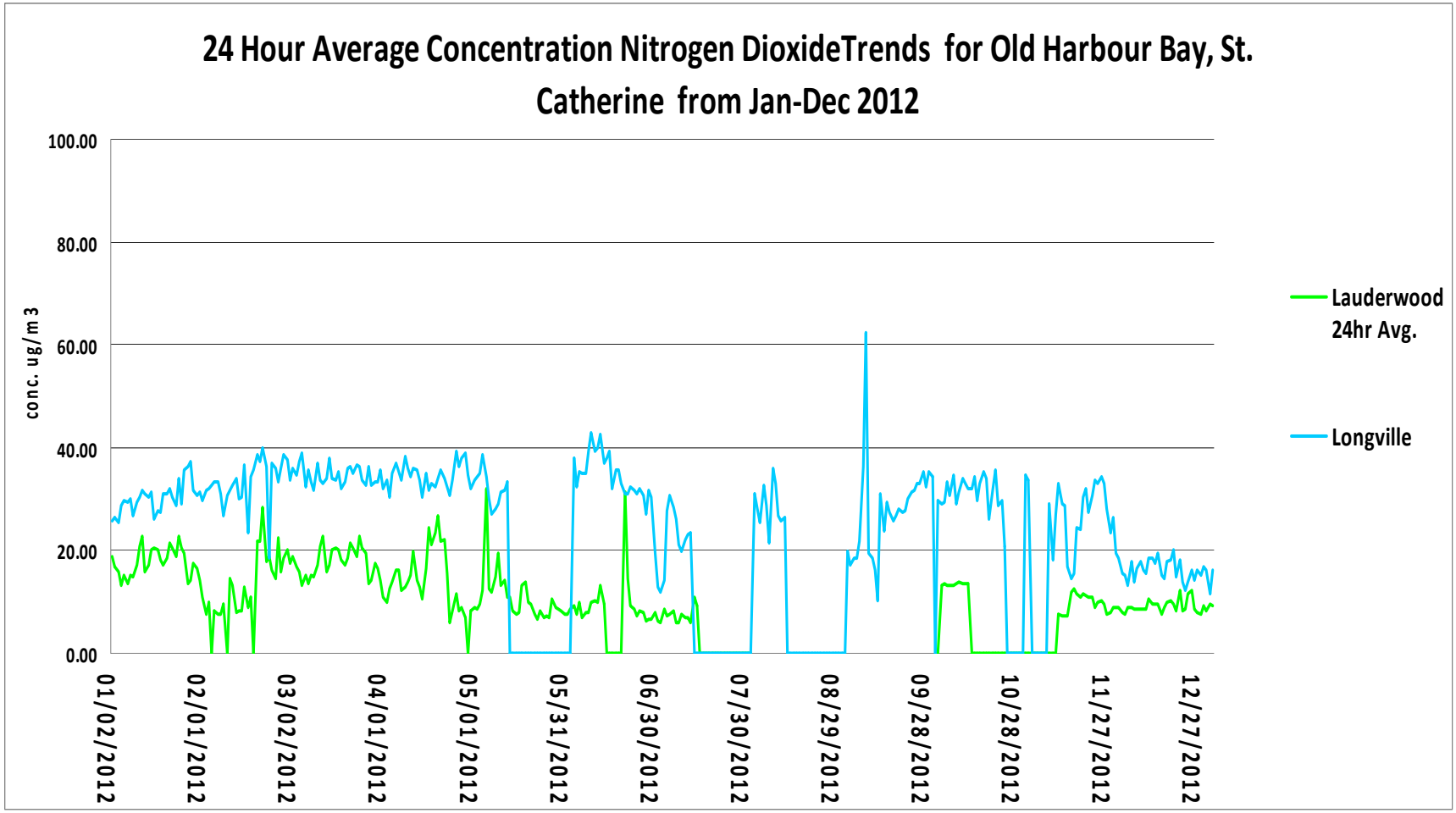


Figure 45A: Graph showing trend in ambient air quality for Nitrogen Dioxide at the stations in Old Harbour Bay St. Catherine from Jan-Dec 2012



***No daily standard exists for Nitrogen Dioxide; however, a guideline 1 hour standard of 400ug/m³ was developed by the NRCA**

Figure 46A: Graph showing Annual Nitrogen Dioxide average concentrations at all monitoring stations in Old Harbour Bay St. Catherine for 2012

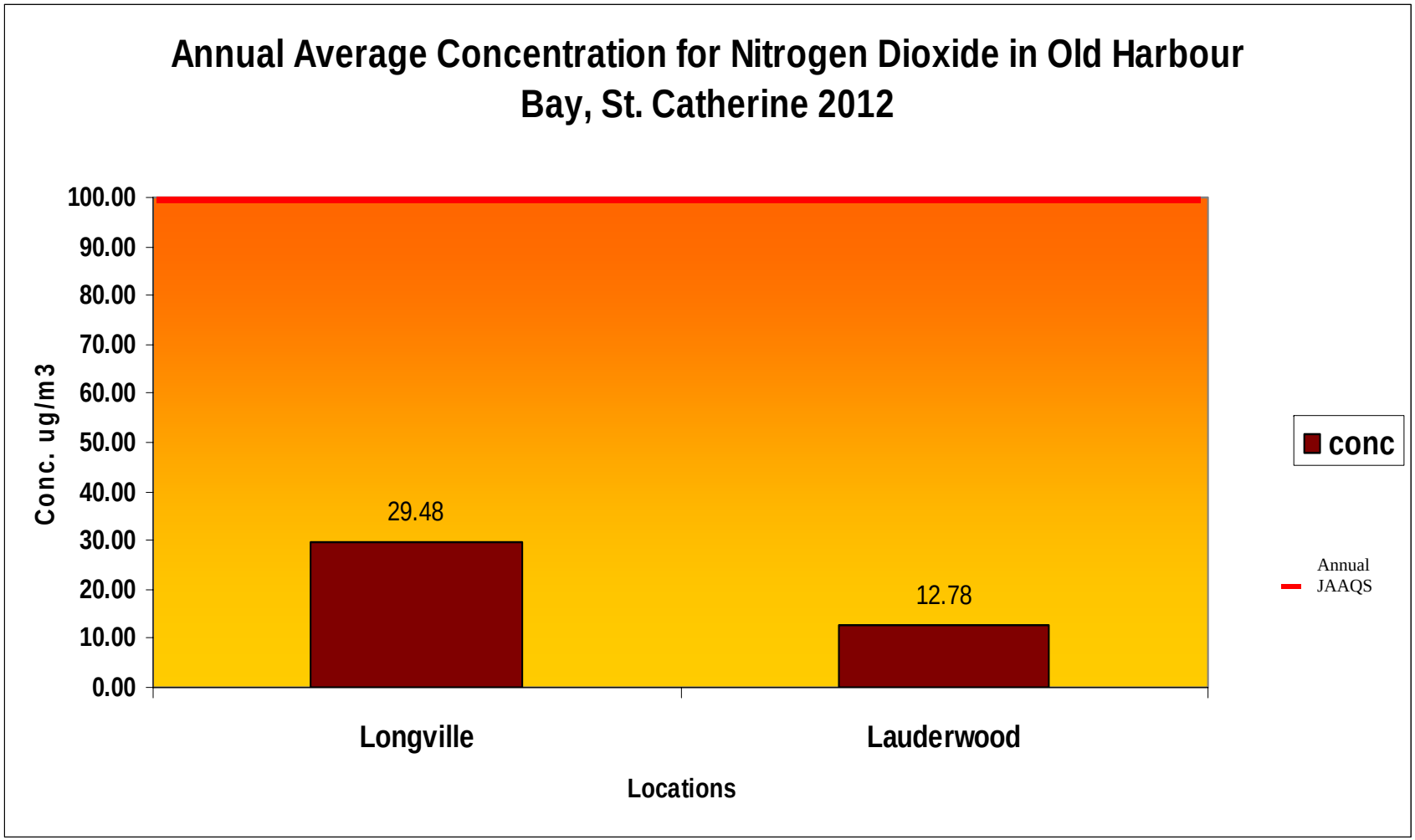
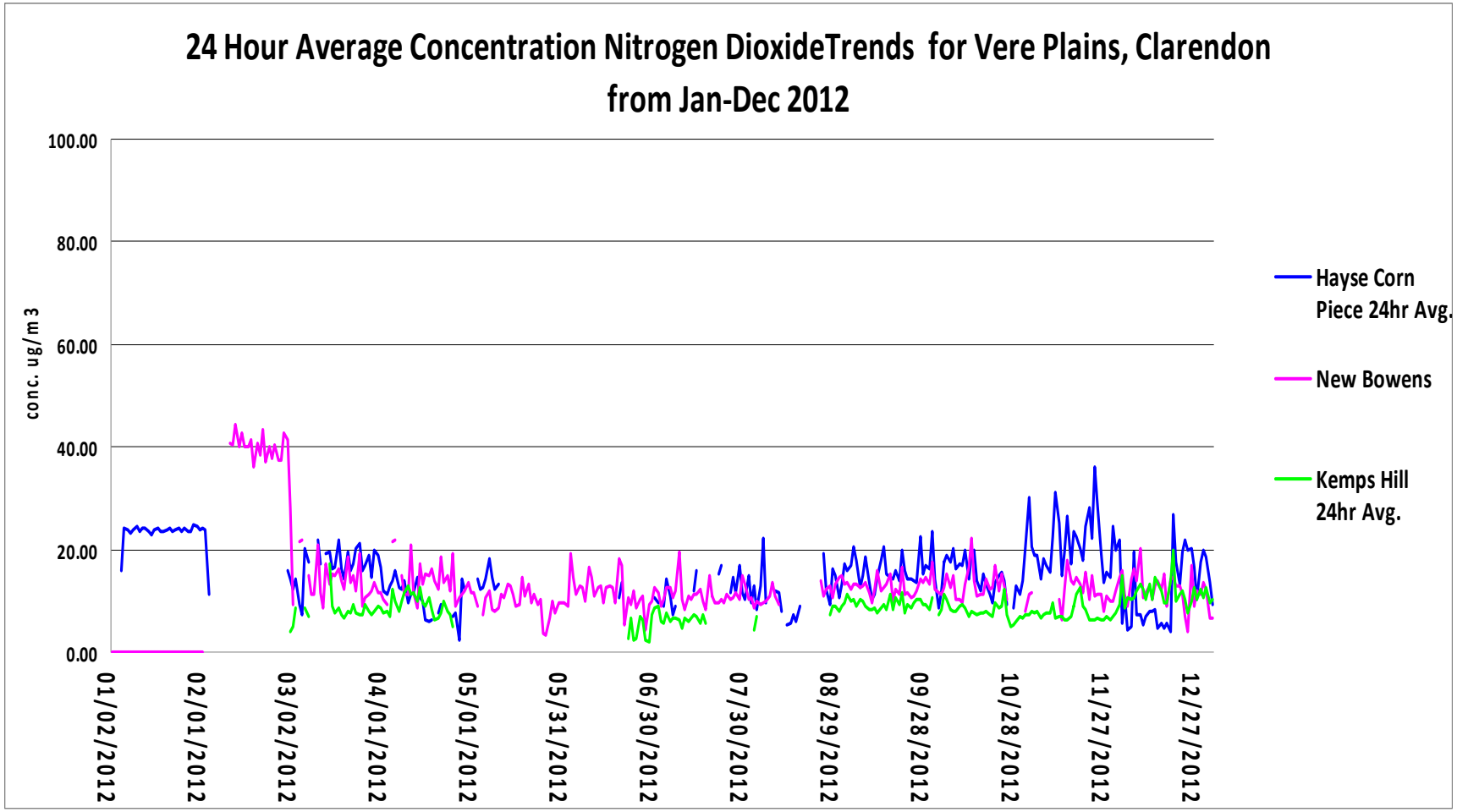


Figure 47A: Graph showing trend in ambient air quality for Nitrogen Dioxide at the stations in the Vere Plains, Clarendon from Jan-Dec 2012



***No daily standard exists for Nitrogen Dioxide; however, a guideline 1 hour standard of 400ug/m³ was developed by the NRCA**

Figure 48A: Graph showing Annual Nitrogen Dioxide average concentrations at all monitoring stations in Vere Plains, Clarendon for 2012

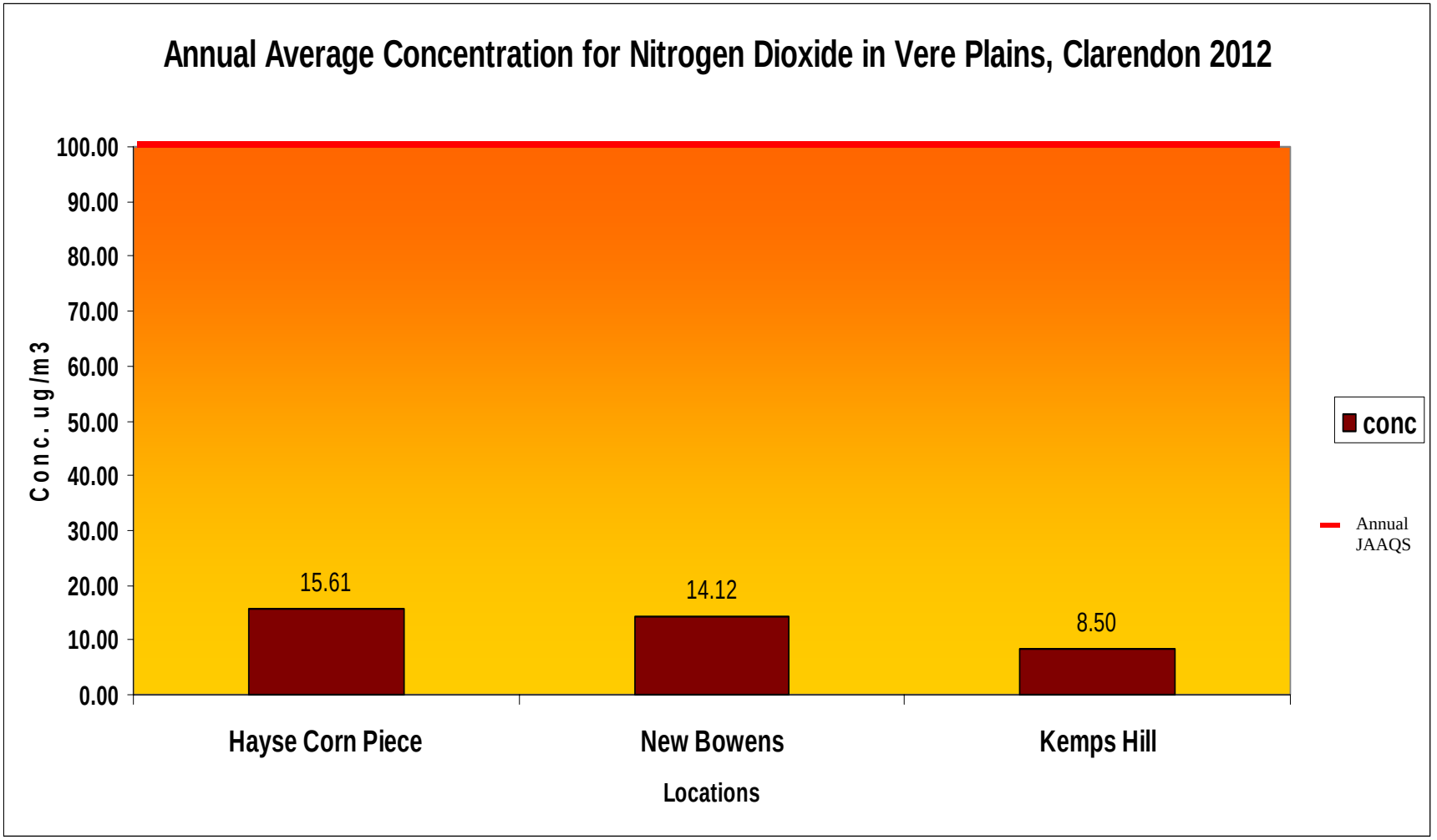


Figure 49A: Graph showing trend in ambient air quality for Ozone at the Rockfort station in Kingston from April-Dec 2012

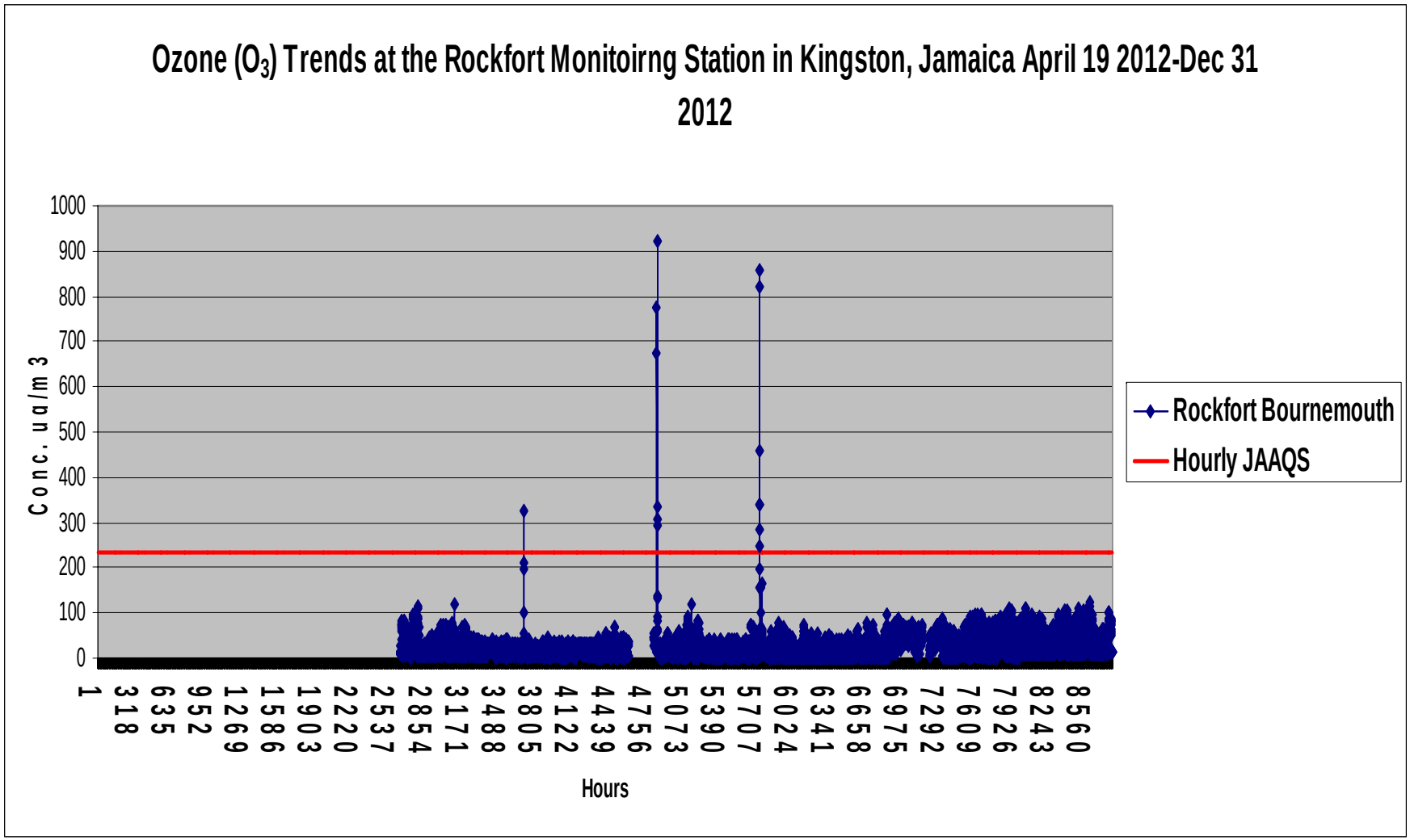
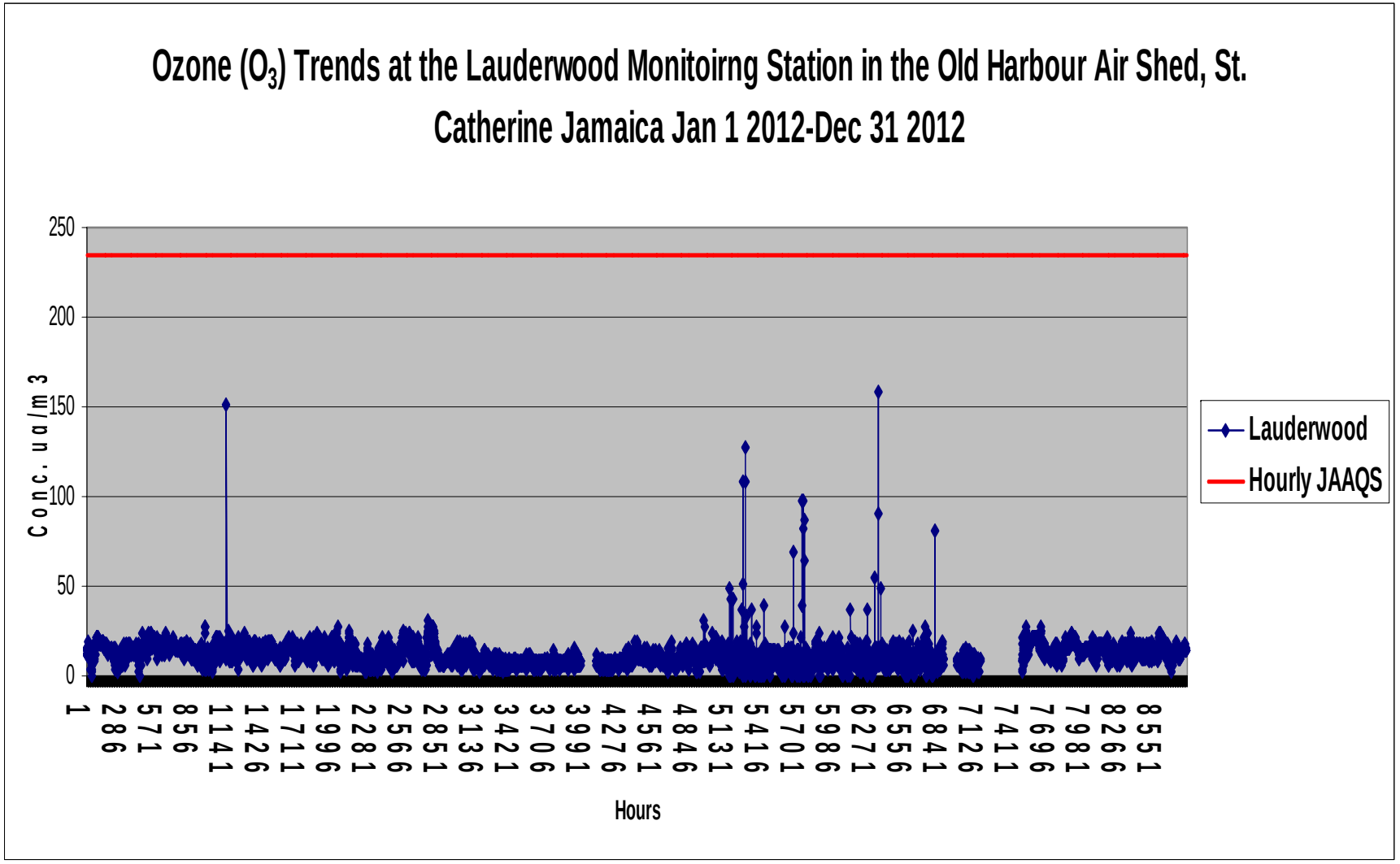


Figure 50A: Graph showing trend in ambient air quality for Ozone at the Lauderwood station in Old Harbour Bay St. Catherine Jan-Dec 2012



Carbon Monoxide

There were four sites monitored in 2012, namely:

- Hayes Corn piece, Clarendon
- New Bowens, Clarendon
- Kemps Hill, Clarendon
- Orange field, Clarendon

None of the four monitoring sites recorded a breach in the 1 hour and 8 hour standards.

APPENDICES B
Graphs of Analytical Trends in Concentrations

Urban Area Trends

Figure 1B: Shows concentrations for TSP at stations across Kingston and St. Andrew from 2010-2012

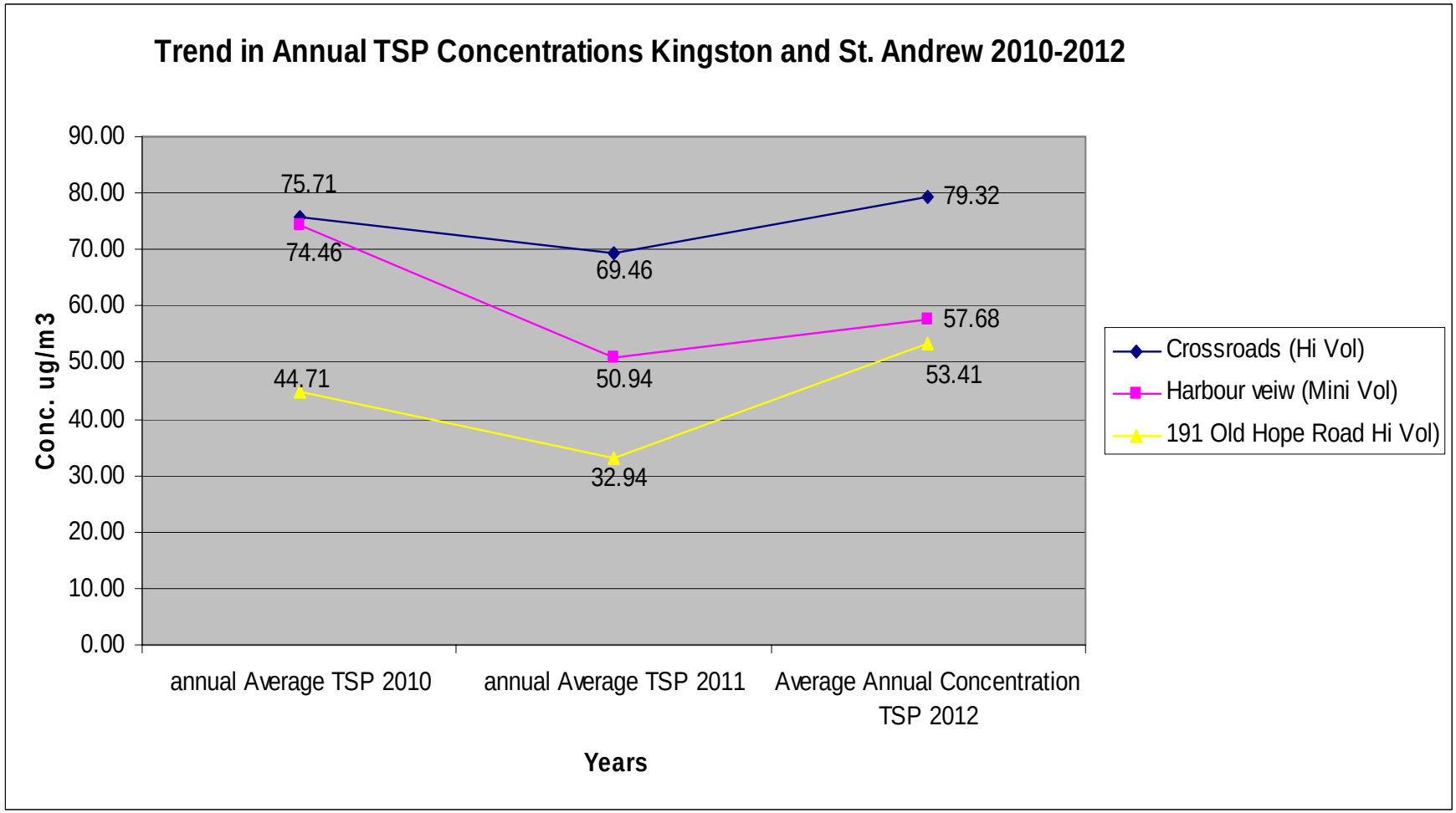


Figure 2B: Shows concentrations for PM_{10} at stations across Kingston and St. Andrew from 2010-2012

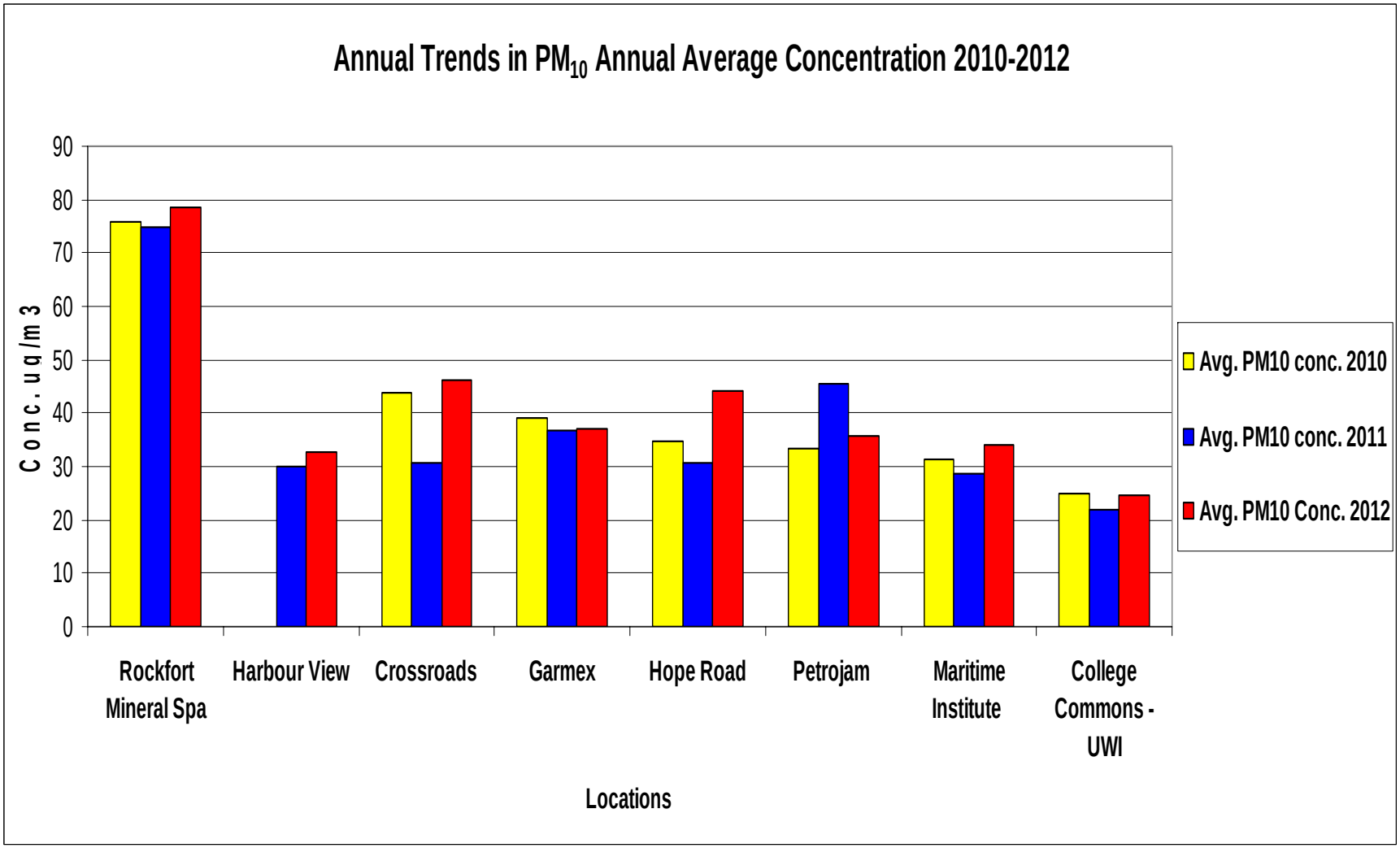


Figure 3B: Shows concentrations for Sulphur Dioxide at stations across Kingston and St. Andrew from 2010-2012

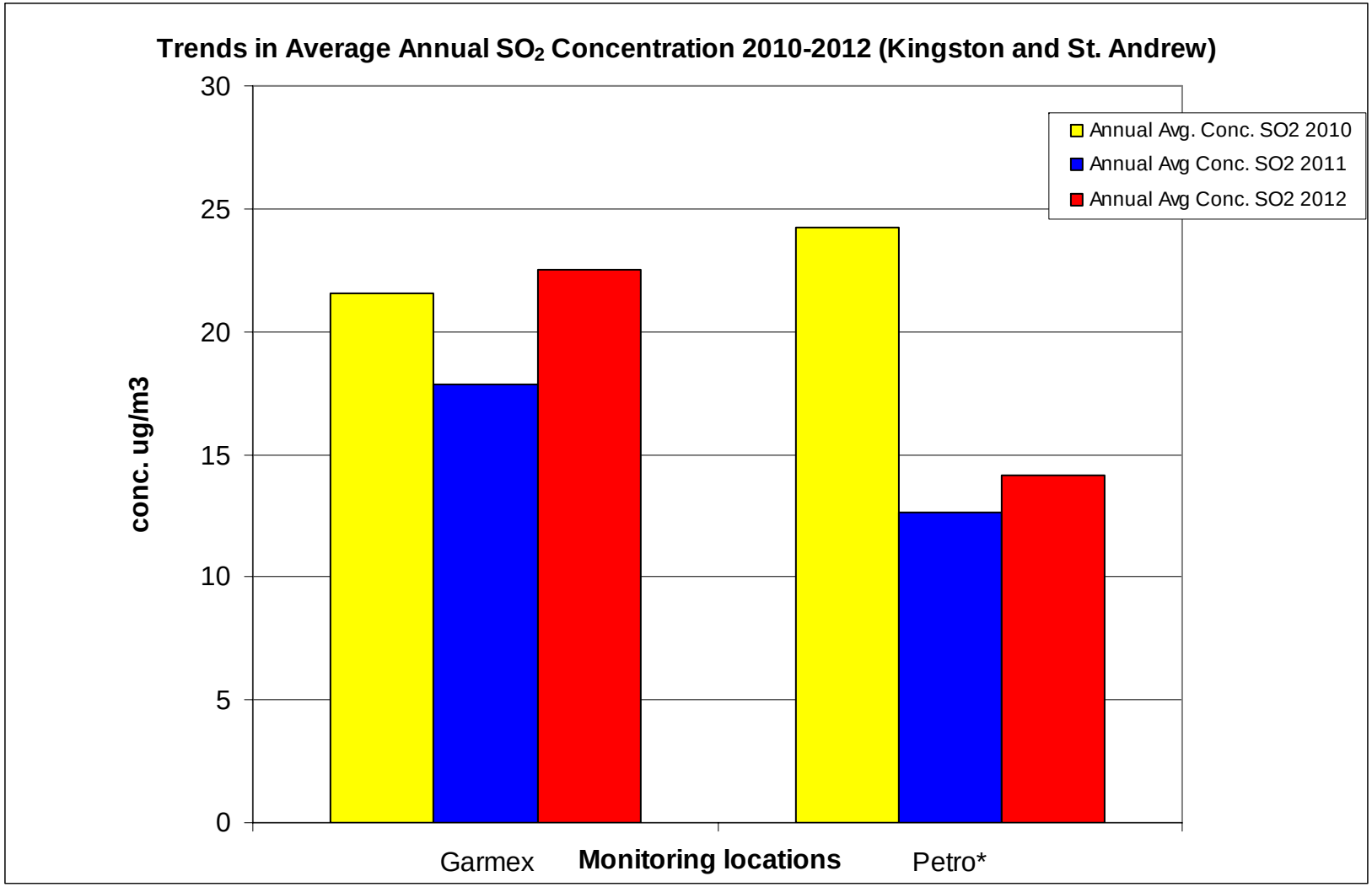
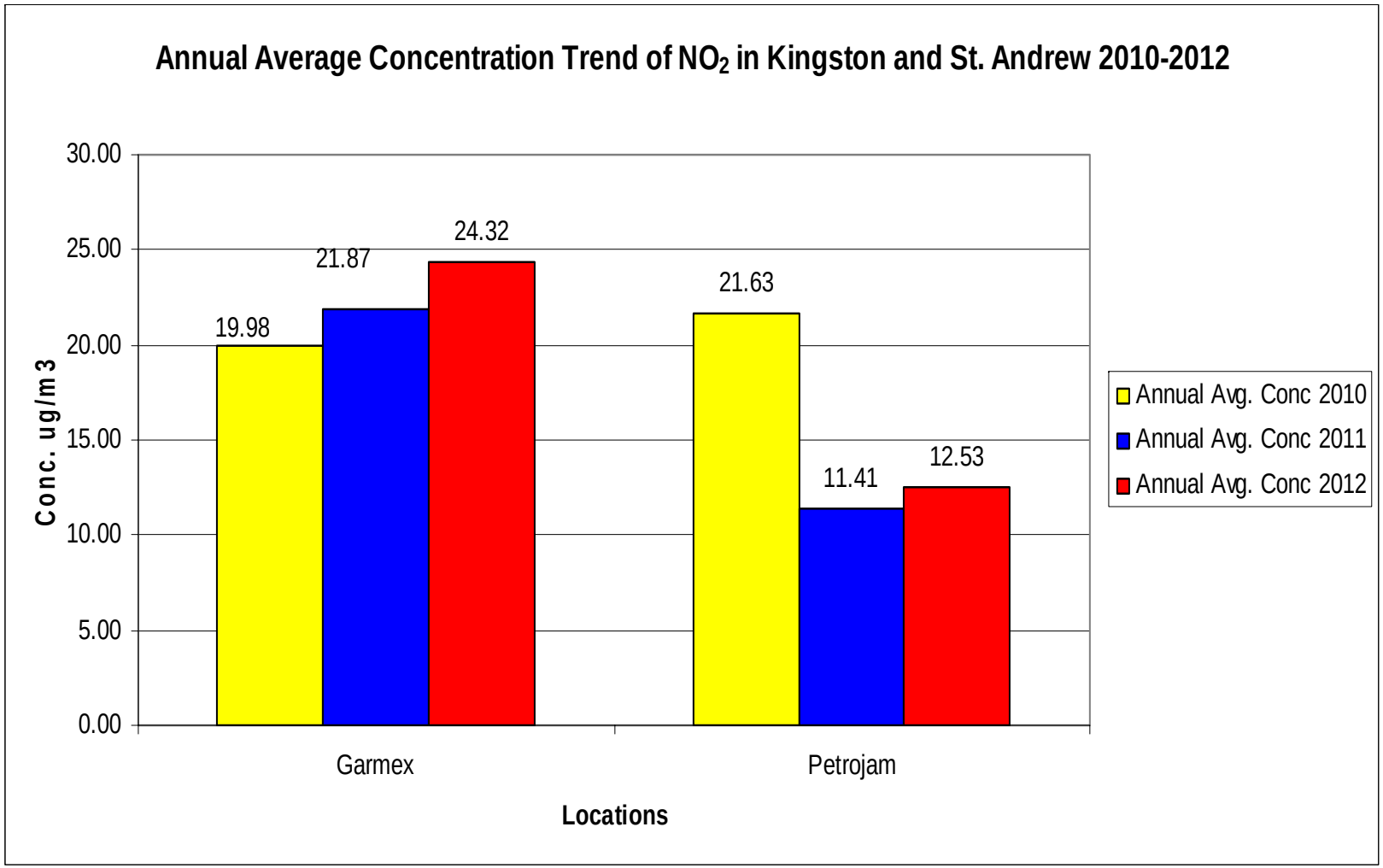


Figure 4B: Shows concentrations for Nitrogen Dioxide at stations Kingston and St. Andrew from 2010-2012



Rural Area Trends

Figure 5B: Shows concentrations for TSP at stations outside urban areas from 2009-2012

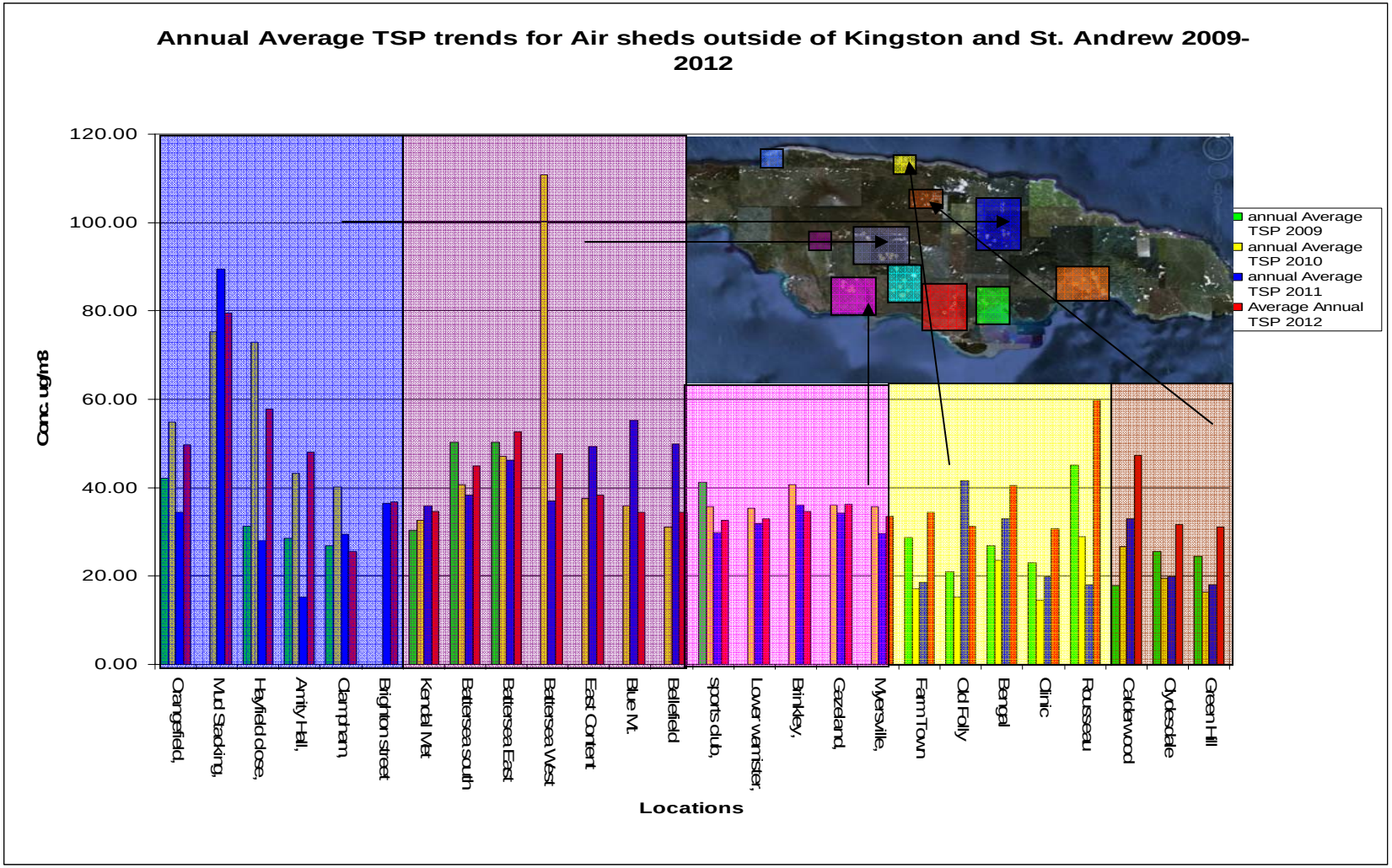


Figure 6B: Shows concentrations for PM_{10} at stations outside of Kingston and St. Andrew from 2009-2010

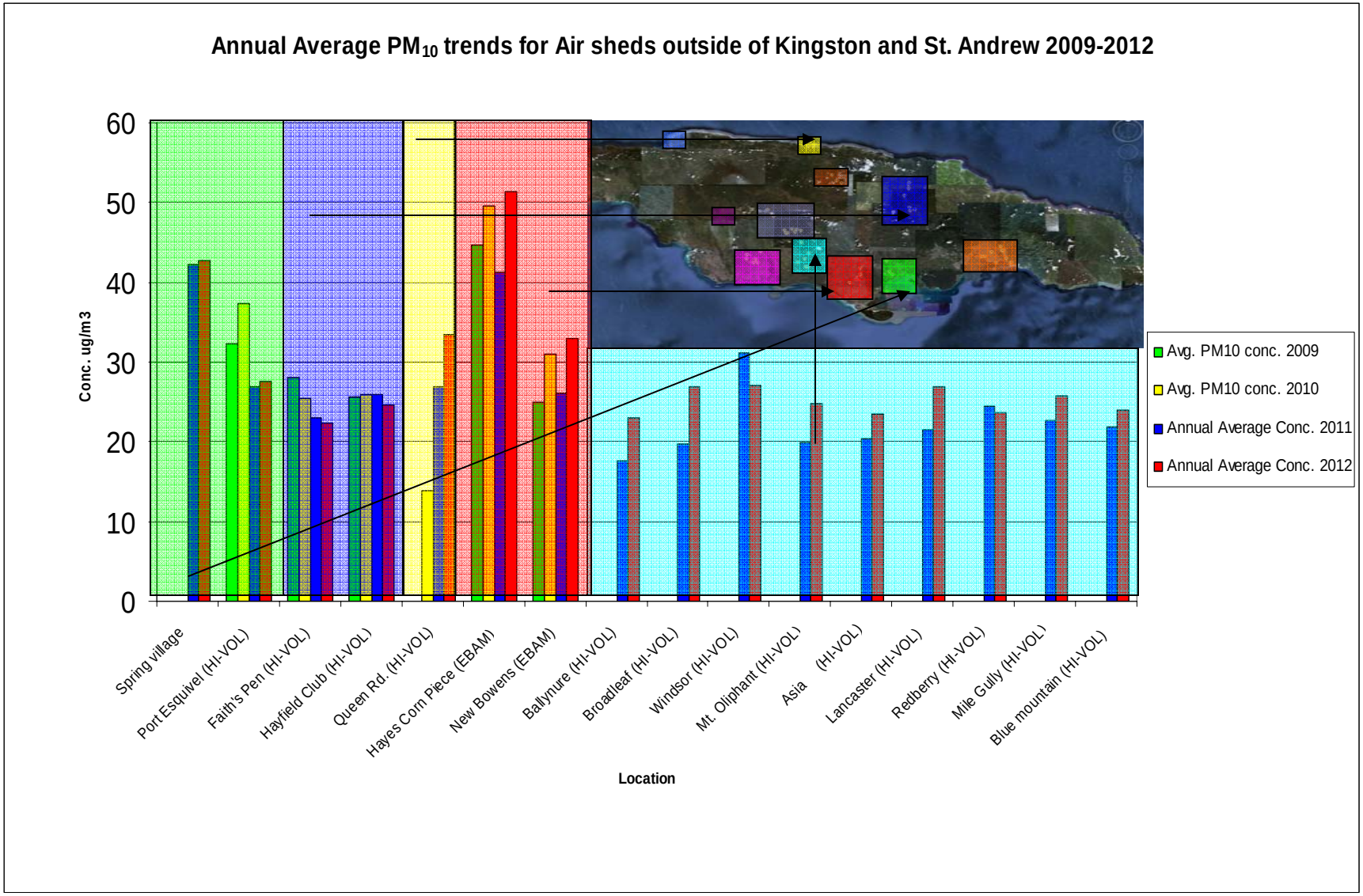


Figure 7B: Shows concentrations for Sulphur Dioxide at stations outside of Kingston and St. Andrew from 2010-2012

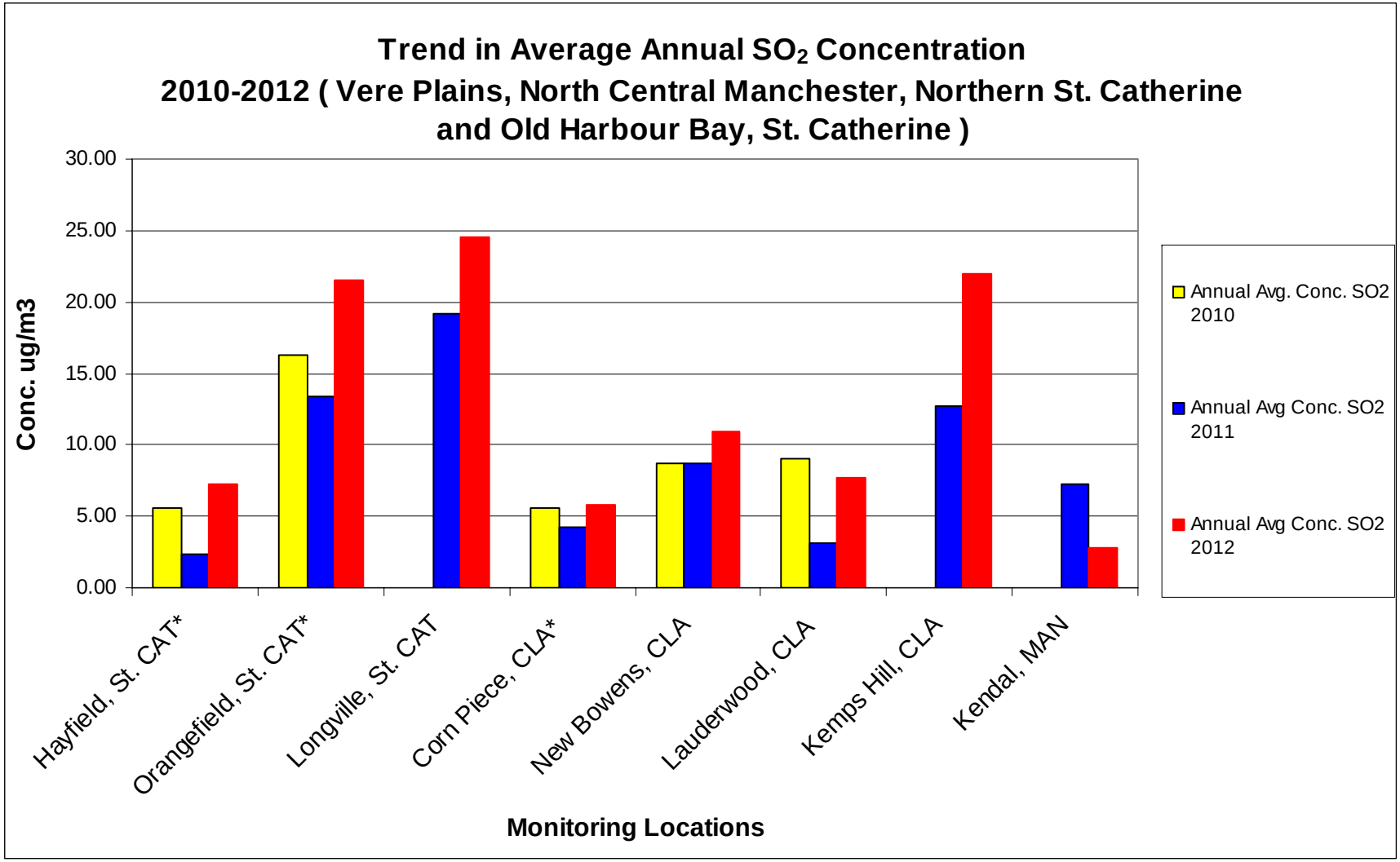


Figure 8B: Shows concentrations for Nitrogen Dioxide at stations outside of Kingston and St. Andrew from 2009-2012